Investigating the relationship between sugar and ethanol industries and analysing the impacts (if any) of ethanol production on the sugar industry in UK and Pakistan.

Thesis submitted in partial fulfilment of the award of the Doctor of Philosophy at the De Montfort University

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ABSTRACT

The sugar industry is important to economies; however, health concerns are emerging as a threat in developed countries. The sugar industry can benefit from biofuel, particularly bioethanol. The sugar – fuel relationship and the reverse relation particularly the possible effects of ethanol production on the sugar industry have not been analysed. This study sought to delve deeper into this investigation by comparing the factors influencing sugar production and the effects of ethanol in the United Kingdom and Pakistan. This study is unique in that it examines both an industrial and an agricultural country that are constantly involved in sugar and ethanol production and trade. Since the data collected is ordinal, qualitative, and quantitative, data analysis will use a combination of qualitative and quantitative methods. This research study considers the use of primary, secondary, and official sources. A semi-structured questionnaire was used in this study. The survey questions were designed to be open-ended, allowing respondents to express themselves freely. The model was created to perform multiple analyses, such as SWOT analysis, demand and supply analysis, pestle analysis, thematic analysis, technoeconomic analysis, and future scenario analysis, to better understand the factors influencing sugar production in Pakistan and the United Kingdom, as well as to assess the potential impact of ethanol on the sugar industry.

According to the findings of this study, several factors influence the sugar industry in Pakistan. Such as a lack of government policy to align prices, control surplus sugar, subsidise export sugar to align with the international sugar price, and a lack of yield in the available variety due to a lack of interest in research for better sugar cane varieties with higher sugar yields, as well as farmer awareness of the crop and transportation. There are several factors affecting the sugar industry in the United Kingdom, including a lack of quotas, being bound by the EU, only being able to buy from certain countries, and paying high taxes on imported sugar. In Pakistan, ethanol is made from molasses, which is a by-product of the sugar industry, whereas sugar is made from sugar cane juice. The study concludes that the impact of molasses-based ethanol production in Pakistan has a positive impact on the sugar industry by creating a lucrative and profitable market for cane growers, sugar industry owners and investors. In the United Kingdom, ethanol is produced from sugar beet (5%) and feed grade wheat (95%). More ethanol produced in the UK from sugar beets will have a negative impact on the sugar industry, reducing sugar production. Because it is a different crop, feed grade wheat or grains for ethanol will have no impact on the sugar industry. The consequences differ for both countries due to a variety of factors. The factors include ethanol and sugar sector production technologies, government policies, the legal framework, and the socioeconomic and environmental environment.

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Dedication

This thesis is dedicated to:

My parents; My father Fateh Sher khan and my mother Sardar Fatima

My wife & children; Mrs Monireh, Ali Mahdi, Ali Haider, and Ali Mustafa

My siblings; Ali Mohammed, Mehwish Fatima, Aleen Fatima and Ali Nawaz

My extended family: Dr. Mohammed towliat & family and Dr. Ali Zeb Khichi

My nephew: Ali abbas khan

Thanks all for your support and prayers.

Acronyms/Abbreviations

1G:	First Generation feedstock
2G:	Second generation feedstock
3G:	Third generation feedstock
ACP:	African, Caribbean and Pacific
AEDB:	Alternative Energy Development Board
AMIS	Agriculture Marketing wing Punjab
ASR:	American Sugar Refinery
BBL:	Barrel of oil
CAP:	Common Agricultural Policy
CNG:	Compressed Natural Gas
Co2:	Carbon dioxide
CPI:	Cleaner Production Institute
DDGS:	Distillers Dried Grains with Soluble
DEFRA:	Department for Environment Food and Rural Affairs
DfT:	Department of Transport
E10:	Mixture of 10% ethanol into gasoline
EIA:	Energy Information Administration
EU:	European Union
FAO:	Food and Agriculture Organization
FFV:	Flexible-fuel vehicles
FQD:	Fuel Quality Directive
GBP:	Great British Pound
GBP:	Great Britain Pound
GDP:	Gross Domestic Product
GHG:	Greenhouse Gases
GREET:	Greenhouse gas, Regulated Emissions, and Energy use in transportation
IEA:	International Energy Agency
IEA:	International Energy Agency

IMF:	International Monetary Fund
ISO:	International Sugar Organization
LCA:	Life Cycle Assessment
LDC:	Least Developed Countries
NFU:	National Farmers Union
NPO:	Pakistan National Productivity Organization
OECD:	Organization for Economic Co-operation and Development
OECD:	Organization for Economic Co-operation and Development
OPEC:	Organization of the Petroleum Exporting Countries
PBS:	Pakistan Bureau of Statistics
PEMA:	Pakistan Ethanol Manufacturers Association
PPP:	Purchasing Power Parity
PSMA:	Pakistan Sugar Mills Association
PSO:	Pakistan State Oil
RED:	Renewable Energy Directive
RFA:	Renewable Fuels Association
RTFO:	Renewable Transport Fuel Obligation
SDS:	Sustainable development scenario
SSB:	Sugar sweetened beverages
T&L:	Tate & Lyle
TCD:	Tons of crushing per day
TEA:	Techno Economic Analysis
USA:	United States of America
USD:	United States dollar
WHO:	World Health Organization

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Chapter 1: Introduction

1.1.Fossil fuel dependence of the transport sector and biofuel as a viable decarbonization option

The transport sector is dependent on fossil fuels heavily. The sector accounts for 25% of the world energy use and uses 61.5% of the oil (Rodrigue, 2020). Diesel and petrol-based petroleum products including biodiesel blends and bioethanol blends are the dominant energy source for the sector of transport. Figure 1.1 indicates the transport sector energy use and most of the energy being used is motor gasoline and diesel fuel.

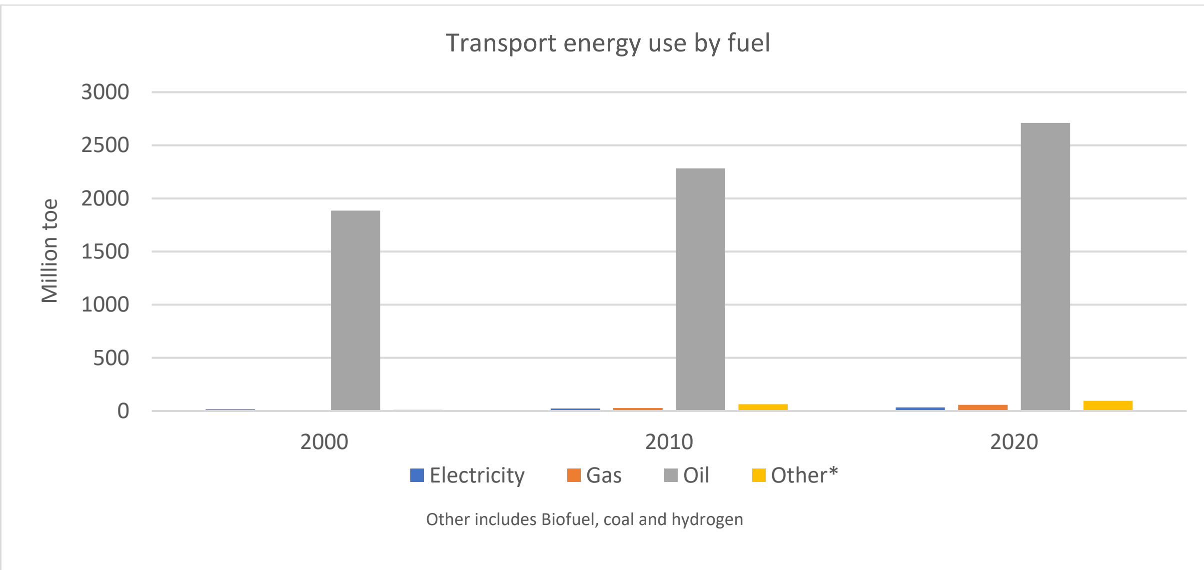


Figure 1.1 Global transport energy use (Source: Author based on the data from British Petroleum (2020)for energy consumption in the transport sector)

Oil usage is constantly increasing but demand will increase slowly to 2030 due to increase in shipping, transport, and aviation sectors. By 2040 the demand for the oil will reduce due to a greater number of electric cars and more biofuels consumption (International Energy Agency, 2019). Transport sector's dependency on the fossil fuel is damaging the local environment. World health organization guidelines for the Air Quality recommend annual mean values not to exceed 20 $\mu g/m^3$ for PM_{10} and $10\mu g/m^3$ for $PM_{2.5}$. Pakistan has a very poor quality of air: WHO (2016) reports the median PM2.5 level in urban areas at 68 $\mu g/m^3$. According to World Health Organization (2016), three million deaths are occurring from the ambient air pollution in 2012 globally, of which 87% arise from the third world countries. Most of the deaths (97%) are due to noncommunicable diseases in adults (such as heart disease, lung disease, etc.). In Pakistan, 59,000 deaths are attributable to air quality issues. As shown in Tables 1.1 and 1.2, Pakistan ranks 3rd in terms of level of pollution and 3 Pakistani cities figure in the top 10 most polluted cities in the world.

Table 1.1 Top 10 Polluted countries in the world (Source: WHO, 2018)

Rank	Countries
1	India
2	Cameroon
3	Pakistan
4	Uganda
5	Bangladesh
6	China
7	Qatar
8	Mongolia
9	Kuwait
10	Saudi Arabia
78	United Kingdom

Table 1.2 Top 10 Polluted cities in the world (Source: IQAir 2018)

Rank	Cities
1	Ghaziabad, India
2	Hotan, China
3	Gujranwala, Pakistan
4	Faisalabad, Pakistan
5	Delhi, India
6	Noida, India
7	Gurugram, India
8	Lahore, Pakistan
9	Greater Noida, India
10	Bandhwari, India

In Pakistan, air pollution is increasing since last decade and according to Amnesty International (2019) transportation, industrial and agriculture practices are the major reasons behind the smog which occurred in different cities of Pakistan and was very hazardous. UK air pollution is also continuously on the rise and policies related to air pollution have often been criticized by the people. Major cause for the air pollution in UK is due to transportation and industrial practices and in air pollution, London is the worst city in UK. One of the major causes for the health issues in the UK is poor air quality and it imposes environmental risks as well. It also estimated that, it can cause up to 20 billion GBP in health costs (DEFRA, 2019).

Further, according to IEA (2019), the transport sector is responsible for 24% of the total CO_2 emission and three quarter of it comes from the road transport such as cars, trucks, 2 and 3-wheeler trucks and buses. According to the WHO (2016), almost 29% of CO_2 emission of Pakistan comes from the transport sector while the UK's share is 28.5%. In line with the ambitions of the Paris Agreement, countries must significantly reduce their dependency on the fossil fuels to reduce carbon footprint intensity of the sector.

In addition, all oil non-producing countries are exposed to volatile fuel prices since the supply is not in their hands. Countries like UK and Pakistan are exposed to volatile fuel prices due to their local demand and need. Price volatility, particularly high prices, contributes to uncertainty, inflation and often hardship of users and reducing oil dependence can mitigate this challenge. UK is planning to introduce electric cars and increasing the use of biofuel to decrease the dependency of fossil fuel. Pakistan is also starting to think over about the electric cars and have initiated the step to remove the import duties to import electric cars in cheap. Pakistan is one of the top ten producer of ethanol in the world, currently exporting most of its ethanol to international markets, and can introduce higher percentage of ethanol blending to fuel to decrease the fossil fuel imports and eliminate GHG emissions.

To mitigate the risks and challenges it creates in terms of energy security, climate change, local pollution, economic stress and sustainability, a reduction in the fossil fuel reliance of the sector is required with the goal of reaching a 100% renewable economy in the long-term. Therefore, it is necessary for developed and developing countries to find a mechanism to convert to more renewable sources. Figure 1.2 (International Energy Agency, 2019) shows that so far 13.5% of the world energy production is from renewables, of which biofuel accounts for only 9.2% and liquid biofuel for transport is only 4.4% (International Energy Agency, 2019). Biofuels such as biogas, bioethanol, biodiesel, and bio methanol are one of the alternative options to fossil fuels. These are produced from the fermentation of the agriculture food crops such as sugar cane, corn, wheat, sugar beet, cassava; classified as the first generation (1G) ethanol, and from waste product such as molasses or from the biomass classified as the end generation (2G) ethanol. Their production is largely dependent on available agriculture area that may compete with other food crops.

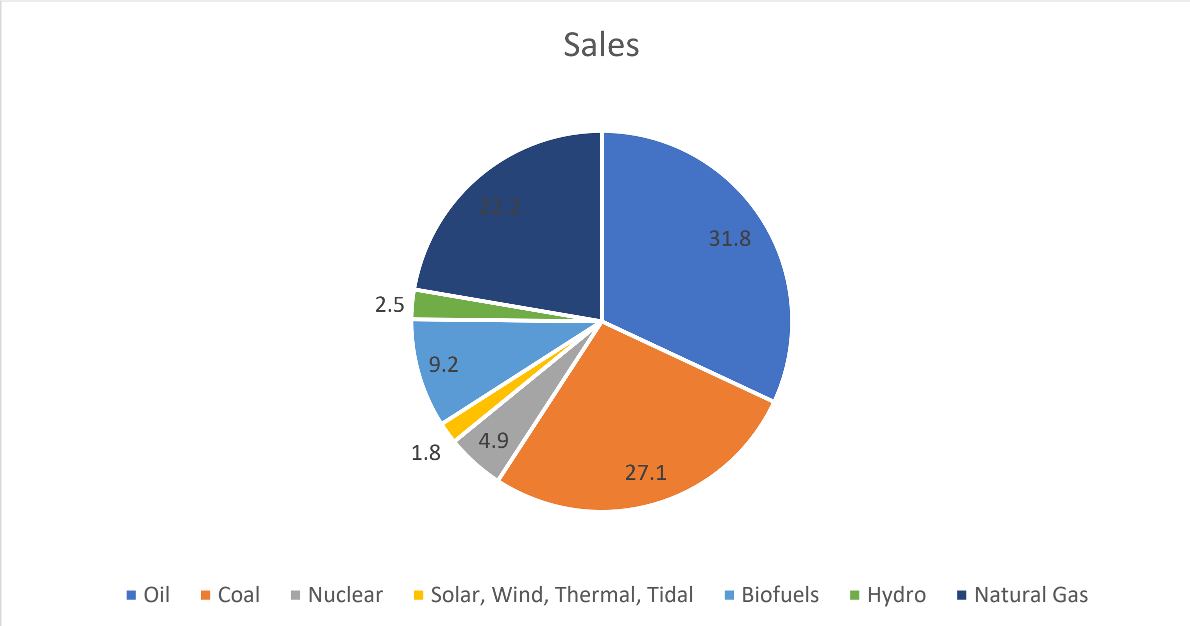


Figure 1.2 Total percentage of Renewable energy used in overall energy production (Source: International Energy Agency, 2019

The production of biofuel is largely dependent on the government policies, mandate in blending, availability of land, available technology, and infrastructure**.** 4.4 % of the world fuel comes from biofuel, which is far less from the original targets of 9% and targets align with the Sustainable development scenario (SDS) (IEA, 2019). This is just the low share of biofuels in the transport fuel mix and does not meet the energy need of the transport sector.

Higher fuel prices and the energy security concerns prompted the alternative fuel development. Since early 1970s, countries had been at the mercy of the global crude oil cartel known as OPEC for the supply of crude. The OPEC as a cartel seeks to protect the interests of its members only and not that of non-oil producing states that demand the crude commodity. This had led to the unstable price paid for the demand in the international market and prompted the search for alternative fuels. Demand for the fossil fuel is inelastic and even higher fuel prices has little or no impact on the growth of motorization. Despite the high fuel prices in developed countries like UK, number of vehicles has increased. However, according to the Department of Transport (2019), there was an increase of 1.2% licensed cars from 2017 in the year 2018 and 23.7% higher than 2009 in the United Kingdom. If the fuel prices remain high, countries which rely heavily on the oil, need to look for alternative fuels such as biofuels. Governments could set a target for alternative fuel vehicles. The increase in alternate fuel demand such as biofuel, can reduce the GHG emissions. The future issues of the transport sector need to be addressed accordingly and urgently by the world policy leaders to reduce the GHG emissions associated with transport sector.

Researchers have been on a quest to find alternatives to fossil fuels by creating biofuels using ecological bioresources (Bezerra and Ragauskas, 2016). Eggleston (2010) pinpointed biofuels as alternative energy resources. Biofuels are renewable fuels gotten from biological feedstocks. Biofuels are classified as bioethanol (gasoline-related) or biodiesel (diesel-related) (Kapasi et al., 2015). Ethanol, according to Gumienna et al. (2016) is the fuel made from biomass or agricultural products as an alternative to fossil fuels. Ethanol and biodiesel are the leading biofuels in the transportation sector (Goldemberg, 2010). Today, ethanol is manufactured using both sugar and starchy agriculture crops to produce fuel grade ethanol, industrial grade, and food grade, which are used as fuel or used to produce pharmaceutical products, beverages, cosmetics, and toiletries etc. (IEA, 2007). Rosillo-Calle and Walter (2006) believe that 95% of the ethanol is produced from food crops. However, 60% of the ethanol today is produced from corn, 25% from sugar cane and rest from molasses, wheat, sugar beet and cassava and 77% of the biodiesel is produced from the vegetable oil crops and rest from the used cooking oil (Food and Agriculture Organization, 2019).

Sugar cane, sugar beet, wheat, and corn are the most used agriculture crops to produce ethanol. Non-starchy produces like; sugarcane and sugar beet are preferred over starchy raw materials as sugary materials are easily fermented (Gumienna et al., 2016). Biofuel can be a good option in terms of decarbonization and economic viability. However, massive production and extensive use of ethanol, however, initiate the food vs. fuel worries (Bezerra and Ragauskas, 2016).

1.2.Biofuel as the main alternative to fossil fuels

To cut down the cost on foreign oil buying and reduce GHG emission, governments need to look for main alternatives to fossil fuels and must work with car companies, stakeholders to pursue for alternative energy. Biofuels are among the few options available which is a clean burning fuel. The time has reached to look for an alternative and to confront energy crisis. Considering volatility in oil prices and import costs and environmental issues will lead to explore biofuel more as a main alternative to fossil fuels. Table 1.3 below compares the fossil fuel to biofuel and how biofuel is one of the major alternatives to fossil fuel and its benefits. It shows that biofuels are renewable, emit less GHG emission, and low amount of energy per unit as compared to fossil fuels. Environmental protection agency (2014) states that biofuels are renewable. It releases less GHG emission and releases few amounts of Co2 emission (Hertel et al., 2010; Huang et al., 2013). Hosseini (2022) states that fossil fuels are non-renewable, it releases GHG emission and is the major reason for the global warming. Bertrand (2021) believes that fossil fuels destroy our eco system as compared to biofuels. Martins et al. (2019) also confirms that fossil fuels are non-renewable, unlike biofuels, it releases more GHG emissions, destroys the ecosystem and is produced by non-safe environments.

Table 1.3 Comparison of Fossil fuel and Biofuel (Source: Author derived from Hosseini 2022, Hertel et al, Huang et al.)

Fossil fuel	Biofuel
Non-renewable	Renewable
High amount of energy per unit	Low amount of energy per unit
GHG Emissions	Less GHG emission
Produced in un-safe environment	Produced in safe environment
Reason for global warming	Fewer amount of CO_2emission
Mining destroys the eco-system	Use excessive water

The quest to search for alternative fossil fuel that started many decades ago ended their findings that biofuel as a favourable alternative replacement to fossil fuel (Masjuki and Kalam, 2013; Tomei, 2015). These researchers based their conclusions after considering many factors such as: financial cost, Biofuels as a GHG mitigation option, and the expected ease of use of biofuels. These are discussed below.

1.2.1. The Financial Cost of Biofuel

The perceived financial costs of using an innovation are very important, especially as it applies to the use of renewable fuels such as ethanol (Khatiwada et al., 2016); selection should be made for renewable energy with the lowest lifetime costs. Lisboa et al. (2011) mention that sugarcane ethanol is considered a useful and cost-effective replacement for fossil fuels. Monteiro et al. (2012) considers that sugar cane-based ethanol production is more cost-effective than corn-based ethanol in USA. Harijan et al. (2007) argued that about US$200-400 million of crude oil import will be saved annually if Pakistan utilised the blending of ethanol to gasoline in the transportation sector. This, in turn would bring about the cost reduction in foreign spending on oil (Silalertruksa et al., 2017).

According to Masjuki and Kalam (2013), biodiesel is more cost-efficient than diesel. This paper pinpointed that biodiesel can be sourced locally which makes it very cheap compared to diesel that depends on the fluctuations of oil prices of OPEC. Dufey and Grieg-Gran (2018) support this statement that with the high cost of oil and its by-products, the use of bioethanol becomes more profitable, and it suggests a cost saving in Pakistan. Guevara et al. (2017) pinpointed price as a relationship shared between sugar and ethanol. The costs of producing ethanol can be spread whereby reducing financial risks (Tomei, 2015). Mixing of molasses-based ethanol with gasoline can reduce the cost (Muhammad A et al., 2019). Biofuel can be cost effective, if the oil prices are higher and/or tax relief or subsidies are given. In terms of cost, biofuel may not be a good option for some countries in the Middle East: where they are the oil producers. These countries can accept to produce ethanol and use as blending if environmental concern needs to be addressed. There are many factors, which affect the production cost, pricing, and profitability of biofuel. Feedstock cost is the major contributor in the production cost. To assess the profitability of biofuels, one needs to see the value of co-products such as: Distillers Dried Grains with Soluble (DDGS) from corn/wheat-based ethanol and molasses and bagasses from sugar cane-based ethanol. Bagasses are waste products and are used to generate electricity, which itself saves much on the energy cost in sugar cane-based ethanol production. International Energy Agency (2018) with collecting data from F.O. Lichts and EIA indicates that with high fuel prices, ethanol will be favourable to produce. It can be seen from the table 1.4 (IEA, 2018) that ethanol production cost in Brazil was between 0.54 to 0.62 USD per litre from sugar cane based-ethanol and in USA it was between 0.51 and 0.58 USD per litre from corn bases-ethanol.

Table 1.4 Average ethanol production cost comparison with breakeven (Source: IEA, 2018)

	Ethanol production cost (USD/L)	Ethanol break even (USD/bbl)
Brazil	0.54 - 0.62	50 - 60
USA	0.51 - 0.58	64 - 76

Crude oil price in 2017 was between 46 USD/bbl and 64 USD/bbl as compared to break even oil price of biofuel which was between 50-60 USD/bbl in Brazil and between 64-75 USD/bbl in USA. Winchester and Ledvina (2017) explains the threshold for the low and high oil prices, they believe that if the oil prices are higher, there will be more biofuel production. But if the oil prices are below, biofuel will not be economical to produce unless there are government policies and health issues to back up. Timilsina, Mevel and Shrestha (2011) indicated that biofuel production increased by 5.4% when oil prices went up by 65% in 2020 from 2009. The data suggests that cost of production of ethanol in Brazil was favourable as compared to USA. There is an incentive of $0.18/l from the US government to ethanol producers, making it favourable as well. However, as figure 1.3 (IEA. 2018) indicates that, even in Brazil, bioethanol can struggle to compete with gasoline when oil prices are low. It suggests that ethanol is favourable in terms of financially, when the oil prices are higher, or it is favourable in terms of environmentally if only GHG emissions concerns are considered.

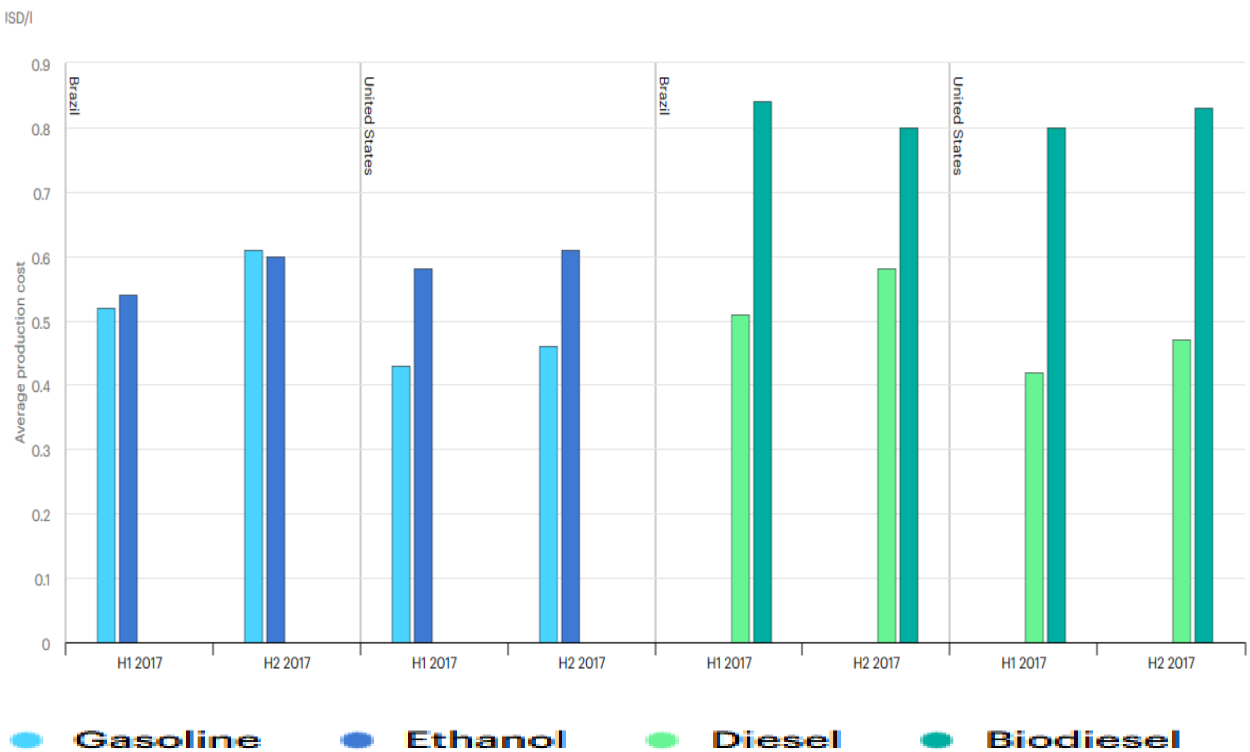


Figure 1.3 Average production cost in Brazil and USA in 2017 for biofuel against oil prices (Source: IEA, 2018)

1.2.2. Biofuels as a GHG mitigation option

The utilisation of biofuels technology promotes economic sustainability (Kapasi et al., 2015) by creating employment, rural development and saving in GHG emissions. Chen et al. (2018) conducted a study on LCA of the biodiesel system in US and concluded that soy-based biodiesel can reduce 76% GHG emission. Another study was conducted by Chillrud (2016) for Environmental and Energy Study Institute concluded that traditional ethanol could reduce the GHG emissions by 20-50% approximately as compared to gasoline. The application of a blended mixture of ethanol and gasoline will reduce the cost and emission (Muhammad A et al., 2019). This is further supported by the Chillrud (2016) who suggested that E10 will reduce the emission. However, this is only true if the lifecycle emission of biofuels is lower, and their cost of production is cheaper than fossil fuels. Due to recent COVID-19 outbreak (World health organization, 2020), the oil prices have gone to 21 years low (World oil, 2020), which makes the ethanol unfavourable to be produced worldwide. Therefore, the usefulness of the biofuel industry is showing up, as many countries are introducing policies to mandate the use of ethanol and biodiesel in the energy portfolio but only if the price of ethanol is lower than gasoline and less GHG emission is produced than gasoline.

1.2.3. The expected ease of use of biofuels

Masjuki and Kalam (2013) cited that the biodiesel production is easier to produce, more environment friendly and less time-consuming. Also, the renewable source of energy is easy to use for automobile mechanisms (Muhammad et al., 2019). The ethanol powered automobile engines are easier to use when compared to non-renewable fuels such as gasoline. This is because the blending is easier and may present certain air quality benefits (Dufey and Grieg-Gran, 2010). The perceived ease of use of ethanol is boosted because it is less inflammable compared to gasoline by careless users (Dufey, 2006). It is important to highlight that biofuel has advantage over other renewable energy as existing sugar refineries can be used to produce ethanol. The same storage, distribution and transportation networks can be used for biofuels. This comes as an advantage compared to other alternatives such as electric vehicles or CNG.

The purpose of this study was to highlight some of the advantages of biofuels compared to conventional fuel. Saving of foreign reserves, employment, rural development and GHG savings are among the highlights of biofuel advantages. However, all biofuels which are produced in the world are from the food crops such as sugar cane, corn, sugar beet, wheat, soy, rapeseed, and other oil crops thus resulting in a never-ending debate of food vs fuel.

1.3.Food Vs fuel debate and how ethanol can have an impact

Global population is growing at an alarming rate and more food is required to feed them and more energy will be needed to support the economic activities. This raises the debate about food versus fuel: how much land and resources are available and how they should be used? The role of biofuel in the hike of global food prices is under debate since 2007. There are claims that biofuel was the main reason behind the higher food prices; however, some stakeholders contradict the claim. In recent years, the biofuel production was increased in many developed and developing countries. Food commodities like sugar cane, sugar beet, corn, wheat, and vegetable oil crops can be used either for food, feed or for biofuel production. Currently due to limited fossil fuel resources and rising GHG emissions, there is a global thinking about biofuels. Thus, there will be a need for crops to be dedicated to biofuels. Food prices in 2000 and 2001 were relatively low and they were stable and the price hike in later part was abnormal. Mitchell (2008) stated that higher food prices were due to crops being used to make biofuel. Prices of different commodities like corn, wheat and rice rose by 125%-300% in the year 2008. The World Bank believed that corn and wheat were main reason for higher food prices globally and there was a global rise in the sugar prices.

However, later studies contradicted the above view and found out that sugarcane production was increased, and it did not affect the sugar or food prices elsewhere and specially sugar cane from Brazil to have no effect on food prices. Mitchell from World Bank (2008) believes that sugar cane-based ethanol production has not contributed to the higher food prices. Corn prices went high due to ethanol production from corn in the US and resulted in high food prices in Mexico which relies heavily on corn. Due to increased demand of biofuel, it was blamed for the world food price crisis, but FAO (2008) indicated that rice prices went high during this period, while rice was not directly used for the biofuel. Baffes and Haniotis (2010) carried out the further study and have indicated that biofuel impact on the food prices is not as much as it was thought originally. Finally, the later report by Baffes and Dennis (2013) concluded that biofuel has no to very little impact on the food prices and there were other factors behind the higher food prices such as higher oil prices and exchange rate movements.

However, the ethanol produced from corn in USA and wheat in EU region can be politically challenged; Corn and wheat are the major sources of food. Sugar is one of the main items for adding sweetness to different foods or it can be indirectly used in numerous food industries not limited to chocolates, juices, soft drinks, bakery items, baking items, coffee, and tea sweetener etc. Brazil is considered as world first sustainable biofuel economy and sugar cane-based ethanol in Brazil have not contributed to food crisis of 2008 (World Bank, 2008*)*. However, there may be a case for land use change as more biofuel is produced instead of sugar. In the food-fuel debate, the issue of changes in land use pattern becomes important. Farmers may clear forest lands for sugarcane production or corn cultivation. Areas used for other crops could be diverted to biofuel crops. This can have significant implications in terms of food production, prices, and the environmental impacts.

Ethanol can have impact if it is being produced from the same feedstock such as sugar cane and sugar beet, which are used to make sugar and if sugar cane or sugar beet are used to produce ethanol, then it can lay an impact on sugar prices and food prices. Ethanol produced from wheat and corn can also impact the food prices because wheat and corn are the major foods. It depends on each country how ethanol can have or cannot impact food industry. In UK, much of the ethanol is produced from wheat and 5% from sugar beet. It is worth investigating the relationship between sugar and ethanol and see whether by using these two raw materials or other possible raw materials will have any impact on the sugar industry. Similarly, for Pakistan, where ethanol is produced from sugar cane needs to be investigated to see any relationship between sugar and ethanol and to investigate further if it has any impact on sugar industry in Pakistan.

1.4.Health concerns and Biofuel to offer alternative pathway

Bioethanol, being one of the main biofuels produced globally, production competes with sugar production but in a changing world where sugar is coming under scrutiny from health perspectives, biofuel production could offer an alternative pathway to add value. Bioethanol as an alternative to fossil fuel offers a potential monetisation option for the raw material for sugar (beet or sugar cane) which introduces a competition with sugar production.

Simultaneously, countries like UK are facing health issues arising from high consumption of sugar through drinks, sweets, and savoury items. The so-called sugar tax and voluntary sugar content reduction actions by companies will reduce sugar demand in the future. Depending on the market conditions for ethanol and sugar, the sugar industry could decide whether to produce more sugar or more ethanol.

However, it is to be noted that UK only produces half of the sugar needed in the UK and rest half is imported in raw sugar form; to be later refined. If the demand of sugar becomes less due to reduction in sugar need, less raw sugar will be imported. In Pakistan, the sugar production or consumption per capita (kg/person) is steady from last few years and it is unlikely that the demand of sugar will decrease. Pakistan wanted to start sin tax which could double the taxed-on cigarettes and sugar-based products but later the notion was removed without presenting in the national parliament for implementation in 2019.

Many countries have imposed different level of taxes on sugary products to control the diseases related with sugar. This perhaps will bring the demand down or less sugar will be consumed so less supply is needed. Surplus stock or sugar cane be converted to ethanol. Table 1.5 (London

School of Hygiene & tropical medicine, 2018) shows the countries with different level of taxes on sugary products. The benefit will be huge and enormous if the taxation works. UK modelling study predicts that by reducing 40% of the added sugar over 5 years will save approximately 300,000 people from diabetes (Thornton, 2018). Malaysia has introduced the sugar tax of 40 sec per litre on fizzy, carbonated, and other non-alcoholic beverages to tackle the obesity (Tay, 2019). South Africa has increased the sugar tax to 20% and became the first African country to do so (Chutel, 2019). Chile is the biggest example for many developing and developed countries: heavy stop signs on the sugar and salt packaged food labels, removed cartoon characters from the packaging to discourage children and adults (Jacobs, 2020).

Pakistan must learn from other developed countries and developing countries like Chile to control the obesity level. Obesity is one of the major problems in UK as a chronic disease. UK government introduction of sugar tax will probably lower down the sugar production as well as the diseases associated with obesity. Amies, Briggs and Scarborough (2019) believe that sugar reduction programme will bring the obesity related diseases down. Obesity is becoming a serious issue in many countries, with many countries starting the initiative to introduce the taxes to stop people in consuming less sugar. Health concerns related to obesity can provide a pathway for ethanol production as well, by converting more or extra sugar to ethanol. The sugar industry conditions of two countries are different and a comparative analysis of the conditions will generate a better appreciation of the potential synergies and differences. The factors affecting sugar production in the United Kingdom and Pakistan will give a better idea of what are the factors affecting these both industries and how these can be sustainable.

Table 1.5 countries with different level of taxes on sugary products (Source: London School of Hygiene & tropical medicine, 2018)

Countries	**Taxes, duties, Levy**
UK	Industry levy of 24p/litre on SSB exceeding 80g/Litre
Portugal & Catalonia	Two-tiered tax on sugary drinks- 15c increase per bottle (30c if over 80g/litre)
USA	1 cent/OZ sugar tax on sugar drinks
Chile	Taxes drinks with level of sugar over 62.5grams per litre at 18% (10% if under)
Hungary	Taxes om products exceeding 80grams per litre of sugar at 7 HUF/Litre
Brunei & Thailand	Excise duty on sugar drinks exceeding 60 grams per Litre
Mexico, Finland & France	Taxes on SSB (Mexico 1 peso/lire; Finland €0.220/litre; France €7.5/100 litres)
UAE & Saudi Arabia	50% tax on carbonated drinks

SSB* sugar Sweetened beverages

1.5. Trade-off between Sugar and Ethanol

A trade-off is any situation where the diminishing or losing one quantity for the increasing or gain in another quantity. Brazil have started to bring long term ethanol policies; pushing car manufactures to produce flex-fuel vehicles or engines where car can take up to 80% ethanol in their cars. Brazilian government approved the new program called Renovabio to push manufacturers to produce more biofuels by 2020. It proved that the ethanol provides an attractive trade-off for the Brazilian sugar mills, as more biofuels can be produced when demand of sugar is less, or surplus is in the market. Many sugar mills in Brazil have installed the distillation columns in their existing facilities to give the mill the option to produce with what ratio between sugar and ethanol, which becomes an attractive trade off. In 2018, Brazilian sugar mills used 64% sugar cane to make ethanol and rest to make sugar. This involved the switching to ethanol production from the normal production of sugar as the world's giant exporter of sugar. Business News (2018) indicates that the opportunity provides an attractive trade-off between sugar and ethanol. It will be easier for mills to switch between the products due to multiple use model.

In Pakistan, the potential for trade-off between sugar and ethanol may be limited, as ethanol is only produced from the molasses, which is a sugar industry by-product. Pakistan has not produced ethanol from any other feedstock so far. The only use of sugar cane in Pakistan is to produce sugar from it and by-product use it for other products mainly ethanol and co-generation.

Pakistan must bring the policies and infrastructure to build distillation columns to have a choice in future to produce more sugar or more ethanol according to the demand and situation. It could be interesting and profitable trade off situation in Pakistan.

In the United Kingdom, ethanol is produced from wheat or sugar beet. Wheat has no trade-off between sugar and ethanol since wheat is not the raw material to make sugar. Sugar beet provides a trade-off route, currently in UK only 5% of the sugar beet production is used in the ethanol production. It would be a trade-off if more sugar is produced from sugar beet or if all or certain land is used to produce ethanol. The sugar selling price locally and world market will influence the trade-off. Another trade-off between sugar and ethanol indicated that some of the sugar cane can be used to make ethanol and jaggery. Jaggery is a local variant of sugar, which is largely produced and consumed. Jaggery is a consumer item which is not linked to the biofuel production chain but by the fact that jaggery production signifies a trade-off with sugarcane ethanol (Bilal et al. 2010). This involved the switching to ethanol production from the normal production of sugar as the world's giant exporter of sugar. The linkage and possible changes in the business conditions or other parameters would make the trade-off analysis interesting and meaningful. It will help to understand the changed level of ethanol production trend and how it can or cannot impact the sugar industry in UK and Pakistan. Once the possible impacts of ethanol industry on sugar industry is knows, will give a better understanding on the mitigation measure to eliminate the impacts.

1.6. Justifications of the choice of the UK and Pakistan

This research is considering two different economic, environmental, and political contexts of ethanol versus sugar production. The findings of this research will assist in comparing how ethanol production is or is not influencing the sugar industries in UK and Pakistan and then respectively, whether there is any trade-off between these options. The selection of the UK and Pakistan was based on their different feedstock for ethanol production and due to their different geographical locations. The ethanol production capabilities of the UK and Pakistan are strategically and geographically favouring ethanol. Another reason for the choice of the UK and Pakistan is the legislative strategy towards the adoption of ethanol production. The governments of the UK and Pakistan enacted laws supporting the adoption and production of ethanol. The legislative apparatus in these countries is similar which affect the production of ethanol positively.

UK has made a commitment to decarbonise the economy by 2050 and if the transport sector must reach this objective, it must look for different alternative fuels, including biofuels. UK is committed to biofuel promotion. On the other hand, Pakistan as a major sugar producing country has the potential for biofuel development. UK is trying to reduce its sugar for food consumption which can offer opportunities for bioethanol diversion. Contrasting conditions and feedstocks can allow a comparative understanding of the industry issues.

Extensive studies have been conducted since 2008 on biofuels but there are few concerns with regards to the methodology being used to analyse the biofuel sector, trade-off between sugar and ethanol or other useful product such as disinfectant in the time of Covid-19 and sugar vs ethanol scenario. Furthermore, the case of Developed and developing country in terms of comparative study is missing from the past studies; there are studies related to USA and Brazil or specific studies on Thailand, India, Brazil, EU, etc but none ever concentrated on comparative studies. This scenario will put a weight to this research and will allow policy makers to make policies where are covering all aspects. A more detailed gap analysis is available in the Literature review chapter.

1.7. Research Objectives

The purpose of this research is to explore the relationship between sugar and ethanol industry to understand the effects if any of ethanol production on the sugar industry and the fundamental changes that could be made to diminish or dispose of these impacts. This will be undertaken through case studies in two countries (UK and Pakistan) considering their different feedstocks, market conditions, regulatory arrangements, and social conditions.

1.8. Research Questions

The research objectives will be achieved through the following research questions:

i) What are the factors affecting sugar production in the United Kingdom and Pakistan respectively?

ii) What are the possible impacts of ethanol production on the sugar industry in the UK and Pakistan? And how changed level of ethanol production will have or will not have any impact on the sugar industry in the United Kingdom and Pakistan?

iii) What are the available mitigation alternatives to reduce or eliminate the impact of the ethanol industry on the sugar industry in the UK and Pakistan and how ethanol production and sugar production can be made sustainable and viable?

1.9. The Significance of the Research

This study has substantial contributions to the sugar and ethanol industries and will help them to be sustainable. The first part of the research laid the base for the research. It started with identifying fossil fuels, what can be done to replace fossil fuels in the transport sector, biofuel as main alternate to the fossil fuel, cost of biofuels, the food vs fuel debate, trade-off between sugar and ethanol and the justification of the research. It established that transport sector is the main driver behind the biofuel production or to increase in biofuel production soon. The next chapter will cover the basic background of the statistical data available to analyse the overall background of the sugar and ethanol sectors in UK and Pakistan. Overall, based on the analysis which will be performed for this research project such as PESTLE analysis, Techno economic analysis, Thematic analysis , and Demand and supply analysis will contribute to the existing knowledge to make better policies for sugar and ethanol production, will help managers to mitigate the risks associated with sugar cane, sugar production and ethanol production, government to make policies aligning with Sustainable Development Goals, renewable fuels and mandate for biofuel, and will provide insight to researcher and financial institution to analyse the current demand and supply of sugar and ethanol and how changing scenarios will have impact each industries in the future and this will help them to prepare accordingly.

Chapter 2: Background of sugar industries and ethanol production in the UK and Pakistan

2.1. Background

Sugar, which is sucrose, plays a vital role in our food and beverages. Sugar is known for different names in each language; Sucre in French, shakar in Persian, sakkar in Arabic and sugar in English. Moxham (2002) mentions in his book 'The Great Hedge of India' that sugar was first produced in the Indian sub-continent and sugarcane is native to Indian-subcontinent and southeast Asia today. Sugar comes normally in the shape of crystals and is produced mainly from Sugarcane and sugar beet in the world. It is used as a sweetener for drinks and food. Sugar gives a sweet taste to the food, and we have been using it for years. Sugar provides rich colour, flavour, and texture to the food as well. Sugar is a carbohydrate which is the most important fuel for our body. 80% of our sugar, which we eat, is produced from sugarcane and rest 20% from the sugar beet according to International Sugar Organization (2019). Sugar is made of up glucose and fructose. There are about hundred countries which produce sugar from either sugarcane or sugar beet and there are only eight countries which produce from both (ISO, 2019).

Sugarcane is a family of grass which grows to 12 feet or even higher in some countries. It is cultivated for ten to 12 months before being cut and used. Sugarcane is grown in tropical and sub-tropical regions while sugar beet is grown in temperate climate countries. Unlike sugarcane, sugar beet has a growing time of 5 months. In the United Kingdom, sugar is primarily produced from sugar beet. France is the largest producer of sugar beet and sugar from sugar beet in the EU. Majority of the sugar produced is sold to the industrial users for the manufacturing of different kind of drinks, food, and confectionary mainly. 75% of Sugarcane which is produced globally is consumed by the manufacturing sector (Ceres, 2017; Huntrods, 2018).

World sugar consumption has increased to 172 million MT in 2018 from 123 million MT in 2001, which is an average growth of 2% per year (IS0, 2019). However, growth was only 0.84% per year between 2016 and 2018 (ISO, 2019). Major consuming markets are India, China, EU, US, and Brazil mainly. OECD/FAO (2019) mentions in their report that there was a decrease in the world population growth rates, decrease in the demand of sugar due to increasing concerns about the potential effects of excessive sugar consumptions and due to health concerns in 2017 and 2018. OECD/FAO (2019) further states that global sugar production will increase by 14% by

2028 and global demand will increase to 203 million MT in 2028 due to increase in consumption in Asia, North Africa, and Middle East. The trend line in figure 2.1 confirms that production and consumption will increase gradually over the time.

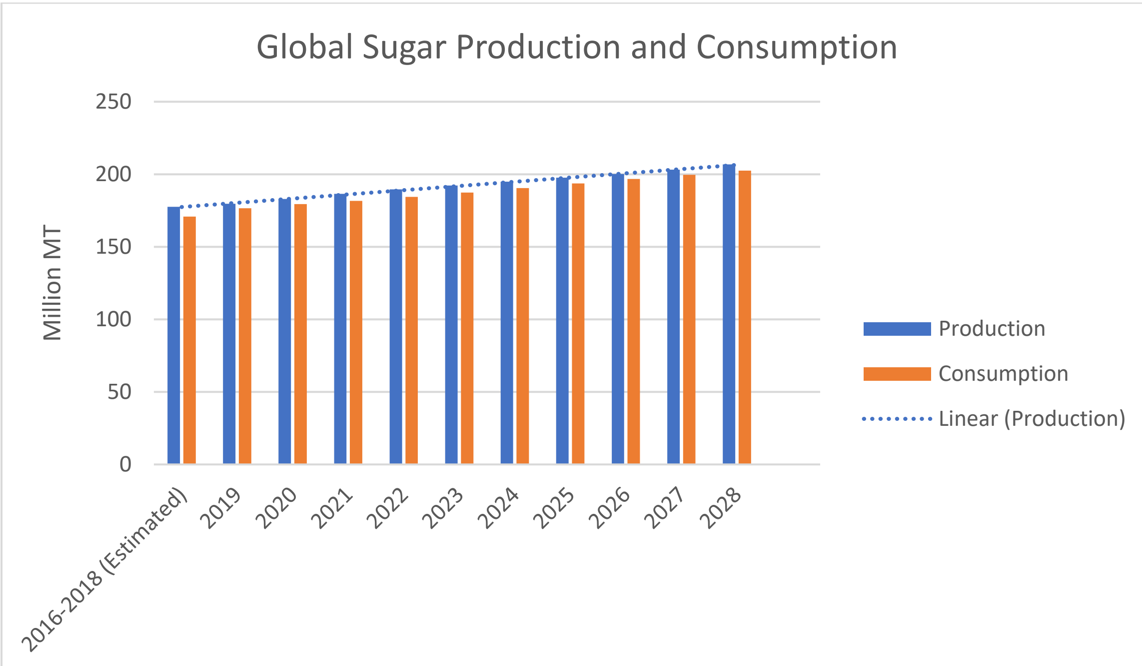


Figure 2.1 World Sugar Projections (Source: Author data taken from OECD/FAO, 2019)

Sugar crops are not only grown for food purposes but also, it is a great source of fuel. Sugarcane not only supplies 80% of the sugar but also is one of the key feedstocks for the ethanol production in the world (FAO, 2019). One of the main features of the sugar market is its strong relationship with the energy market, because sugar crops can be used to produce ethanol (British Petroleum, 2021). Ethanol is not only used in the fuel, but it is used in the other industries such as, personal care products like lotions, sanitizers, beauty care products, home care products like solvents and cleaning product, food additives, medicines and for alcoholic beverages. Ethanol is produced by fermentation and distillation process but if starch crops are used then liquefaction and saccharification are needed before it is fermented and distilled. According to OECD/FAO (2019) biofuel production has increased in 2018 in all major countries. Ethanol is linked with the oil prices; if the oil price is higher the biofuel becomes affordable and financially viable (British Petroleum, 2021). While crude oil prices increased in 2018, ethanol prices fell due to oversupply (EIA, 2019). However, to have sustainable sugar and ethanol, one needs to understand the sugar industry, its relationship with the ethanol and trade off opportunity between both products (Arif, 2019). Furthermore, ethanol can survive if oil prices rise, blending mandates are implemented, GHG emissions are reduced, subsidies are implemented, and higher taxes/restrictions on petroleum products are imposed (Abas, N. et al., 2017). However, to have sustainable sugar and ethanol, one needs to understand the sugar industry, its relationship with the ethanol and trade off opportunity between both products.

2.2. Country Information – Pakistan

2.2.1 Overview

Pakistan is the thirty-sixth largest country in the world, with a total area of 796,096 square kilometres. Pakistan currently has a population of about 208 million people (Pakistan Bureau of Statistics, 2017). Figure 2.2 indicates the number of provinces and neighbouring countries. Pakistan's GDP was approximately 314.5 billion USD in 2019, Pakistan's GDP, purchasing power parity in USD is 1.181 trillion, and GDP per capita growth is 5.83% in 2019. (World Bank, 2019).

Pakistan is an agricultural-based country, and agriculture is the backbone of the economy; it accounts for 18.5% of GDP and employs 38.5% of the total labour force (Ministry of Finance, 2019). Pakistan's agriculture sector continues to lag due to a lack of research, poverty, and a decline in productivity across all important crops (Abas, N. et al., 2017). Climate change is another factor affecting Pakistan's agriculture industry, threatening the country's water availability and food security (Ministry of Finance, 2019).

Figure 2.2 Pakistan Map (Source: Geographical data taken from NASA)

Pakistan has a great diversity in terms of climate. The south and middle of the country is hotter than the upper and northern areas. Pakistan gets two rainy seasons: one between June and September which is called pre monsoon and monsoon and the second one is between December and March. Annual rainfall in the country is less than 250mm but in the northern part, it is between 760mm to 2000mm, but it was 21% above normal rainfall in 2019 (Asian Development Bank, 2017: Pakistan Meteorological Department, 2019). The agricultural sector benefits from ideal climate, soil conditions, and rainfall. However, global warming and a lack of industry knowledge and research are affecting the sector. Sugarcane is an important crop for sugar production and a high-value crop in Pakistan. It is mostly grown in Punjab and Sindh and requires a lot of water. It requires a harvest time of 10 to 16 months, depending on the area and need. Sugarcane and sugar prices in Pakistan are regulated by the government (PSMA, 2020).

2.3. Country information – UK

2.3.1 Overview

The United Kingdom is an island country and made up of four countries: England, Scotland, Wales, and Northern Ireland (World Bank, 2018). It is situated on the north-western Europe. It is surrounded by water mostly, by North Sea, Atlantic Ocean, English Channel, Celtic Sea, and

Irish sea. Figure 2.3 below shows the map of UK and its location. The total area of UK is 240,000 sq km and its population is approximately 66 Million (Commonwealth, 2017). UK is considered as a developed country, and it has the world's 5th largest economy in terms of GDP and 9th largest by purchasing power parity

According to Office of National Statistics (2019) the service sector is the largest sector in the UK and accounts for more than ¾th of the GDP. Major economic activities are services industry, manufacturing, tourism and the agriculture sector accounts for less than 1% of the GDP. In the United Kingdom, sugar is primarily manufactured from sugar beet. UK is the 10th largest sugar beet producer in the world, and 4th largest beet producer in EU. Although 80% of the world sugar is produced from Sugarcane, 20% is produced from sugar beet. UK grows 7.5 million tons of sugar beet per year (Department for Environment, Food and Rural Affairs, 2019).

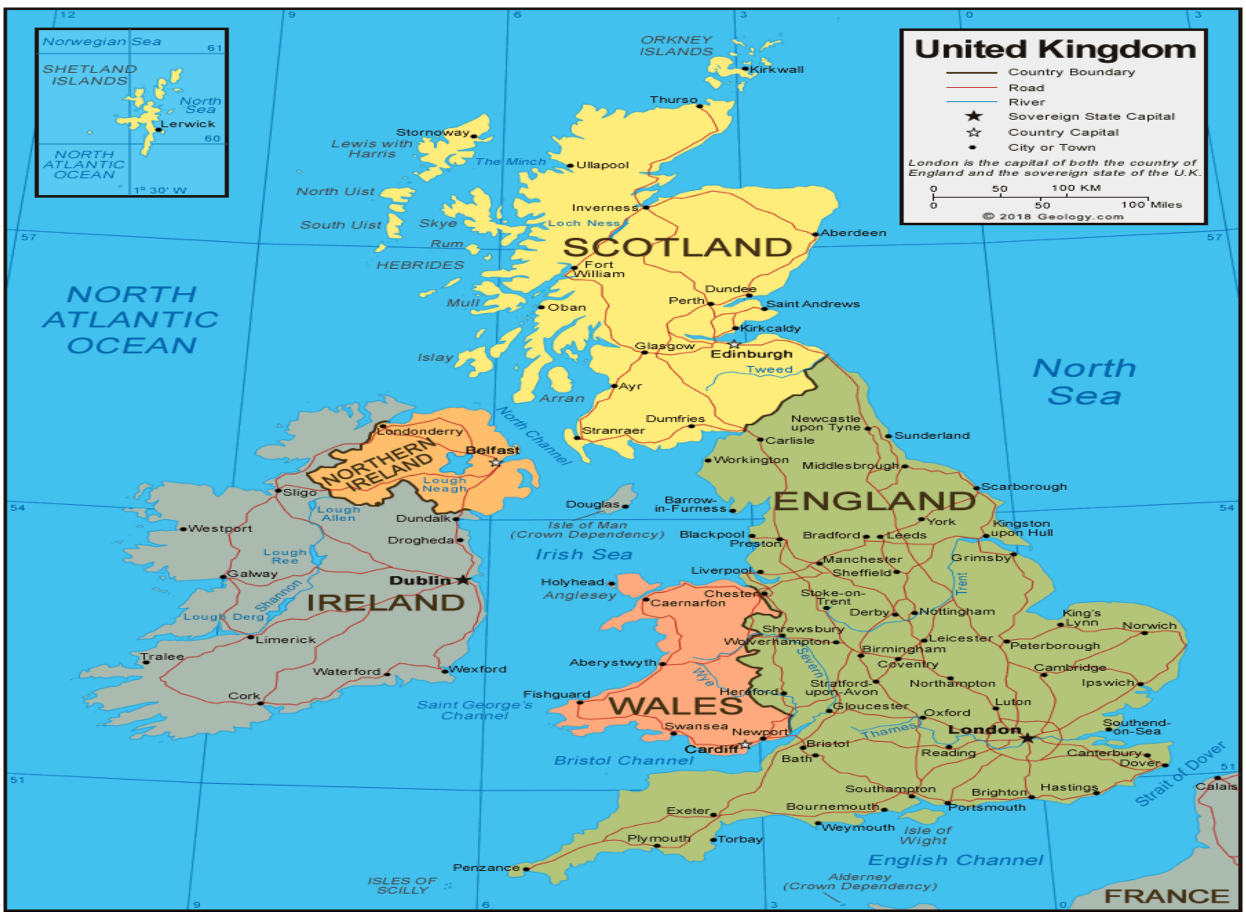


Figure 2.3 UK Map (Source: Geology data taken from NASA)

The UK has rich soil which is ideal soil for sugar beet cultivation. The country also has a good irrigation system and most of the water used in agriculture comes from rivers and streams (Institute of Engineering and Technology, 2016). Sugar beet provides more than half of the sugar in the UK and plays a vital role in soil health (Countryside, 2019). Therefore, British government works with the National Farmers Union to set the price and for the selling and the protection of the crop (British Sugar, 2020).

2.4. The Sugar Industry Developments in Pakistan

According to the Pakistan Sugar Mills Association (2020), Pakistan is the world's fifth largest sugarcane producer in terms of area grown for sugarcane and the seventh largest producer of sugar. According to PSMA (2020), the sugar industry is the second largest contributor to the country's industrial sector growth in terms of GDP, after the textile industry, implying that sugarcane cultivation and sugar production are important not only for their agricultural products but also for their role in the country's industrial sector (PSMA, 2020). The following statistics in table 2.1 further clarify the significance of sugar industry in Pakistan in 2018-2019 & 2019-2020 respectively. It compared the 2019-2020 season with the previous season. It can be noted that area was decreased slightly but yield was more than last year, and overall sugar production was less due to low sugar recovery and less available land.

Table 2.1 Pakistan sugar and ethanol data for year **2018-2019 & 2019-2020** (Source: Author data taken from PSMA annual report 2019,2020)

	2018-2019	**2019-2020**
Area of Sugarcane Cultivation	1,101,073 Hectares	1,038,879
Number of Sugar mills	89	90
Sugarcane Production	67,129,645 MT	66,334,369 MT
Sugarcane crushed for sugar	49,768,113 MT	48,717,544 MT
Sugarcane Yield per Hectare	60.97 Ton per Hectare	63.85 Ton per Hectare
Sugar Production from sugarcane	5,210,744 MT	4,819,793 MT
Sugar beet crushed for sugar	523,199 MT	540,893 MT
Sugar Production from sugar beet	56,828 MT	61,432 MT
Total Sugar Production	5,267,572 MT	4,881,225 MT
Recovery rate	10.47%	9.90%
Molasses production	2,263,109 MT	2,236,628 MT
Ethanol production 2017-2018	616,030 MT 781,089,024 Litres	EST 610,000 MT 772,870,000 Litres
Total Sugar export	691,994 MT	181,447 MT

Sugarcane production is an important contributor to Pakistan's economy through its sugar industry and is considered as one of the important cash crops and the main source of raw materials constituting 99% of sugar production. Only 1% is being produced by sugar beet and that too is about to decline. Sugarcane occupies more than 1 million hectares of cultivated land out of 22 million hectares (PSMA, 2020). Sugarcane is cultivated mostly in Punjab and Sindh but also in very few hectares in KPK state (PSMA, 2020).

Sugarcane growing area has been approximately 1 million hectares since 2011-2012 except for year 2016-2017 and 2017-2018 when there was a bumper crop. Table 2.2 indicates the Sugarcane growing area in Pakistan in hectares from 2011-2012 till 2018-2019 season along with the yield per hectare. The trend for the last season 2018-2019 (PSMA, 2020) is decreasing due to weather issues and yield issues. It can be seen from the table 2.2 and figure 2.4 that yield was increasing until 2017-2018 but started to decrease in 2018-2019. Pakistan Sugar Mills association (2020) estimated that for the year 2019-2020 the yield will be higher than last year, but it will be less than 62.11 tons per hectare in 2017-2018.

Table 2.2 Pakistan sugar can plantation area with **total yield per hectare** (Source: Author data taken from PSMA annual report 2019)

Year wise	Sugarcane plantation area	Yield per Hectare (Tons)
2011-2012	1,046,000	55.48
2012-2013	1,128,098	56.48
2013-2014	1,171,687	57.55
2014-2015	1,113,161	56.41
2015-2016	1,130,820	57.88
2016-2017	1,216,894	62.00
2017-2018	1,340,926	62.11
2018-2019	1,101,073	60.97

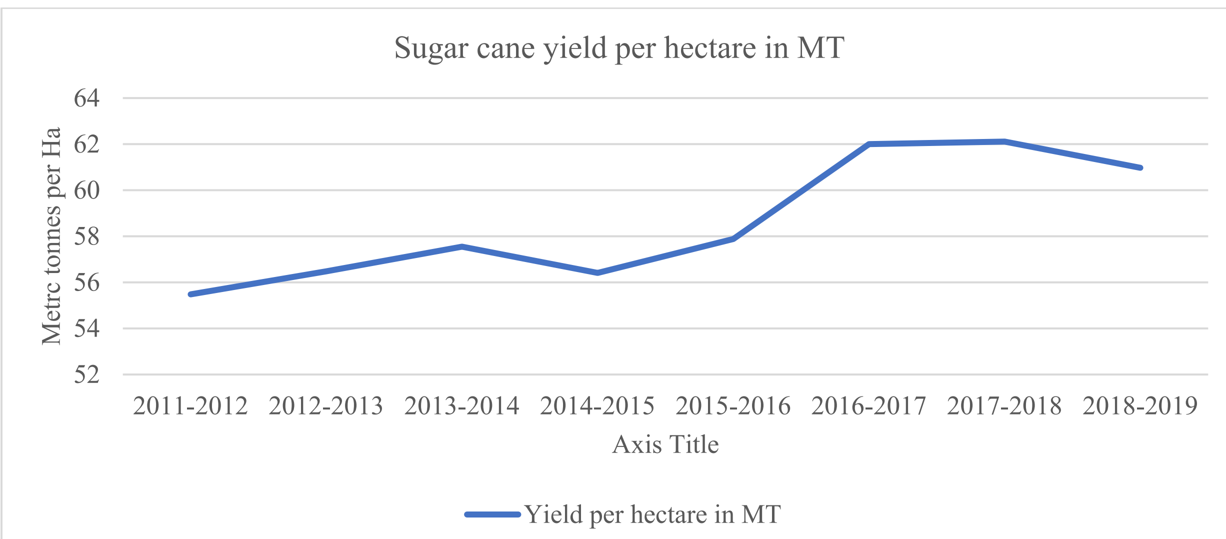


Figure 2.4 Sugarcane yield per hectare (Source: PSMA data from annual report 2019)

The Sugarcane production has ranged from 63 to 83 million tonnes per year over the last seven years (PSMA, 2020). There are approximately 89 sugar mills in the Punjab region, 38 in Sindh, and 6 in KPK. It directly employs 1.5 million people and indirectly employs 9 million people (PACRA, 2O2O). Pakistan is the eighth-largest sugar consumer, with an estimated 25.10 kg per capita consumption in 2017-2018, but this has dropped to 24.42 kg per capita per year in 2018-

2019. (PSMA, 2020). This trend can be seen in Figure 2.5, which shows data from 2011-2012 to 2018-2019.

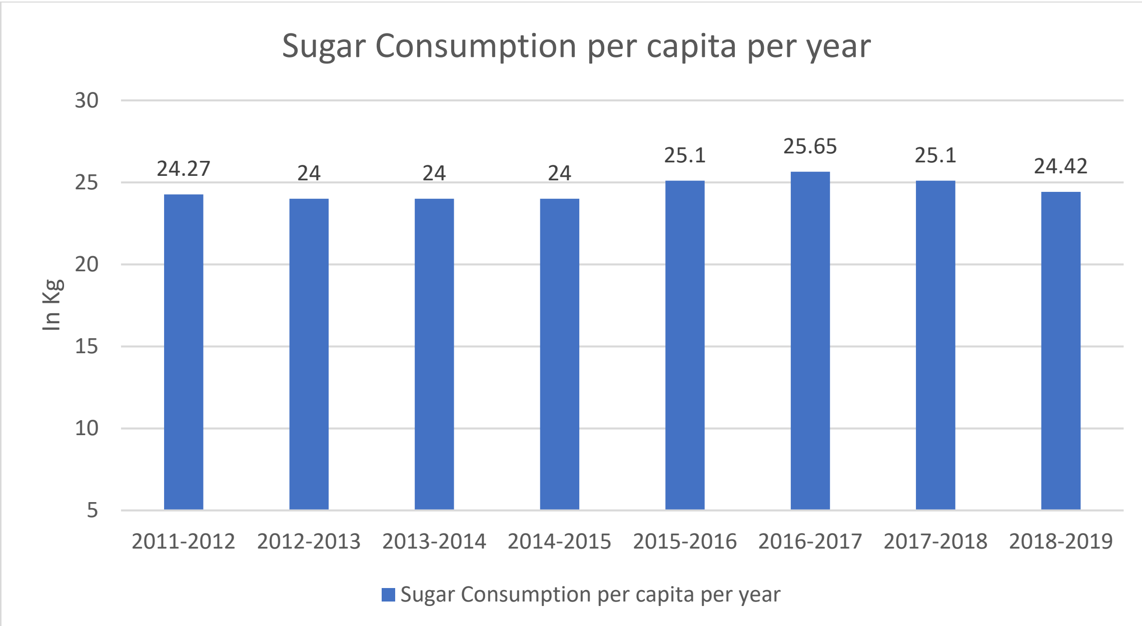


Figure 2.5 Sugar consumption per capita (Source: PSMA data from annual report 2019)

The sugar industry is dependent on sugarcane and is regulated by the federal and as well provincial government through Pakistan sugar mills association. Sugar price is determined by an administrative price setting mechanism following the cost-plus approach. Through regulation, the mills are only allowed to sell sugar only to registered brokers, dealers, wholesalers or bulk consumers (PSMA, 2020). Provincial governments negotiate with sugar bodies and farmer's associations to develop costs based on processing costs and projected profits to establish the minimum support price (MSP) of sugar. In recent years, the price of sugarcane per 40 kg was 190 rupees, while price of sugar has gone up from Rs 55 per kg to Rs 75 per kg (PSMA, 2019). The low price for sugarcane is leading towards the decline of sugarcane cultivation. Price trend from last few years can be seen from the table 2.3 against the sugar prices per kg. Sugarcane area is decreasing in last few years due to volatile policies of the government that are unable to protect sugarcane farmers. The government subsidizes sugar sales at State-controlled Utility Stores. Prices at the stores are Rs. 85 per Kg ($483 per ton). Moreover, through utility stores, the government attempts to control retail distribution below market price. This leads to sugar hoarding and scarcity. Because production is dependent on support prices, production, consumption, and demand all play important roles. Because the government has failed to strike a balance between demand and supply, sugar prices have risen.

In recent years, the price of sugarcane per 40 kg was 190 rupees, while price of sugar has gone up from Rs 55 per kg to Rs 75 per kg. The low price for sugarcane is leading towards the decline of sugarcane cultivation. Price trend from last few years can be seen from the table 2.3 against the sugar prices per kg. Sugarcane area is decreasing in last few years due to volatile policies of the government that are unable to protect sugarcane farmers. To that end, there have been other issues in the sugar sector, as sugar recovery has been 9.5%, compared to 10.5% in the previous five years (PSMA, 2020). The problems are as follows: a) processing, b) zoning, c) late crushing, d) late payments by mills, and e) transportation (Arif, 2019).

Table 2.3 Pakistan Sugarcane prices per 40 kg with sugar price per kg average (Source: Author data taken from PSMA annual report 2019 as per PBS DATA)

Year	Sugarcane Price per 40/kg in PKR	Wholesale Sugar Price per kg in PKR
2011-2012	150	60.99
2012-2013	170	53.41
2013-2014	170	54.80
2014-2015	180	58.91
2015-2016	180	63.76
2016-2017	180	61.43
2017-2018	180	53.57
2018-2019	180	64.27
2019-2020	190	75.00 * estimated

Pakistan produces sugar from sugarcane that can fulfil its local needs and export the surplus sugar. Pakistan also produces ethanol from molasses, which is a by-product of sugar industry. To use 100% molasses to produce ethanol in Pakistan, government of Pakistan needs to establish the blending mandate and vehicles must have flex fuel supported engines. This means the market structure for exporting the fuel grade ethanol will depend on countries using flexible-fuel vehicles (FFV), which have a dedicated engine for both ethanol and gasoline. However lower blends can easily be achievable and workable in existing engines

Pakistan has also risen to the top ten ethanol producers in recent years, with output more than doubling from 287,000 MT in 2016-2017 to 560,000 MT in 2017-2018. (PSMA, 2019). This demonstrates the significance of ethanol. Previously, Pakistan exported molasses, which is used to make ethanol, but the recent imposition of molasses export duties discourages locals from exporting and encourages them to use locally for ethanol production and feed. Pakistan implemented 5% blending, making ethanol more appealing to producers. Awareness about ethanol in terms of economic saving and GHG saving is limited. It can be seen in figure 2.6 those multiple products can be produced from sugarcane and even a by-product is useful, and ethanol can be produced from it. Sugar mills with integrated distillery are available in Brazil where multiple products can be produced depending on the demand and can be seen in figure 2.6.

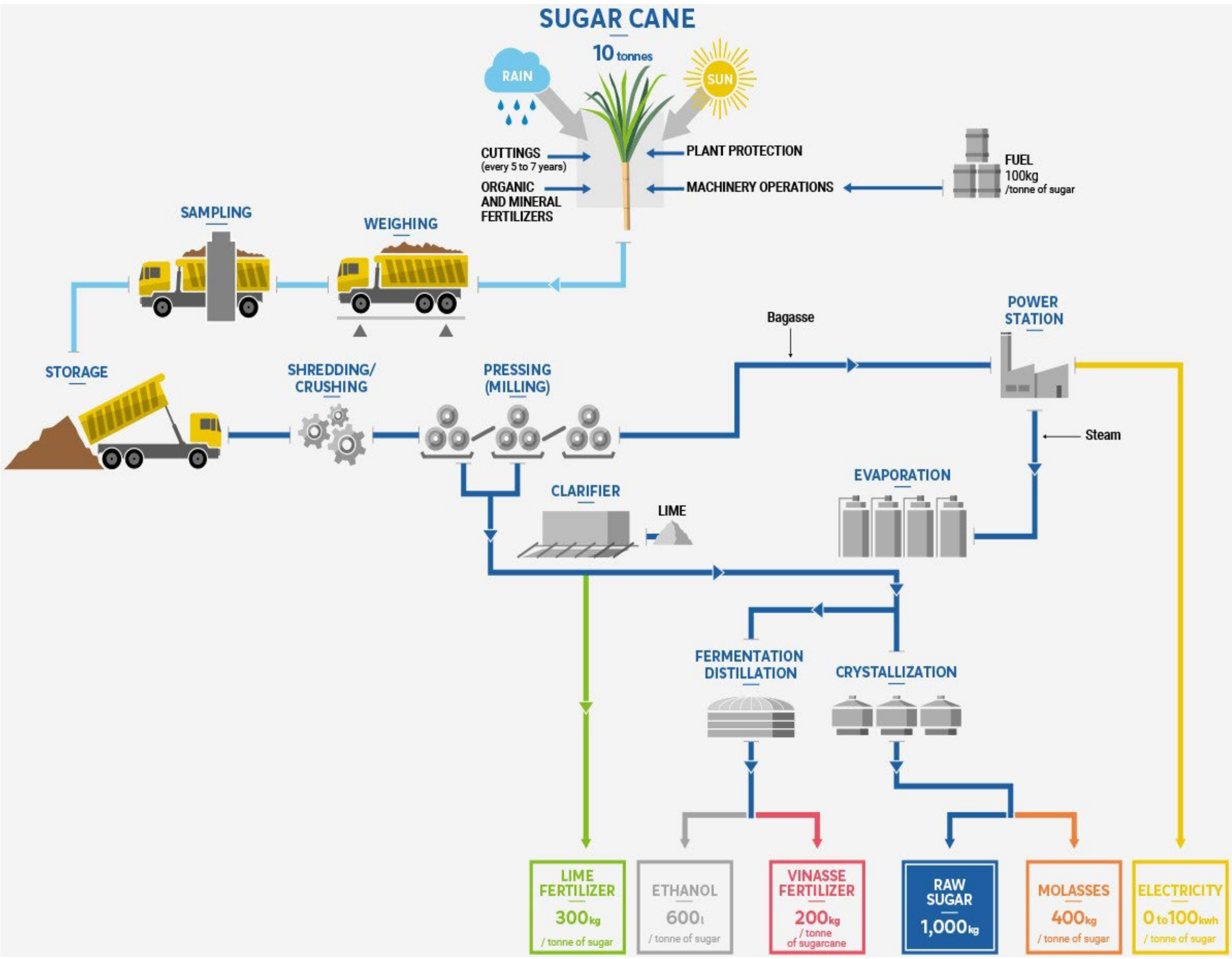


Figure 2.6 Sugarcane to sugar and other productions flow chart (Source: Sucden, 2020)

2.5. The Sugar Industry Developments in the UK

UK produced 7.6 million tons of sugar beet per year in 2018 (Department for Environment, Food and Rural Affairs, 2019). Majority of the sugar is sold to industrial users for manufacturing of food, soft drinks, and confectionary mainly. There are only two sugar processers in the United Kingdom which are British Sugar and American Sugar Refinery. British Sugar is the only company to use local sugar beets to produce sugar.

The industry is divided into two main streams: sugar beet milling and refining of raw sugar. British Sugar is producing sugar from locally grown sugar beet, while American sugar refinery is engaged with refining. It can be seen from Figures 2.7 and figure 2.8; how sugar beet is processed to be converted to sugar and ethanol and how raw sugar is refined to become white sugar. British Sugar has a monopoly and competitive edge over ASR (BBC, 2013; European Commission, 1998). The industry has faced problems in recent years; however, the challenge was in the form of EU policies. In 2006, sugar policy was introduced to protect the sugar beet farmers and introduced the quota management system and taxes (European Commission, 2014). The quota system restricted the output of the domestic sugar producers.

The quota can be decreased or increased depending on excess or shortage of sugar in the market. Under the quota management system, agreements are laid down between beet growers and sugar manufacturer to have the minimum payment for the sugar beet. Since the reform, the EU has become one of the biggest importers of raw sugar to refine from African, Caribbean and Pacific (ACP) and Least Developed Countries (LDC) states: which has a duty-free access to the EU market. Sugar beet is an important crop in the UK, it contains 17% sugar and provides half the sugar that the UK needs. The remaining comes from the refining of raw sugar. Sugar beet is sown in March and beet farming mainly exists from Yorkshire to Essex and in the Midlands. The leaves of the sugar beet are used as feed for animals. Once cut in December, to avoid losing the sugar content it must be converted into sugar as soon as possible so all the factories in the UK are located near the sugar beet plantations.

From the limited agricultural supply of sugar beet in the United Kingdom and a monopolistic structure of the market, the UK government are still focused on increasing their ethanol production and consumption. According to Department for Transport (2018), the Renewable

Transport Fuel Obligation in UK dictates that 4.75% of all transportation fuel in the country must come from renewable resources by 2018. However according to new regulations, changes have been made in RTFO; Mandate has been increased from 4.75% currently to 9.75% by 2020 and 12.4% by 2032 and reducing the crops grown for biofuel from 4% in 2018 to 3% by 2026 and finally to 2% by 2032 (RTFO, 2018). Department of transport believes that by restricting the crops used for the biofuels will help them to tackle food vs fuel debate and by additional sub-target added for development fuels, defined as advanced renewable fuels made from waste. They are pushing towards a 1st and second-generation feedstocks, but many believes that this crop cap threatens the rural jobs and restricting the manufacturing capabilities. Government is encouraging ethanol producers to produce more ethanol to reach the required obligations by 2020. Recently introduced sugar tax provides an incentive to divert more towards ethanol.

Sugar beet is grown in only 1% of the agricultural land in England and less than 1% in complete UK and largely grown in eastern part of England. According to DEFRA (2019) the beet farming has fallen by 64% in 2018 since 2000. The UK in collaboration with the EU had enacted mandatory policies that support the sugar industry development, market structure and sugar sustainability growth that complied with other certification. Recently in the UK sugar industry, as an initiative to combat childhood obesity and diabetes the beverage industry has been taxed which increases cost and reduces demand forcing companies to modify these products and reduce sugar use. Ethanol production in the UK is growing at an exponential rate with a lot of potential. Thus, through this initiative, more sugar beets in the market can be converted to ethanol production. There is also discussion of extending the state of the ethanol blend as well.

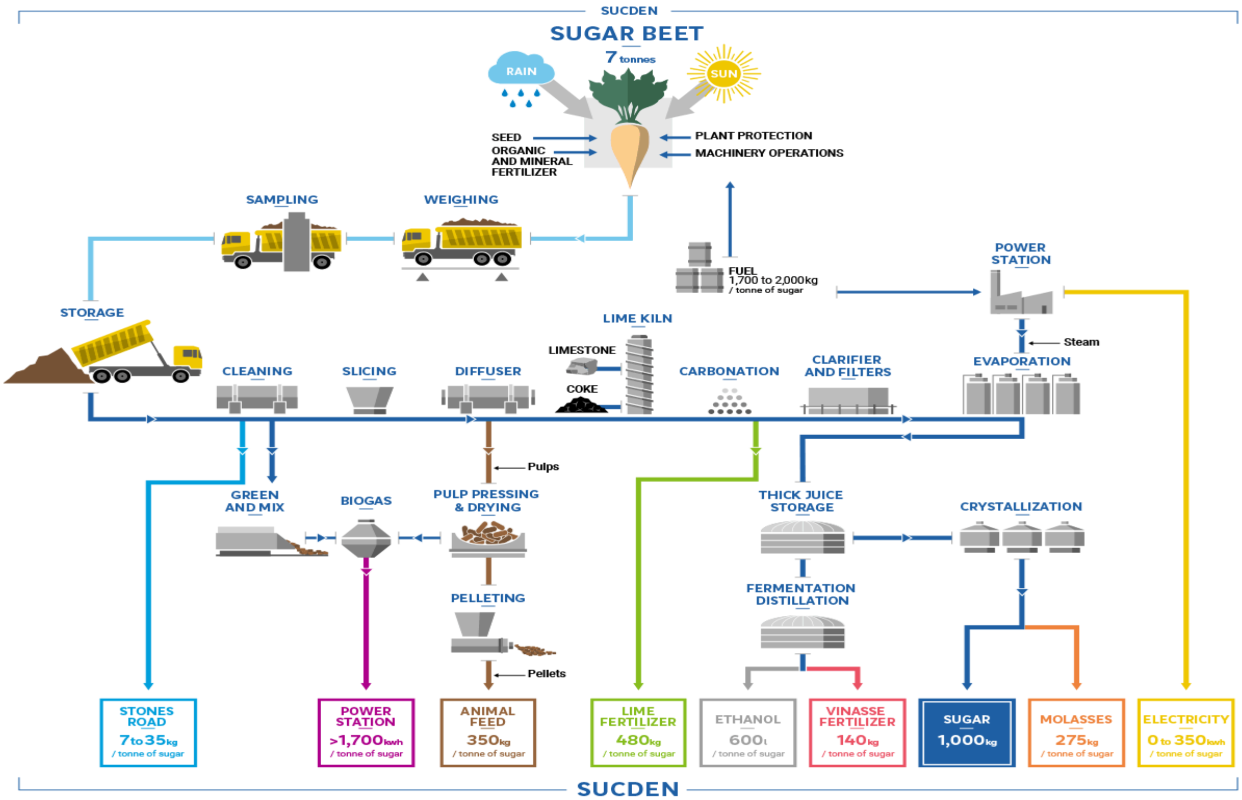


Figure 2.7 Sugar beet to sugar and other productions flow chart (Source: Sucden, 2020)

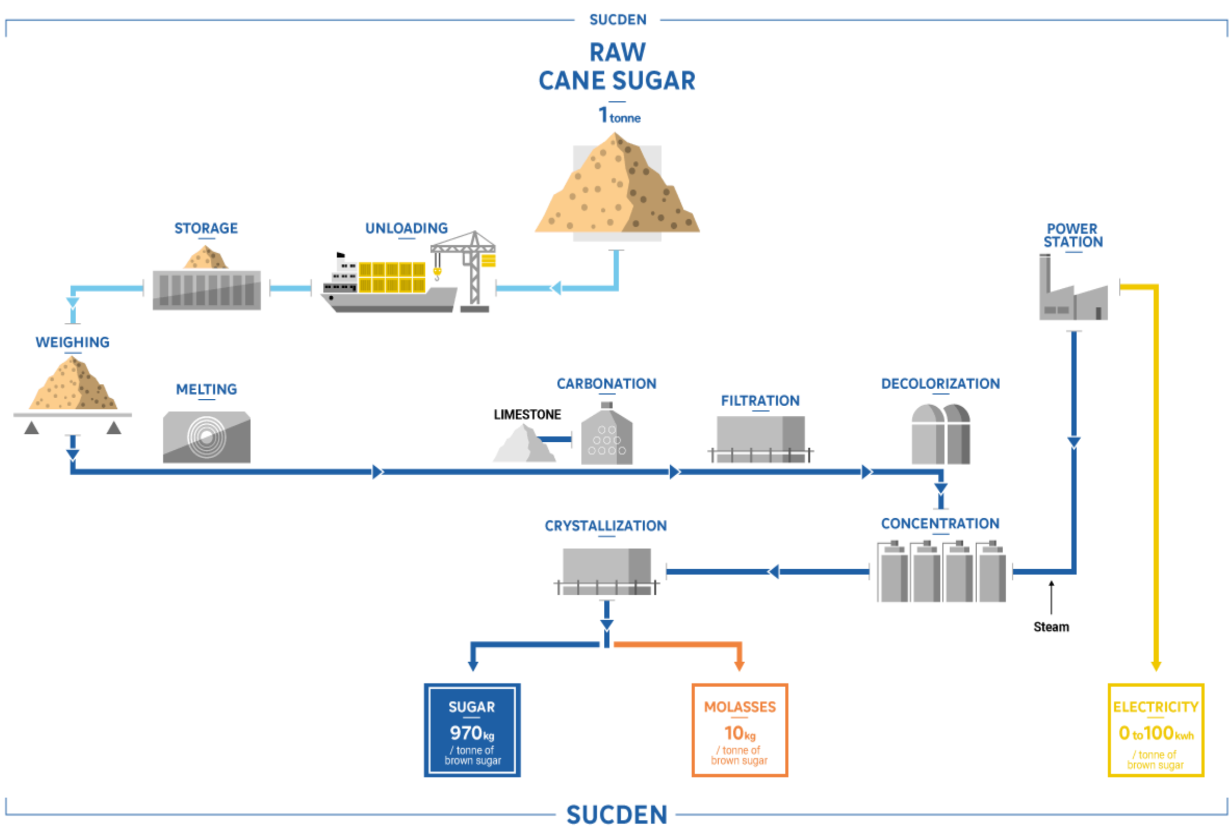


Figure 2.8 Sugar refinery process and flow chart (Source: Sucden, 2020)

2.6. Basic Statistical Information about Sugar production in the World

There are about 110 countries which produce sugar: either from sugarcane or sugar beet. Brazil, India, Thailand, Pakistan, China, Mexico, Russia, France, USA, and Australia produce 70% of the world sugar. Sugar crops give alternatives such as feed, fibre, biofuel, and energy (ISO, 2019). World sugar production was 183 million MT in 2017/18 and it went to 175 million MT in 2018/19, which was a steep decline. The decline continued for 2019/20 and for 2020/21 due to unfavourable weather conditions, covid and transportation issues (FAO, 2022). The forecast for the world's sugar production in 2021-2022 is 174.6 million MT. This is up by 3% (5.1 million MT) due to high production in India, EU and Thailand and the previous trend can be seen from the table 2.4 below that how sugar production is changing with the utilization from last few years to year.

Table 2.4 World sugar production and utilization (Source: Author data taken from FAO food outlook: Sugar report, 2018,2019,2020, 2021, 2022)

World Balance In million MT	2016/17	2017/18	2018/19	2019/20	2020/21 estimated	2021/22 Forecast	2031expected
Production	169.2	183	175	171.0	169.5	174.6	190.1
Trade	65.3	61.7	58	62.2	60.1	59	--
Total utilization	170.5	172.3	169.3	164.9	170.5	172.8	
Ending stocks	87.4	89	92.4	104.5	103.6	105.3	--

The world sugar consumption has increased to 172.4 million tonnes in 2018 from 123.4 million MT in 2001 (ISO, 2019). World top 10 producers can be seen in Table 2.6, World to 10 consumers can be seen in table 2.7, World largest sugarcane producers and sugar beet producers in table 2.8, net exporters in table 2.9 and net importers in table 2.10. These tables from 2.6-2.10 will give overview of the sugar producers, exporters, importers, and consumers. Moreover, table 2.5 presents forecast of the sugar production from sugarcane, sugar beet, yield, area utilization, sugar consumption with the prices. Sugar production from sugar beet expected to increase from 290.8 million MT in 2019 to 317.4 million MT in 2028, sugar beet growing area will also slightly increase from 4.7 million hectares to 4.9 million hectares in the same period. Sugarcane production will increase to 1,947.7 million tonnes in 2028 from 1,731.1 million tonnes in 2019, the area will increase slightly from 25.3 million hectares to 25.9 million hectares, while sugar can yield will increase from 69 ton per hectare to 75 tons per hectare in the same period. World sugar overall production will increase to 206.8 million MT in 2028 from 179.7 million MT in 2019 and consumption will increase to 202.5 million MT from 176.6 million MT in the same period.

Table 2.5 World sugar production future forecast (Source: Author data taken from FAO Agriculture outlook, 2019)

		Avg 2016-18est	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
WORLD												
SUGARBEET												
Production	Mt	291.4	290.8	293.5	295.1	297.6	300.1	303.2	307.0	310.3	313.8	317.4
Area	Mha	4.7	4.7	4.7	4.7	4.8	4.8	4.8	4.8	4.8	4.9	4.9
Yield	t/ha	61.91	61.59	61.88	62.35	62.56	62.80	63.24	63.81	64.23	64.69	65.15
Biofuel use	Mt	13.8	14.0	14.0	14.0	14.1	14.1	14.1	14.1	14.1	14.1	14.1
SUGARCANE												
Production	Mt	1 758.2	1 731.1	1 771.0	1 800.3	1 825.5	1 849.1	1 870.8	1 892.6	1 908.8	1 926.7	1 947.7
Area	Mha	25.3	24.9	25.3	25.5	25.6	25.7	25.8	25.8	25.8	25.9	25.9
Yield	t/ha	69.36	69.40	69.90	70.56	71.26	71.95	72.59	73.25	73.87	74.51	75.16
Biofuel use	Mt	360.6	376.6	389.5	403.9	412.5	421.4	429.6	437.7	446.1	455.1	464.1
SUGAR												
Production	Mt tq	177.6	179.7	183.0	186.5	189.6	192.2	194.9	197.7	200.2	203.2	206.8
Consumption	Mt tq	170.8	176.6	179.4	181.7	184.4	187.4	190.5	193.7	196.8	199.7	202.5
Closing stocks	Mt tq	80.8	83.5	83.4	84.5	86.0	87.2	87.9	88.1	87.9	87.7	88.3
Price, raw sugar (1)	USD/t	314.9	303.0	315.4	331.9	339.4	341.1	341.4	339.0	341.1	346.0	350.0
Price, white sugar (2)	USD/t	392.6	376.1	391.3	410.2	419.1	422.7	423.8	422.9	427.2	433.0	438.4
Price, HFCS (3)	USD/t	908.9	691.7	693.7	704.0	709.9	715.1	720.2	723.9	731.8	740.3	746.0

1* raw sugar prices were taken from ICE contract No11, 2* reefing sugar price taken futures contract no.407 and 3* HFCS as per USA wholesale price

The consumption of sugar in the world is continually increasing together with the growth of the world population. The increase in the per capita income as global production is increasing, and especially the value of the global GDP per capita (Jeníček, 2012). The price of sugar, alternative sweetener price, growth in purchasing power is transformed into an increased demand for food (Popkin, 1994) – thus including sugar and products containing sugar., and health concerns.

World sugar trade will continue and was average 64 million MT per year (ISO, 2019) and India, Brazil, Thailand, EU were the main exporters. FAO's (2021) initially forecasted for the season 2021-2-22 that sugar consumption will grow by 1.9% following the Covid-19 contraction in 2019-2020. The increase was due to rapid growth of worlds economy. India and China mainly, will drive the sugar consumption in the world along with African and south American countries. World trade of sugar in 2021-2022 is forecasted at 59 million MT, down from the last estimated (FAO, 2022) due to lower trade from Brazil. Ragus (2021) states that sugar supply in 2019-2021 was affected due to covid-19, weather disruptions, shortages of available containers, health concerns and high energy cost.

Table 2.6 World Top 10 producers in the world in 2018 (Source: Author data taken from ISO, 2019)

Country	Production
India	33.30 million MT
Brazil	29.29 million MT
EU-28	18.18 million MT
Thailand	15.44 million MT
China	10.71 million MT
USA	7.83 million MT
Pakistan	6.28 million MT
Russia	6.18 million MT
Mexico	5.92 million MT
Australia	4.64 million MT

Table 2.7 World Top 10 consumers in the world (Source: Author data taken from ISO, 2019)

Country	Production
India	25.39 million MT
EU-28	17.94 million MT
China	16.10 million MT
Brazil	10.47 million MT
USA	10.19 million MT
Indonesia	6.89 million MT
Russia	5.82 million MT
Pakistan	5.25 million MT
Mexico	4.27 million MT
Egypt	3.30 million MT

Table 2.8 World largest sugarcane producers and sugar beet producers (Source: Author data taken from ISO, 2019)

World largest cane sugar producers	World largest beet sugar producers
India	EU-28
Brazil	Russia
Thailand	USA
China	Turkey
Pakistan	Ukraine
Mexico	China
Australia	Egypt
USA	Iran
Guatemala	Japan
Colombia	Belarus

Table 2.9 World largest Net Exporters of Sugar (Source: Author data taken from ISO, 2019)

Total Countries	Quantity in Million MT	In Raw sugar	Quantity in Million MT	In White Sugar	Quantity in Million MT
Brazil	21.26	Brazil	17.17	Thailand	4.53
Thailand	11.04	Thailand	6.51	Brazil	3.08
Australia	3.09	Australia	2.98	EU-28	2.78
Guatemala	1.63	Mexico	1.45	India	2.46
EU-28	1.61	Guatemala	0.79	Pakistan	1.15
Mexico	1.58	South Africa	0.68	Guatemala	0.84
Pakistan	1.15	Cuba	0.49	UAE	0.83
India	0.88	El Salvador	0.40	Algeria	0.59
Colombia	0.64	Nicaragua	0.30	Ukraine	0.58
Ukraine	0.58	Colombia	0.27	Morocco	0.37

Table 2.10 World largest Net importers of Sugar (Source: Author data taken from ISO, 2019)

Total Countries	Quantity in Million MT	In Raw sugar	Quantity in Million MT	In White Sugar	Quantity in Million MT
Indonesia	5.23	Indonesia	5.13	China	**2.81**
China	5.06	Algeria	2.36	Sudan	**0.96**
USA	2.37	China	2.25	Uzbekistan	**0.52**
Malaysia	1.95	Malaysia	1.94	USA	**0.51**
Bangladesh	1.90	USA	1.87	Sri Lanka	**0.50**
Algeria	1.77	Bangladesh	1.82	Egypt	**0.48**
Korea	1.61	Korea	1.80	Israel	**0.46**
Saudi Arabia	1.31	India	1.58	Afghanistan	**0.44**
Egypt	1.29	Canada	1.24	Saudi Arabia	**0.43**
Canada	1.23	Nigeria	1.22	Chile	**0.41**

2.7. Basic Statistical Information about Sugar Production in Pakistan

Pakistan is producing 99% of its sugar from sugarcane and rest from sugar beet. Sugarcane is mostly grown in Punjab and Sindh region mainly and sugar beet is only grown in the KPK province in Pakistan. Sugarcane is the main growing crop for producing sugar in Pakistan, although sugar beet and Sugarcane both can be grown. The figure 2.9 is presented in shape of world map, where red colour indicates the sugar beet growing regions, whereas orange shows the sugarcane growing area and Green reflects the area, where both sugarcane and sugar beet is grown in the world. It also demonstrates that Sugarcane and beet both can be grown in Pakistan.

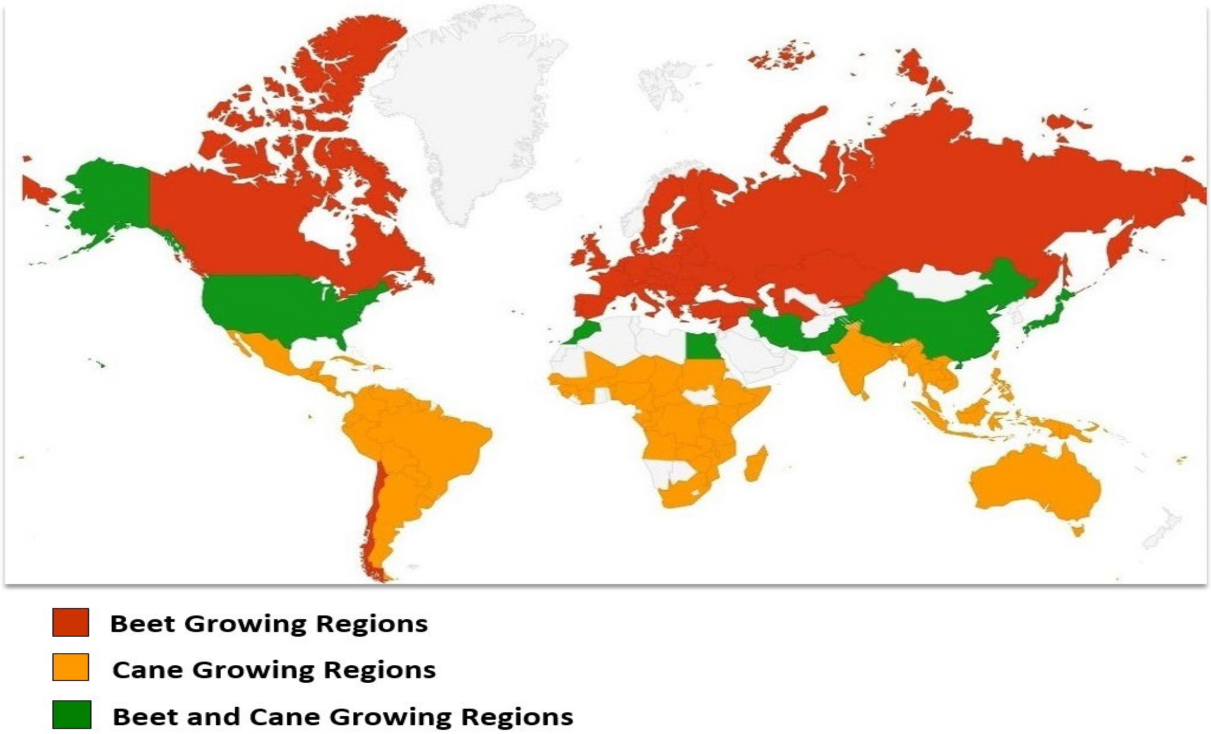


Figure 2.9 Sugarcane, sugar beet and both growing areas in the world chart (Source: ISO, 2020) – move this from here

According to FAO (2020) it requires about 1500-2500 mm of water, depending on the climate for the sugarcane production. Sugarcane cultivation area in Pakistan has been mostly constant; it went high to 1,340,926 hectares in 2017-2018 but again it felt to 1.1 million hectares in 2018-2019, further fell to 1.04 million hectares in 2019-2020: it shows that area fell by 21% in 2019-2020 from 2017-2018 but overall increase in area of 16.78% since 2005-2006. Sugarcane yield per hectare has increased by 12.8% since 2005-2006. It can be highlighted from table 2.11 that sugarcane growing area increased overall but fell from the year 2017-2018 to 2019-2020 and same for the yield per hectare due to lack of government policies and timely payments to farmers.

Table 2.11 Pakistan Sugarcane growing area in hectares against Sugarcane production and yield per hectare (Source: Author data taken from PSMA annual report 2019)

Year wise	Sugarcane plantation area in hectares	Sugarcane production in Tonnes	Yield per hectare in Tonnes
2005-2006	906,980	44,292,000	48.80
2006-2007	1,029,000	54,871,000	53.00
2007-2008	1,241,300	63,920,000	51.49
2008-2009	1,029,400	50,045,400	48.60
2009-2010	942,870	49,372,900	52.36
2010-2011	987,700	55,442,100	56.13
2011-2012	1,046,000	58,038,200	55.48
2012-2013	1,128,098	63,718,523	56.48
2013-2014	1,171,687	67,427,975	57.55
2014-2015	1,113,161	62,794,827	56.41
2015-2016	1,130,820	65,450,704	57.88
2016-2017	1,216,894	75,450,620	62.00
2017-2018	1,340,926	83,289,340	62.11
2018-2019	1,101,073	67,129,645	60.97
2019-2020 Est	1,059,197	65,271,680	61.62

Sugar production in Pakistan has increased from 2.5 million MT to 5.2 million between 2005 and 2020. There was a peak in the sugar production of 7 million MT in the year 2016-2017 (PSMA, 2020). There was an increase of sugar production by 100% since 2005 and increase of 21.7% in the sugar recovery rate. It can be seen from the table 2.12 that how sugarcane production increases since 2005, how sugar production has increased with the better recovery rate till 2020. The yield per hectare is around 61tonnes.

However, the global average yield is 69.40 ton per hectare (OECD/FAO, 2019). Pakistan's average yield per hectare is significantly below the international average although Pakistan produces approximately 3% of the world sugar. Though there is an increase of 100% in the sugar production till 2020 compared to 2005, yield has not improved due to poor quality of Sugarcane seeds and poor outdated techniques. The production is following a declining trend since 2016-17. The production is falling in Pakistan due to limited policies, delay or non-payments to farmers, and poor supply chain.

Table 2.12 Pakistan Sugarcane production, Sugarcane processed for sugar production and sugar recovery rate (Source: Author data taken from PSMA annual report 2019)

	Sugarcane production in Tonnes	Utilization % by Mills	Sugarcane processed for Sugar in Tonnes	Sugar production in Tonnes	Sugar recovery rate by %
2005-2006	44,292,000	67.94	30,090,632	2,588,177	8.60
2006-2007	54,871,000	73.78	40,483,977	3,516,218	8.69
2007-2008	63,920,000	82.60	52,776,922	4,740,913	8.98
2008-2009	50,045,400	66.21	33,139,418	3,134,145	9.46
2009-2010	49,372,900	70.09	34,611,003	3,133,494	9.05
2010-2011	55,442,100	80.47	44,526,719	4,172,729	9.37
2011-2012	58,038,200	83.13	48,248535	4,670,380	9.64
2012-2013	63,718,523	79.00	50,089483	5,030,129	10.04
2013-2014	67,427,975	84.00	56,460,524	5,587,568	9.90
2014-2015	62,794,827	80.90	50,795,218	5,139,566	10.12
2015-2016	65,450,704	76.45	50,042,249	5,082,110	10.16
2016-2017	75,450,620	94.00	70,989,948	7,005,480	9.87
2017-2018	83,289,340	78.81	65,639,963	6,580,111	10.02
2018-2019	67,129,645	74.13	49,768,113	5,210,744	10.47
2019-2020 Est	65,271,680	No data	No data	5,200,000 Est	No data

Sugar recovery is hardly 9.5 percent as against 12-14 percent in other world sugar producing countries. Recovery rate is low because the ratio is calculated from the sugar produced as a ratio of sugarcane processed. The bagasse is the most important element in this equation. Juice content, loss due to weather or heat and some loss in the processing may be responsible for this figure. The main reasons for the low recovery rate are low yield of sugarcane and sugar per hectare, high processing loss, low-capacity utilization, post-harvest losses and inefficient management. Environmental factors were also responsible for the reduced recovery. Immediate processing of the sugarcane is necessary after it has been harvested due to the rapid loss of sucrose, deterioration of the stems, and significantly lower pH and sucrose content both within 12 hours. This results in the disintegration of fungal taxa using ITS amplicon sequences, which occurs with increasing temperatures, which leads to a decrease in the diversity of the fungal community over time. The structure of the fungal community changed significantly within 12 hours of bagasse storage, whereby bagasse yielded to become fungi plentiful at 30°C and 40°C. This deteriorated the sucrose content and pH of stored sugarcane juice (Peng, 2021).

Pakistan’s sugar mills utilize about 81% average, from last 10 years, of the sugarcane cultivation and rest sugarcane is used for the jaggery production, seeds, fodder, and wastage. Rate of utilization can be seen from the table 2.12 in percentage. Jaggery is an alternative to sugar and mostly consumed in the rural area of Pakistan and by health-conscious people. The highest utilization rate in the last 10 years was 94% in 2016-2017 and the lowest was 74.13% in the 2018-2019 season. Jaggery production lowest estimation data (at least 8.5% recovery rate, while actual recovery rate is 13.5% to 14.5% as per PSMA 2020) can be seen from the table 2.14 Jaggery (Gur) production fell drastically from 2009-2010 from 625,256 MT to 250,000 MT in 2018-2019: which is a fall of 60%. Jaggery production was decreasing until 2015-2016 but recently jaggery production is increasing from 2016-2017. It is important to understand that there is a trade-off between sugar and jaggery. Jaggery can be produced from sugarcane directly and can compete directly with the sugar.

Sugarcane price remained same between 2014-2018 season which was 180 rupees per 40 Kg, but it was increased to 190 Rupees per 40kg in 2019 (PSMA, 2019). Prices increased from 20.50 Rupees per 40 kg from 1994 to 190 in 2019-2020. Price of sugar was 14.36 rupees per kg in 1994 and it went to rupees 75 per kg in 2019-2020 (PSMA, 2018). The trend can be seen from the table 2.13 that how the prices of sugarcane changed along with the prices of sugar. There are several factors which influences the change in price for sugar and sugar cane such as Political factors, demand factor, farmers demand, miller expectations, subsidy and energy cost. The supply-demand situation in sugar market affects sugar price as well. Local conditions such as weather, calamities such as flood, etc. could also influence the prices. According to FAO price of sugar is market driven depends on the demand and supply of the sugar, in addition to the negative impact of climate change, especially temperature and rainfall on sugar cane production (chandiposha, 2013).

However, the sugar prices are volatile: the price per kg in 2011-2012 was 60.99 rupees per kg and then it fell for few years until 2014 when it started to increase. Sugar prices went to historic low to 53.57 rupees per kg in 2017-2018 since 2009, but prices went high to average 64 rupees per kg in 2019 and further increased to rupees75 per kg in 2020.

Table 2.13 Pakistan sugar sugarcane prices and sugar prices in Pakistani rupee and USD against international trade price of sugar and sugar consumption per capita (Source: Author data taken from PSMA annual report 2019,2022)

Year	Sugar cane Price per 40/kg in PKR	Sugar Price per kg in PKR in Pakistan	Pakistan Avg Sugar trade prices USD/MT	International Avg Sugar trade prices USD/MT	Sugar consumption per capita per kg	Pakistan annual sugar consumption in MT
2011-2012	150	60.99	681.4	607.45	24.27	4,385,688
2012-2013	170	53.41	549.20	502.84	24	4,420,000
2013-2014	170	54.80	541.23	461.25	24	4,512,000
2014-2015	180	58.91	578.76	383.78	24	4,600,000
2015-2016	180	63.76	614.73	460.82	25.1	4,900,000
2016-2017	180	61.43	585.03	477.43	25.65	5,100,000
2017-2018	180	53.57	472.27	357.50	25.1	5,200,000
2018-2019	180	64.27	472.99	334.39	24.42	5,196,000
2019-2020	190	79.70	510.86	362.34	25.00	5,279,000

In Pakistan, no research has been conducted to develop a potential sugarcane crop and increase the recovery rate of crushed cane. As a result, sugar recovery is only 9.5 percent, compared to 12-14 percent in other world sugar producers. Agriculture sector is the backbone of Pakistan's economy which contributes more than 22 percent in country's gross domestic product (PSMA, 2020). Major issues pertain to the sugar industries necessitate spearhead required research and development efforts, to meet its raw material requirements. The specific marketing of products, raw material as well as product, has emerged as one of the major issues. The market imperfection must be removed through market efficiency and institutionalization of market intelligence (Abas *et al.*, 2017). This research effort will shape the future of farming community, through research and development, cooperation and creating awareness on the financial opportunities as well as modern farming (Zaidi et al. (2013).

Table 2.12 shows how sugarcane production has increased since 2005, and how sugar production has increased with a higher recovery rate until 2020. The yield per hectare is approximately 61 tonnes. The global average yield, on the other hand, is 69.40 tonnes per hectare (FAO, 2019). Pakistan's average yield per hectare is significantly below the international average although Pakistan produces approximately 3% of the world sugar. Though there is an increase of 100% in the sugar production till 2020 compared to 2005, yield has not improved due to poor quality of sugarcane seeds and poor outdated techniques. The production is following a declining trend since 2016-17. The production is falling in Pakistan due to limited policies, delay or non-payments to farmers, and poor supply chain. Pakistan sugar consumption in kg per capita is 24.42 in 2018-2019, which has decreased from 25.10 from 2017-2018. It has increased to 25.00 kg per capita in 2019-2020. Overall trend can be seen in table 2.13, that Pakistan consumption increased slightly to 5.279 million MT in 2019-2020 from 5.196 in 2018-2019.

Table 2.14 Pakistan Jaggery production in MT (Source: Author data taken from PSMA annual report 2019)

Year wise	Quantity (MT)
2009-2010	625,256
2010-2011	169,150
2011-2012	240,000
2012-2013	270,000
2013-2014	390,000
2014-2015	342,000
2015-2016	395,000
2016-2017	218,806
2017-2018	200,000
2018-2019	250,000

Sugar has a strong relationship with the ethanol market because sugarcane can be used to produce ethanol, which can be used in a variety of industries, including transportation, as an engine fuel. Many countries use up to E10 (a 10% ethanol mixture in gasoline), and Brazil is the only country that can use up to 85% ethanol and can use hydrous ethanol (95% ethanol and 5% water) directly in their new gasoline-powered cars (FAO, 2018). Pakistan is currently producing ethanol from the available sugarcane molasses, which is a by-product of sugar industry. Pakistan is currently using E5 blend, but the talks are underway for the E10 in the future. OECD/FAO (2019) mentions in their report that Pakistan will be top 5 exporter of ethanol in the world by 2028.

Table 2.15 shows molasses production in Pakistan, molasses exports, estimated ethanol production, and ethanol exports. All the figures from the last decade show that the ethanol industry in Pakistan is expanding, and export figures back up this claim. Molasses production is reliant on sugarcane and is a by-product of the sugar industry. When sugarcane is processed, it becomes available for ethanol production in Pakistan. It is estimated that 95% of molasses is available for ethanol production, with the remainder going to feed and other products. According to Renewable Fuels Association (2020) each 1 MT of ethanol equals to 1267.93 litres. According to the trend in Pakistan and the introduction of export duty on molasses, the export of molasses is falling, and more ethanol is being produced in the last few years.

Table 2.15 Pakistan Molasses and ethanol production (Source: Author data taken from PSMA annual report 2019)

Year wise	Molasses Production in MT	Export of Molasses in MT	Export of Ethanol in Litres
2009-2010	1,557,457	961,300	101,260,099
2010-2011	2,034,729	86,437	168,509,200
2011-2012	2.207.632	55,608	215,814,894
2012-2013	2.252,751	225,221	142,065,426
2013-2014	2,524,202	197,342	492,476,805
2014-2015	2,247,137	83,229	421,881,994
2015-2016	2,246,540	73,067	396,940,741
2016-2017	3,095,986	101,410	358,483,301
2017-2018	2,971,992	168,962	699,791,482
2018-2019	2,263,109	117,909	781,089,024

2.8. Bioethanol Facilities and their Statistical Information in Pakistan

In Pakistan, on average between 2–3-million-ton molasses and approximately between 5–6-million-ton sugar are produced each year. Pakistan exports most of its ethanol to various countries (Abbassi Securities, 2019). Pakistan produces ethanol of various qualities such as Anhydrous and hydrous. Pakistan ethanol has a strong market in the EU and the Middle East. There is total 20 ethanol manufacturer in Pakistan, from which 18 are member of Pakistan Ethanol Association and 2 are still non-members. All ethanol produced in Pakistan is from Sugarcane molasses. Pakistan is yet to explore new feedstocks for the ethanol production. Table 2.15 above shows the complete picture of ethanol production in Pakistan since 2009 until 2019. Ethanol production has increased by 671% since 2009, which shows that Pakistan is one of the top countries to produce ethanol and able to export as well. Table 2.16 gives the synopsis of the ethanol industry in Pakistan. However, figure 2.10 will give the ethanol production trend in a graph from last 10 years.

Table 2.16 Pakistan ethanol production (Source: Author data taken from PSMA annual report 2019)

Feedstocks	**Molasses only**
Future feedstock potential	Grain based (Corn, wheat, rice etc.)
Molasses available per annum approx.	3,000,000 (2017-2018)
Ethanol production Average last few years	550,000 MT
Future potential	Depends on the molasses availability
Number of Mills	20
Number of working days in a year (Avg)	250 days
Selling Market	Export mainly
Locations	**Scattered in Punjab, Sindh and 1 distillery in KPK**
Punjab based Distilleries **Sindh Based Distilleries** **KPK based Distilleries**	**11** **8** **1**
Capacity range **Smallest** **Highest**	 **85,000 Litres per day** **400,000 Litres per day**
Location in terms of near to sugar mills	**Half of the distilleries are located next to sugar mill or nearby within the few miles and half of them are independent based.**

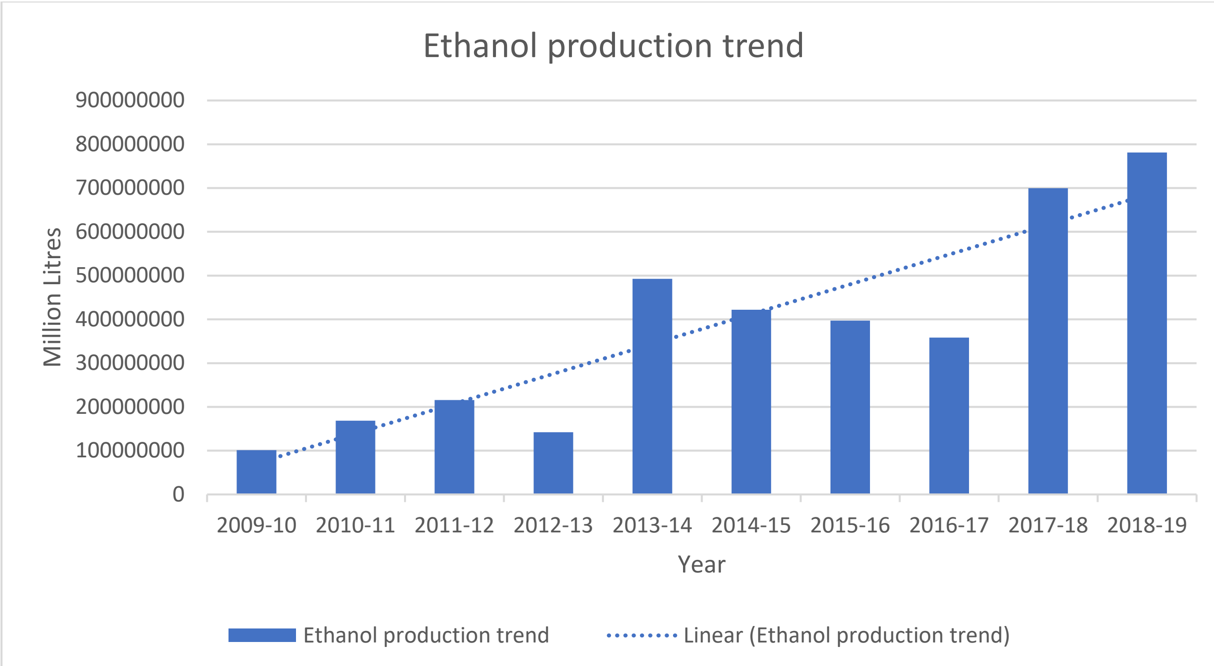


Figure 2.10 Ethanol Production trend since 09' (Source: Author data taken from PSMA annual report 2019)

Molasses to ethanol production process can be seen in figure 2.11, which is a by-product of the sugar industry. In the year 2018-2019, total 2, 263,109 MT of molasses was available to produce ethanol. Pakistan exported 781 million litres of ethanol in 2018-2019 and has helped the economy. Overall average of molasses production from last 10 years was between 2-2.5 million MT.

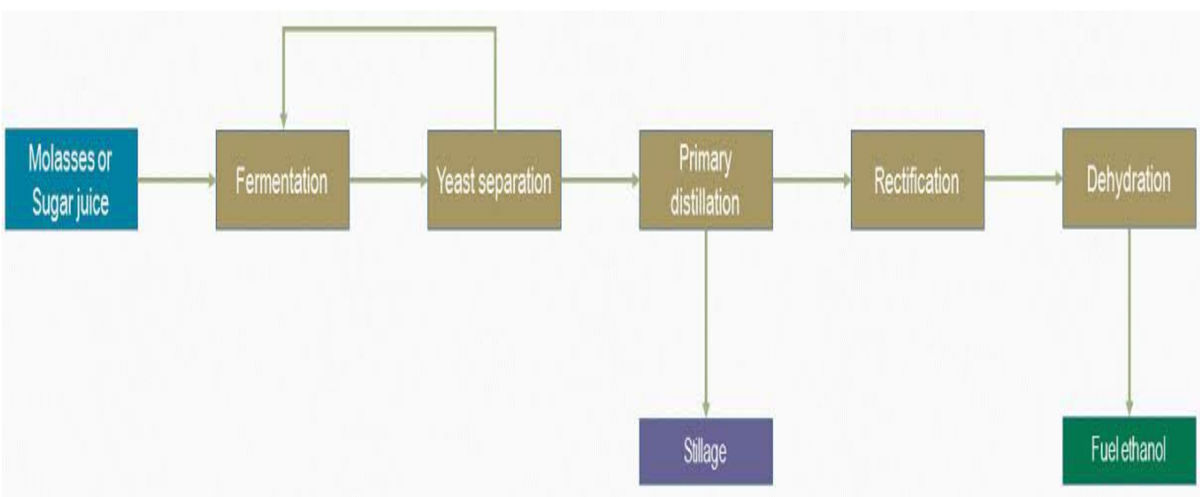


Figure: 2.11 Molasses to ethanol production process (Source: Author data taken from Chematur Engineering AB)

2.9. Bioethanol Production Policy in Pakistan

Pakistan ethanol industry is represented by the Pakistan Sugar Mills Association and the Pakistan Ethanol Manufacturers Association while the Alternative Energy Development Board, and the Ministry of Food, Agriculture and Livestock provide the policy oversight. However, in the past, Pakistan government has directed Ministry of Industry and Ministry of Petroleum to work together on the blending issues of Ethanol into gasoline with Pakistan state oil company. Bioethanol production policies are lacking in Pakistan, and no serious steps has been taken from the government to explore this sector and get benefit out of it. Alternative Energy Development Board, Pakistan State Oil, Pakistan Ethanol Manufacturing Association, and other responsible for bioethanol production and policy making are not serious about this and have yet to consider its real potential. Pakistan State Oil (2010) started its pilot project in 2006 but launched E10 in 2009 and PSO (2010) believes Pakistan will also produce more ethanol and will blend more ethanol to save GHG and reduce import bills.

PSO (2019) released a report in which it calculated E10 with gasoline for the financial statements. However, the data is missing on how much ethanol is being mixed currently. According to the interviews conducted (to be discussed in chapter 4), the ethanol producers believed that Pakistan only uses up to E5 currently (2020). Few says that E5 was due to the reasons of lack of demand in the market and risk for engines in the cars. Pakistan do have the potential to produce at least 10% of their total gasoline demand. Recently government has introduced the policy to restrict the export of molasses, so that more ethanol can be produced.

Pakistan Alternative Energy Development Board introduced an amendment to the previous policy called Renewable Energy Policy 2006 in which they covered hydro, solar, wind and biomass to energy generation; in which they included Sugarcane industry where they use bagasse to generate electricity, but biofuel (bioethanol and biodiesel) was overlooked (AEDB, 2019). Pakistan exports most of their ethanol and this was confirmed by all ethanol producers during the interviews. The export market and the local market can offer a trade-off option. However, Pakistan demand for ethanol locally is low therefore, a trade-off is available by exporting most of the ethanol. It can be seen from the table 2.15 that how ethanol export is increasing every year. Pakistan is producing up to EU standards as most of their buyers are from Europe.

Sugarcane is a bioethanol production driver associated with Pakistan's bioethanol production; if more sugarcane is grown with a higher yield, more molasses can be produced and later used for ethanol production. Other factors that can affect ethanol production positively and negatively include the consideration of other raw materials, the implementation of mandates, the production of flex-fuel vehicles by automobile manufacturers, and the restriction of molasses exports. Lastly, Pakistan sugar price is higher compared to international sugar prices, Pakistan government has been giving subsidy per MT for surplus sugar to be exported. Pakistan government can learn from the Brazil model, which directly produces ethanol from the Sugarcane juice. It can be seen from the figure 2.11 where molasses and Sugarcane juice can be used to produce ethanol. Ethanol selling price is higher than sugar and all surplus sugar which costs too much for government to dump, can easily be replaced by ethanol. The country may have the potential to produce more ethanol. Moreover, the Pakistan ethanol production is greatly influenced by global demand, government policies for blending mandate and government incentives with regards to blending and using to decrease GHG emissions.

2.10. Basic Statistical Information about Sugar Production in the UK

UK produces sugar from sugar beet (see table 2.9). Sugarcane requires a special climate and environment; thus, it cannot be grown in the UK. Sugar beet is normally grown within 28 miles of the British sugar factories and their factories are based in Cantley, Newark, Bury St Edmunds and Wissington. According to FAO (2020), sugar beet requires between 550 and 750 mm of water per season during the growing season, but this can vary depending on the climate and crop length. Sugar beets typically yield 40-60 tonnes per hectare and contain 15% sugar (FAO, 2020).

The total agricultural area in the United Kingdom is approximately 17.5 million hectares, of which 6.125 million hectares are crop-able and only 108,000 hectares are used for sugar beet production (Lynsey, 2019). Sugar beet area has been steadily decreasing since 2017, with a 5.6% decrease from the previous year (British Sugar, 2020a). Table 2.17 catches the synopsis of agriculture growing area in UK in hectares along with sugar beet growing area and yield per hectare. Sugar beet yield decreased in 2018 from the peak which it reached in the year 2017 and predictions are that it will be between 69-83 tonnes per hectare in 2019. The data is yet to be released on 2019 sugar beet yield per hectare. UK Sugar beet yield is clearly above the overall yield predicted by the FAO (2020).

Table 2.17 Total Number of areas for farming in UK (Source: Author data taken from Defra, 2019)

Number of Hectares	2015	2016	2017	2018	2019
(Utilized Agricultural Area in UK	17.147 million Hectares	17.360 million Hectares	17.476 million Hectares	17.361 million Hectares	17.505 million Hectares
Total Croppable Area	6.059 million Hectares	6.073 million Hectares	6.131 million Hectares	6.084 million Hectares	6.125 million Hectares
Total Crop Area	4.679 million Hectares	4.667 million Hectares	4.745 million Hectares	4.667 million Hectares	4.716 million Hectares
Wheat Growing area	1.832 million Hectares	1.823 million Hectares	1.792 million Hectares	1.748 million Hectares	1.815 million Hectares
Sugar beet growing Area	84,000 Hectares	80,000 Hectares	107,000 Hectares	110,000 Hectares	108,000 Hectares
Sugar beet Yield per ha	74 tonnes per Hectare	71 tonnes per Hectare	83 tonnes per Hectare	69 tonnes per Hectare	Prediction between 69-83 tonnes per ha

Sugar beet growing area has been fluctuating since 2009 (British Sugar, 2020b). It reached 122,000 hectares in 2010 and 121,000 hectares in 2013, but there was a sharp decline to 80,000 hectares in 2016 before picking up again and reaching 110,000 in 2018. (Department for Environment, Food and Rural Affairs, 2019). It explains why sugar beet growing area and yield have remained stable over the last decade. The fluctuation in the sugar beet growing area can be seen in table 2.18 due to issues with sugar beet yield and income, but sugar production has remained mostly constant and has ranged between 900,000 MT and 1,200,000 MT over the last ten years. The price of sugar beet is fixed by the National Farmers Union and the British sugar (NFU, 2019), and it can be seen from the table 2.18 that sugar beet prices per MT and sugar price per kg in UK.

Table 2.18 Sugar beet area, sugar production, sugar beet price and sugar price per kg in UK (Source: Author data taken from Defra, 2019 and Office for national statistics UK, 2020)

Years	Sugar beet growing area in ha	Sugar production from sugar beet locally in MT	Sugar beet price avg per MT	Sugar price per Kg in UK on 1st Jan of each year
2009	114,000	1,280,000	29.1	0.88 GBP
2010	122,000	995,000	30.1	1.00 GBP
2011	113,000	1,315,000	29.6	1.00 GBP
2012	117,000	1,144,000	31.2	1.07 GBP
2013	121,000	1,324,000	32.0	0.95 GBP
2014	117,000	1,446,000	33.9	0.86 GBP
2015	84,000	978,000	27.8	0.83 GBP
2016	80,000	897,000	26.3	0.67 GBP
2017	107,000	1,364,000	25.7	0.67 GBP
2018	110,000	1,080,000	32.3	0.69 GBP
2019	108,000	1,180,000 Est	No data	0.73 GBP

It is estimated that UK sugar consumption is between 1.8-2.2 Million MT and UK produces between 55%-65% of the total UK sugar demand as per data taken from Agriculture in the UK (2019) [see table 2.19]. According to OECD/FAO (2019), the average world sugar consumption per capita is between 22.7 kg and 24.2 kg. According to FAO (2016), UK sugar consumption per capita in 2013 was 34.2 kg per year (in comparison, in Pakistan it was 24.4). Public debate about the higher intake of sugar, fat and obesity has sparked the government to introduce sugar tax.

Table 2.19 Sugar beet area, sugar production, Export & import and overall percentage available of local sugar beet and overall sugar beet in UK (Source: Author data taken from Defra, 2019 and Office for national statistics UK, 2020)

Years	Sugar production from sugar beet locally in MT	Total Sugar Consumption in UK per MT avg estimated	Sugar Imports in MT	Sugar Exports in MT	% Of sugar produced in UK
2009	1,280,000	2,000,000	1,337,000	536,000	62%
2010	995,000	2,000,000	1,330,000	510,000	55%
2011	1,315,000	2,000,000	1,228,000	308,000	59%
2012	1,144,000	2,000,000	1,054,000	256,000	59%
2013	1,324,000	2,000,000	1,114,000	233,000	60%
2014	1,446,000	2,000,000	1,175,000	326,000	63%
2015	978,000	2,000,000	1,132,000	333,000	55%
2016	897,000	2,000,000	1,003,000	270,000	55%
2017	1,364,000	2,000,000	988,000	203,000	64%
2018	1,080,000	2,000,000	948,000	361,000	65%
2019 Est	1,180,000 Est	2,000,000	960,000 Est	370,000 Est	65%

UK produces ethanol from sugar beet, wheat, and corn mainly. The Department of Transport is consulting the public to introduce a new policy to make E10 mandate, increasing from 5% which was done previously. E10 which is 10 percent ethanol blended to the petrol and which is made from the renewable feedstock could cut the co2 emission from the transport by 750,000 ton per year (GOV, 2021). The Association for Renewable Energy and Clean Technology, which is the official body in UK, welcomes the report of British Parliament to immediately introduce the E10, as this will save 100 million GBP in the coming years and will help in air quality by decreasing the GHG emissions relative to fossil fuels (House of Commons UK, 2019). Ethanol releases less particulate emission than fossil fuel. Dorsey (2016) mentions that E 10 and E85 both reduces the particulate emissions by more than 95% when compared to 0% of ethanol being used, providing a substantial health benefit. Additionally, Dorsey (2016) explains further that E10 blend had 67-96% lower PAH emissions than E10, While E85 blend has 82-96% lower than E0. E10 blend decreases the toxicity of the emission by 72% and E85 decreases by 83%, it can be concluded that by switching to higher ethanol blend in the petrol can have positive effects on human health and positive affect on GHG emissions.

2.11. Bioethanol Facilities and their Statistical Information in the UK

There are three major ethanol producers in the United Kingdom (Department for Transport, 2020). The UK has the capacity to produce 900 million litres of ethanol (ePURE, 2018). In 2018, the UK produced 99.4 million litres of ethanol for UK road transport, with 94,000 hectares of agriculture land used for total bioenergy crops in 2018, including 5,000 hectares of sugar beet and 22,000 hectares of wheat for ethanol (Defra, 2019), accounting for 1.6% of total arable land in the UK.

Table 2.20 Ethanol production in UK from sugar beet only comparison with tonnage of crop applied and total sugar beet area used for the ethanol production (Source: Author data taken from Defra, *Crops Grown for Bioenergy in the UK* 2019)

Year		Ethanol in Million Litres	Tonnage of crop implied in MT	Sugar beet Yield in MT/ha	Implied area in 000 ha	UK total sugar beet area %
2008-09		41.4	409,000	64	6.4	5%
2009-10		63.0	624,000	74	8.4	7%
2010-11		68.5	678,000	55	12.3	10%
2011-12		21.8	216,000	75	2.9	3%
2012-13		59.9	593,000	61	9.7	8%
2013-14		57.8	570,000	70	8.2	7%
2014-15		67.9	669,000	80	8.4	7%
2015-16		60.0	592,000	74	8.0	9%
2016-17		23.1	228,000	71	3.2	4%
2017-18		46.3	457,000	83	5.5	5%
2018-19 Prov		36.8	363,000	69	5.2	5%

2018-19 data is as of Oct 2018 and is not final, RTFO year starts from 15th April till 14th April. 2019

Wheat was the second most common crop used to produce ethanol in the United Kingdom. According to Defra (2019), wheat from an estimated 22,000 hectares was used for ethanol production in the UK in 2018. Table 2.21 shows that wheat was first used on a large scale in 2010-11, and that it has followed a varying trend since then. Hectares decreased from 66,100 in 2016-2017 to 56,100 in 2017-2018, and total area used for ethanol production from wheat decreased to 3% from 4% the previous year.

Table 2.21 Ethanol production in UK from wheat only comparison with tonnage of crop applied and total wheat area used for the ethanol production (Source: Author data taken from Defra, *Crops Grown for Bioenergy in the UK* 2019)

Year	Ethanol in Million Litres	Tonnage of crop implied in MT	Wheat Yield in MT/ha	Implied area in 000 ha	UK total wheat area %
2008-09	0.0	0	8.3	0.0	0%
2009-10	0.9	3,000	7.9	0.3	0%
2010-11	119.9	327,000	7.7	42.4	2%
2011-12	17.9	49,000	7.7	6.3	0.4%
2012-13	48.2	131,000	6.7	19.7	1%
2013-14	70.8	193,000	7.4	26.1	2%
2014-15	166.1	452,000	8.6	52.7	3%
2015-16	134.9	367,000	9.0	40.9	2%
2016-17	191.7	521,000	7.9	66.1	4%
2017-18	170.7	464,000	8.3	56.1	3%
2018-19 Prov	62.6	170,000	7.8	22.0	1%

In last few years, much of the time the factories were closed due to lack of government policies, support, taxes and cheaper import of USA and EU ethanol. Table 2.22 shows the complete picture of ethanol production in United Kingdom for the road transport market. The total UK production is increasing but it has decreased from 2017 and total ethanol consumption for UK road transport market is averaging 750-800Million litres. Among the share of biofuel usage in UK, biodiesel accounts for 68% and ethanol accounts for 32%.

Table 2.22 UK Ethanol production to UK road transport market (Source: Author data taken from Defra, Crops Grown for Bioenergy in the UK 2019)

Ethanol	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total UK production in Million Litres	281	29	154	524	516	333	468	645	516
Total Ethanol consumption for UK road transport in Million Litres	631	652	775	819	812	797	759	752	761

Table 2.22 shows the UK's future capability for ethanol production and demonstrates that there is a significant opportunity in terms of raw material availability to produce ethanol in the UK. Currently, the UK produces 60% of total capacity and has a capacity of 900 million litres. Table 2.23 shows the percentages of total UK ethanol production and supply.

Table 2.23 UK ethanol production and supply (Source: Author data taken from Defra, Crops Grown for Bioenergy in the UK 2019)

	2012	2013	2014	2015	2016	2017	2018
UK Ethanol production derives from crop raw materials in %	100%	100%	100%	100%	100%	100%	100%
Crop raw materials known to be produced in UK in %	96%	91%	85%	97%	96%	79%	51%
Ethanol Supply in %							
Road Transport UK	61%	63%	50%	95%	50%	27%	34%
Non road transport UK	1%	6%	0%	5%	0%	0%	2%
Heat and power	0%	0%	0%	0%	0%	0%	0%
Export	n/a	31%	50%	0%	50%	71%	64%
Others	38%	0%	0%	0%	0%	2%	0%

Table 2.24 Future outlook for ethanol production in UK (Source: Author data as per Defra 2019)

Feedstocks	Feed grade wheat and Sugar beet
Future feedstock potential	Corn and Cellulosic (waste, residue etc.)
Availability of feedstock.	Abundance
Ethanol production Average 2018	516,000,000 Litres (2018)
Ethanol production capability	900,000,000 Litres (2018)
Future potential	Depends on the policies, mandate etc.
Number of Mills	3
Number of working days in a year	300 days
Selling Market	Local and International

It can be seen from the above tables 2.21, 2.22, 2.23 and 2.24 that UK has a great potential for the ethanol production from various feedstock. There are plenty of available feedstocks such as corn, barley, feed grade wheat, sugar industry waste and cellulosic based biomass. UK is currently producing up to 60% of their capacities, and many times distilleries were forced to close for half of the season.

2.12. Bioethanol Production Policy in the UK

Bioethanol policies are made by the Department of Transport (Department for Transport, 2020). In the UK, they are in the form of Renewable Energy Directive (RED) and Renewable Transport Fuel Obligation (RTFO). Both tell about the blending mandate, quality, quota system, area of land to be used for biofuel crops (Ceres, 2017).

According to Department of Transport UK (2020), the blending mandate was 5% since 2013 and it is under review to make this 10% in 2020 and by 2032 to be 12.4%. However, Government has also put the conditions such as maximum 4% of the land to be used for biofuel in 2020 and proposing to decrease to 2% by 2032 (Department for Transport, 2020). This will increase the demand of waste feedstocks and will force industry to invest in cellulosic based ethanol. Researchers and industry professionals however feel that the cap will have negative impact and will restrict the ethanol market and UK must make 7% cap for the crops, same as EU indirect land use change directive (Ceres, 2017).

Bioethanol industry growth was much slower since it started in 2007 (Amies-Cull, Briggs and Scarborough, 2019). Vivergo Fuels (2016) states that lower mandate is the major factor, which is limiting the investment in the ethanol sector in the UK. Department of Transport is pushing for more use of waste products, but this could backfire due to lack of advance technology or technology is yet to be commercially available and viable (Lynsey, 2019). Furthermore, the EU's Renewable Energy Directives have an impact on UK policies. It states that 10% of transportation fuel must come from renewable sources, including biofuels, by 2020, with a crop cap of 7% allowed to be diverted to biofuels. According to Defra (2019), 94,000 Hectares of agricultural land in the UK were used for bioenergy. Only 29% of the arable land was used for biofuel, accounting for 0.46% of the area, and bioethanol uses half of this area (Defra, 2019).

In 2010, 10% of the sugar beet area was used to make ethanol, which is now 5%. It shows clearly that sugar beet area used for the ethanol production in UK is decreasing. It is also noted from Department for Transport (2019 and 2020) major raw material in 2018 were sugar beet and wheat but in 2019 it was corn. Department for Transport (2020) believes that E10 will be cost effective in UK, can improve air quality, decrease GHG emissions and meet carbon targets. 25% of the emission of GHG is from transport sector in UK .UK transport emission is increasing at alarming rate and these regulatory progresses will reduce transport emissions. Department for Transport (2020) mentions in their report that biofuel can save 82% of GHG emission in comparing the emissions from 1400 litres of diesel against that of 1400 litres of biofuel. In another report by Department for Transport (2021) states that E10 will reduce the carbon dioxide emissions and will tackle climate change. The drivers for change in the UK bioethanol production will greatly depend on the introduction of E10, implementation of E10, import restrictions on cheaper ethanol, and price support.

2.13. Comparative Analysis of the Bioethanol Production in Pakistan and UK

The comparative analysis of bioethanol production in Pakistan and the United Kingdom is based on the data presented in the preceding sections. Table 2.25 compares key similarities and differences. The main similarity is that both countries lack adequate support for the ethanol industry. Pakistan lacks a policy framework, whereas the UK has one, but it may not be sufficient.

This chapter provided a background of the sugar and ethanol industries in Pakistan and the United Kingdom, as well as country information about Pakistan and the United Kingdom, the demand and consumption of the sugar industry, and how sugar is produced in Pakistan and the United Kingdom, respectively. It is understood that Pakistan produces sugar from sugarcane, while the UK produces sugar from sugar beet. Sugarcane-molasses is used as a feedstock for ethanol production in Pakistan, while sugar beet, wheat, and corn are used in the United Kingdom. Pakistan is one of the world's top producers of sugar and ethanol, and the United Kingdom is one of Europe's top three ethanol producers. Ethanol is used in a variety of industries, but the fuel grade for the transportation sector was debated. Most of the ethanol produced in Pakistan was exported, with the UK importing some of it. In both countries, the sugar and ethanol industries are heavily politicised. Further cases will be discussed in the following chapter, which is a review of the Literature. Previous studies will be reviewed, and any similarities or unfinished business will be researched to identify a knowledge gap and work on it further.

Table_2.25 Comparison of Ethanol industry in Pakistan and UK (Source: Author table was compiled using previous sections of the chapter)

Country	Pakistan	United Kingdom
Authorities	**Ministry of Energy**	Department of Transport
Current blending mandate	0%-5%	4.75%
Targets 2020	5%	5%
New Policy for higher mandate	5%	10%
Feedstocks	Sugarcane Molasses	Wheat, Sugar beet, Corn
Future feedstock	Grain based (Corn, wheat etc.)	Cellulosic based, waste feedstocks
Export potential	High	Low
Drivers	Export mainly	Low GHG, Employment, cleaner air, economy support
Future drivers	Policies to use more ethanol locally for blending, Low GHG, Saving foreign reserves, direct and indirect employment, rural development etc.	10% introduction of blending to have cleaner air quality, Low GHG emission, economy support, rural development etc.
Problems	No blending policies, no counting on molasses, no Research done on new feedstocks, neglected industry left on the hands of sugar and ethanol mafia	Cheaper to import of ethanol from other countries, low mandate, Taxes are high

Chapter 3: Literature review

3.1. Literature Review

This Literature review includes upstream Literature (sugary crop-side and factors influencing this), downstream Literature (ethanol and factors influencing this), the trade-off between sugar-ethanol-by-products and drivers influencing this, and methodology Literature (Life cycle analysis and cost-benefit analysis) (Figure 3.1). It provides a detailed description of sugar production from various crops, the ethanol conversion process from sugar manufacturing feedstock by-products, as well as the drivers and factors that influence the sugar/biofuel sector. It also contains lifecycle assessment to determine whether it results in a greenhouse gas emissions reduction and an improved energy balance. Furthermore, sugar and ethanol technology and industry as well as business environment and regulations for bioethanol in both countries have been discussed specifically for UK and Pakistan. Also, the relation between sugar and bioethanol is mentioned considering their trade-off and complementarity.

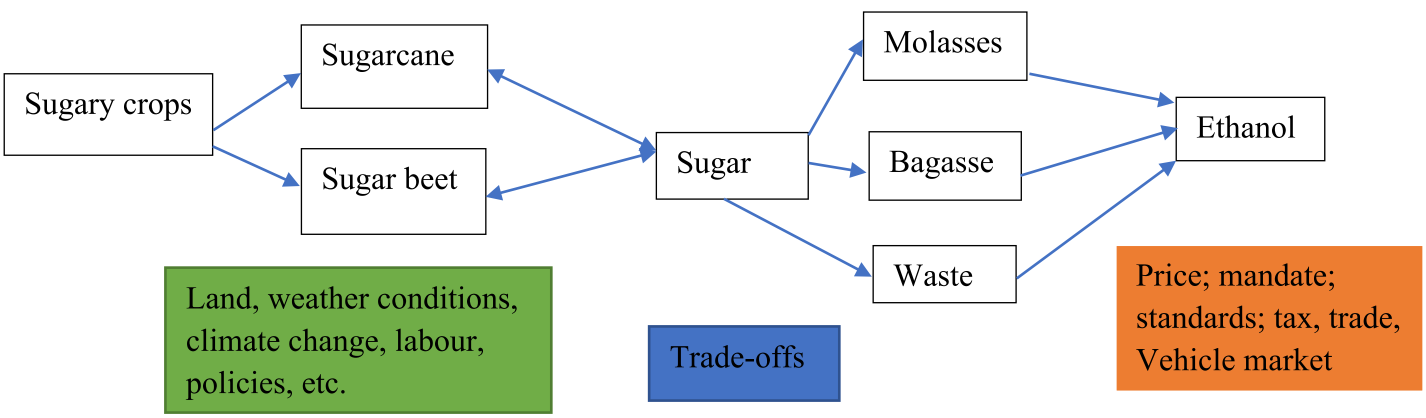


Fig.3.1. Author: Block diagram of process flow

3.2. Sugar Industry Technology and Processes

Sugarcane or sugar beets are the primary sources of sugar. Sugar production involves two major processes: the processing of sugar cane and sugar beets into raw sugar, followed by the processing of raw sugar into refined sugar (Mariano, 2016). According to De Souza Dias et al. (2015), sugar is extracted from sugarcane through a lengthy process. The first stage is harvesting. Harvesting can be done manually or mechanically (Dutton, 2018). The transportation stage transports it to the sugarcane refinery, where chemical changes occur. In the sugarcane refinery, the sugarcane is usually cut into smaller pieces which is milled and mixed with water. The juices are extracted from the bagasse of the cane by pressing the pieces. Mainly, the process of pressing for extraction of juices is carried out through machines. This juice possesses between 10% to 15% solid sucrose (Dutton, 2019). The sucrose extracted contains certain quantities of organic compounds. Thereafter, the juice is heated at 115°C and added to lime and sulfuric acid to prevent harmful inorganics. The obtained juices are then crystallised, which becomes sugar after further processing. Palacios et al. (2014) also state that the machinery used in cane preparation and juice extraction is powered by steam turbines, which require more energy in the form of steam than efficient electric engines. Diffusers are frequently used in juice extraction as well, ensuring increased sugar recovery while using less energy than the milling tandem. The ingredients applied and processed to sugarcane include the first substance water (73-76%) followed by soluble solids ten to sixteen percent (10% to 16%) added bagasse or dry fibre of eleven to sixteen percent (11% to 16%) (Dutton, 2018). The by-products obtained after the production of sugar from sugar cane are molasses and bagasse. Both by-products are used in ethanol production (De Souza Dias, 2015). Figure 3.2 below explains the process of production of sugar from sugar cane and pathway to ethanol.

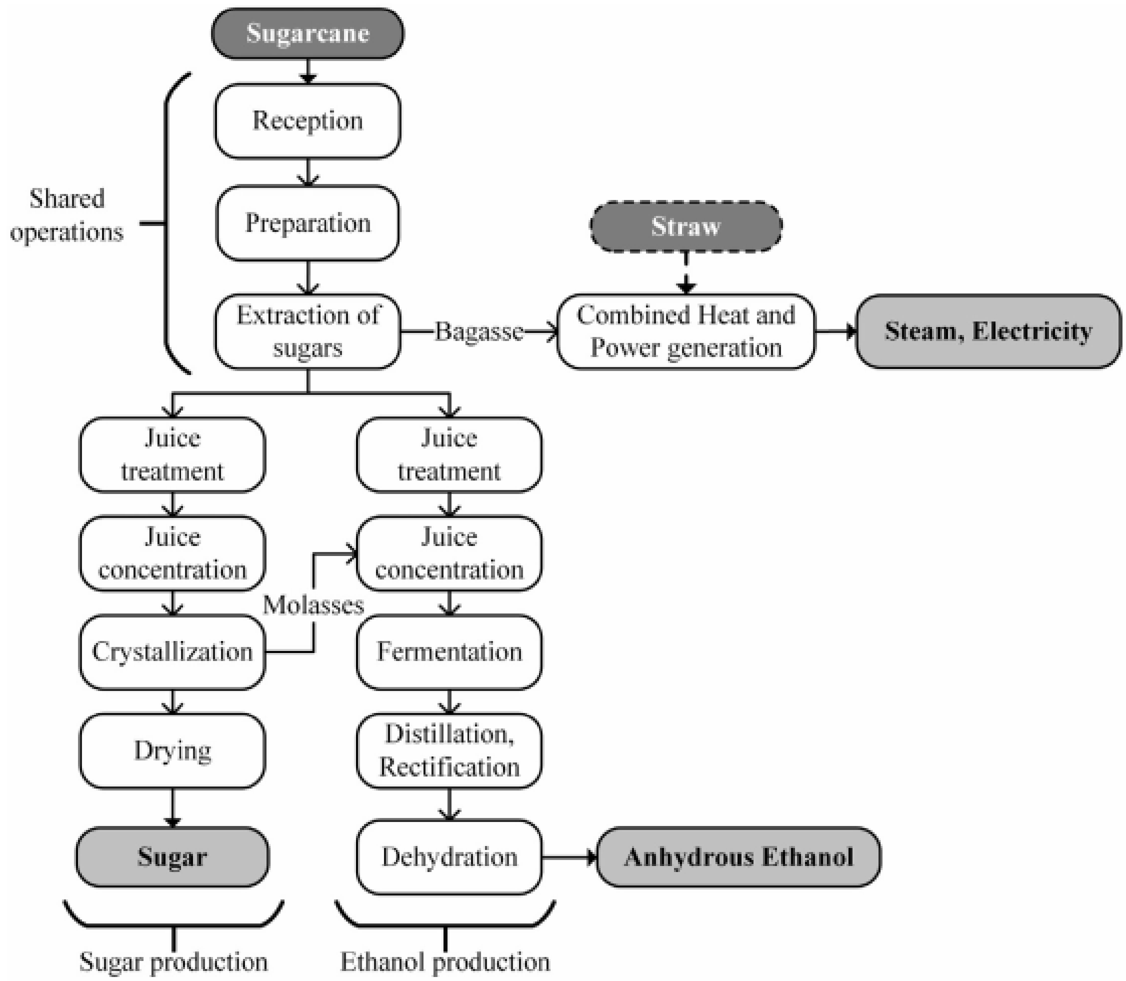


Figure 3.2: Extraction of Sugar for Sugarcane and treatment of molasses for Ethanol production (Dias et al, 2015)

According to Limb (2004), although sugar beet production dates back more than 5000 years, sugar beet cultivation in England began in 1912. By 1928, 18 independent sugar factories had been established for beet sugar production. By the year 2000, however, Britain had risen to third place in the world's sugar production regions. Even today, sugar beets are used to make sugar in the United Kingdom (Limb, 2004). According to Duraisam, Salelgn and Berekete (2017), sugar beets, also called Beta vulgaris, are an industrial crop, are moderate region crops which are quite tolerant of various climates and soils as well. Sugar is present in a large amount in sugar beets. This is the extraction stage which is extracted directly from it by the process of crystallization after leaching and boiling the crop (Duraisam, Salelgn and Berekete, 2017). This process involves non-sugar separation with minimum destruction of sugar beets (Eggleston, 2010). The next stage is the purification process that produces the purest organic substance which can be utilised in the subsequent stage (Eggleston, 2010). Figure 3.3 below explains the process of sugar production from sugar beet. Many by-products are obtained after the extraction of sugar, such as molasses, pulp and residue which are then utilized for various purposes, such as feed stock for animals, alcohol production and bioethanol production (Duraisam, Salelgn and Berekete, 2017).

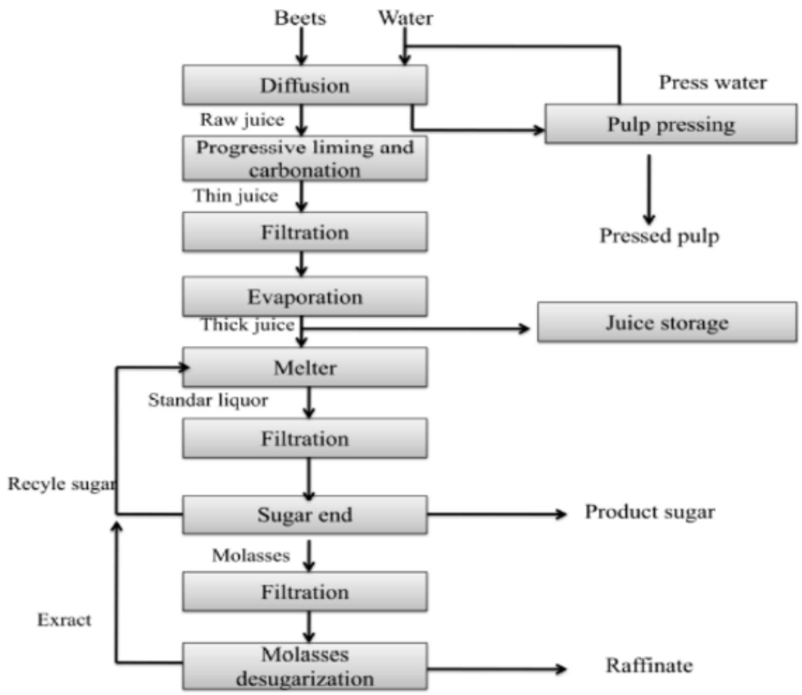


Figure 3.3. The process of Sugar extraction from Sugar Beets (Rafik et.al, 2015)

According to Hinkova and Bubnik (2000) ethanol can also be produced from the sugar beet. Ethanol is produced scientifically through the fermentation and distillation of sugar and starch crops. To make ethanol from beets, the process shown above is modified, and the fermentation process is added after crystallisation. Clean sucrose water or 'thick juice' is diluted or concentrated for the yeast, which ferments the sucrose syrup later. After the fermentation process, distillation must be done to recover ethanol from the fermented product. The final product created after distillation is the bioethanol.

Unlike UK, the main source of production of Sugar in Pakistan is sugarcane; Sugar beets have a barely nominal usage in Pakistan, as per the study of Waheed, Rahman and Gill (2009). Due to the large amount of production and treatment of sugarcanes, Pakistan produces a great number of by-products consisting of molasses and bagasse, besides the jaggery, white and brown sugars, which are the main product of the sugar industry of Pakistan. However, molasses is usually exported in large amounts from Pakistan to different regions of the world. Recently much of the molasses is used for the ethanol production due to increase in demand for ethanol and government introducing export tax on molasses.

3.3. Sugar Industry Technology and Processes in Pakistan

Sugarcane is the sole source of technology and process in Pakistan's sugar industry. Pakistan is a top ten sugar cane grower and producer of sugar, producing 5 million tonnes of refined sugar per year. Sugar is refined in two steps: the raw sugar production process converts sugarcane to raw impure sugar through some steps, and the refining process converts raw sugar to granulated sugar through some industrial processes. Each process requires heat, electricity, or water. Energy consumed by a sugar industry is in the form of 96% steam for heating up of processes and 4% electricity for running the machinery (Pakistan National Productivity Organization (NPO) and Cleaner Production Institute (CPI, 2016). These energy requirements are fulfilled primarily by the combustion of bagasse, a dry residue of sugarcane. Bagasse is utilized to produce steam in steam boilers which in turn rotates the steam turbines. These steam turbines either operate as prime mover of the processing equipment or to produce electricity. Furthermore, the steam exhausted from the turbines is utilized for heating purposes. In Pakistan sugar mills produce an average of 47,700 tons of refined sugar annually consuming 320 GWh of energy and 545,000 m^3 of water (Kumar, Paroha & Mohan, 2015). The energy efficiency ratio for the sugar industry in Pakistan is about 6.6 MWh/T. Pakistan is having a less efficient sugar industry compared to the energy efficiency ratio in OECD (Organisation for Economic Co-operation and Development) countries with a ratio of 1.6 MWh/T. (Pakistan National Productivity Organization (NPO) and Cleaner Production Institute (CPI), 2016).

The sugar industry in Pakistan employs good equipment that match up the production demand of sugar. According to the Goswamia and Choudhury (2019), the international standards and government of Pakistan stimulating innovation and advancement in technology by providing security to the sugar industry to invest in biofuel production in the long term. This research pointed out that sugar industry technology and processes in Pakistan are like countries such as the US and the UK, but the feedstock is different. According to Abasa et al. (2017), the developed countries such as the US, UK and EU create the policy environment to support innovation and technology advancement.

As a result, the positive effects, trade-offs, and economic integration involved varied depending on the type of energy crop, conversion technology, cultivation method, and regional trade flexibility available (Pieragostini, Aguirre and Mussati, 2014). Finally, this paper demonstrated that the sugar industry in Pakistan can produce efficient sugar when given the necessary technology and process support to compete favorably with their UK counterpart.

3.4. Bioethanol Technology and Processes

Bioethanol or simply ethanol is biochemically engineered biofuel which is a liquid biofuel substitute or is added into the natural liquid fuels such as petroleum to preserve natural fossil fuels and minimize their harms. According to Nigam and Singh (2011) ethanol is a renewable biofuel that is more environmentally friendly then fossil fuels.

For the ethanol production, there are mainly three groups including sugars, starches, and lignocellulosic biomass (Knauf and Moniruzzaman, 2004). Table 3.1 shows the raw materials and process of ethanol production. The production processes used for ethanol by main feedstocks is depicted in Figure 3.4.

Table 3.1 Raw materials and ethanol production by different groups (Mussatto,2010; Bušić,2018; Limayem and Ricke, 2012)

Groups	Raw materials for ethanol	Production of ethanol	Advantages/Challenges
Simple Sugars	Sugarcane, sorghum, sugar beet, whey, and molasses	Ethanol is manufactured by the fermentation of: 1) sugarcane juice, beet juice, sorghum juice or from sugarcane by product molasses 2) lactose content from whey, a by-product obtained during production of cheese (Mussatto,2010).	Comparatively a simpler process of converting sugar into ethanol than other raw materials (Mussatto,2010). Sugar cane used for bioethanol production appears to be less expensive as compared to other raw materials because of easier processing and higher productivity (Bušić,2018).
Starch	Maize, wheat, and cassava	Ethanol production from grains such as maize, wheat, rice and cassava require pre-treatment to break the glucose with enzymes. It requires milling, cooking, and Liquefaction. Then ethanol is produced by the fermentation of yeast (Mussatto,2010) and distillation to reach the required percentage of ethanol	Corn has got the criticism because of high prices of food and world shortage of food. Furthermore, the ethanol production from corn has some environmental concerns, including erosion of soil, loss of biodiversity, and NOx pollution. It also needs plenty area for plantation and water (Mussatto,2010). Ethanol produced from starch improves yeast strains and application of enzyme with high ethanol tolerance (Bušić,2018).
Lignocellulosic biomass	woody material, straws, crop residues and agricultural waste	Lignocellulosic materials contain polysaccharides, cellulose, and hemicellulose. They are breakdown to simple sugars, then ethanol is produced by fermentation of sugars (Mussatto,2010).	The methods to produce ethanol from woods and grasses can be cost effective and environmentally friendly, but the amount of ethanol produced is relatively low (Limayem and Ricke, 2012). It is sustainable because lignocellulosic biomass does not compete with oil and food crops, and it is renewable (Bušić,2018).

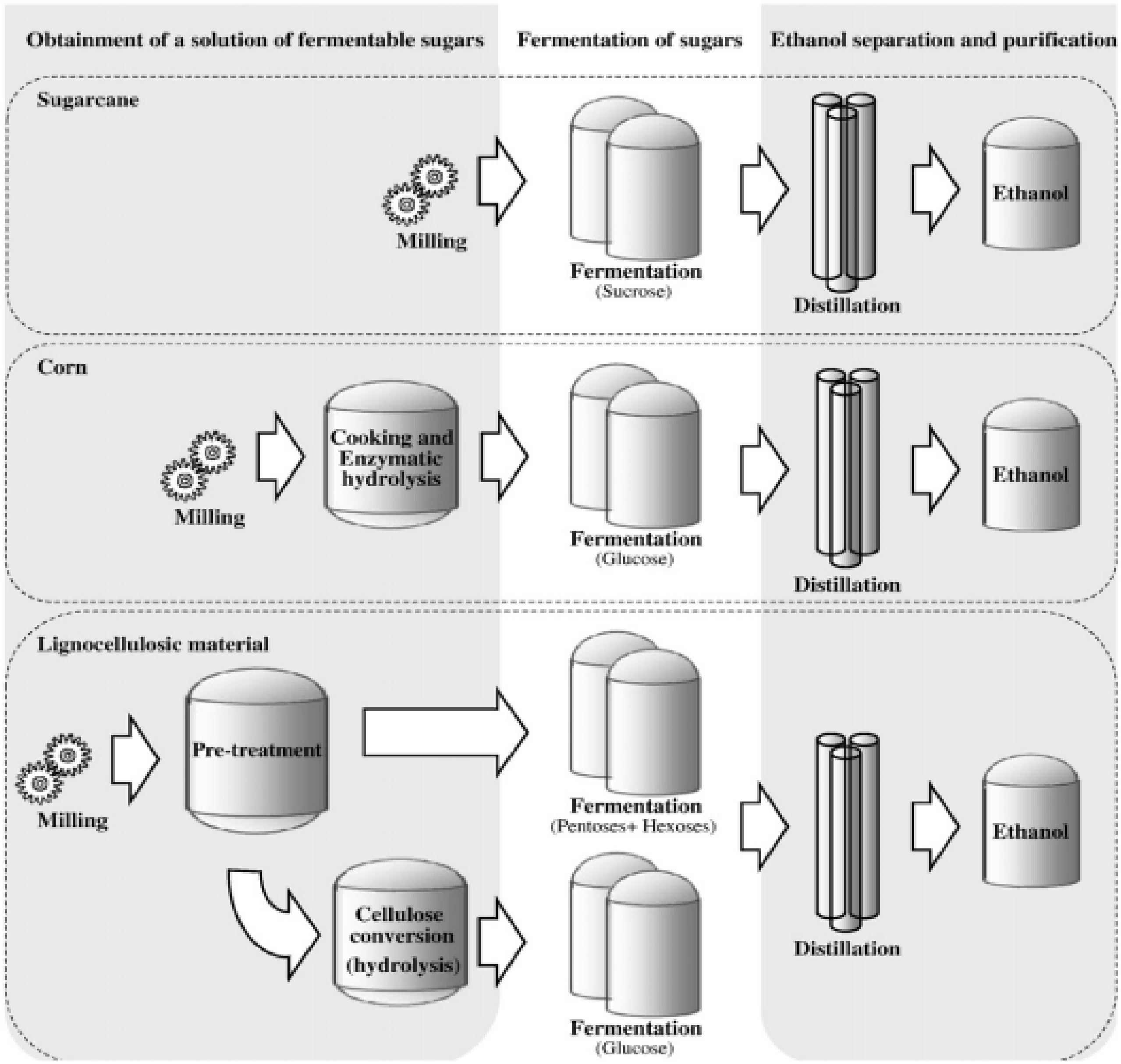


Figure 3.4 Ethanol production processes from main raw materials (Mussatto,2010).

3.4.1 Ethanol Technology and Processes in Pakistan

In Pakistan, ethanol technology and processes are solely based on molasses and have been used for commercial purposes for nearly 30 years. In Pakistan, 20 distilleries with an installed capacity of approximately 500 million litres annually produce various grades of ethanol (Arshad, 2019). Very few of the distilleries are integrated as they are located inside of sugar mills. Integrated not in terms of Brazil, where they have a dual process in same factory, whereas in Pakistan distilleries are either in the factory means next to sugar mill or nearby. The sugar mills process the sugarcane to produce sugar and send the molasses to storage area or tanks, from where distilleries used the molasses to produce the ethanol. In Pakistan, most of the ethanol distilleries are using molecular sieve technology for the ethanol production.

Some of the integrated sugar mills include Al-Abbas in Sindh province at Mirwah Gorchani, Shakarganj sugar mill in Jhang, Crystalline Chemical Industries (Pvt.) Ltd in Sargodha. Al Abbas mill has a production capacity of 87,500 L ethanol per day, with crushing potential of 7500 M ton per day of sugarcane. The ethanol distilleries are using French technology mostly but there are few with Chinese technology based on multi-effect vacuum distillation. The recovery rate from French technology-based distillery is slightly higher than Chinese based technology or machinery.

Shakarganj sugar mill is producing ethanol with various grade and for various uses along with methylated spirit and denatured ethanol according to customers need. The mill exported almost 90% of its ethanol. The plant produces eco-friendly anhydrous ethanol with dry dehydration technology.

Another integrated sugar mill sugar is in Nankana, Sheikhupura, Pakistan with production potential of 125,000 l ethanol per day. It also produces fuel grade ethanol from molasses with 99.8% purity. The distillery has very good control system of ultra-modern machinery and transmitter controllers. It uses cost effective devices and following international standards for operating processes to produce high quality ethanol (Mirza,2016).

Recovery of ethanol is approximated to be 0.240-0.270 litres from one kilogram of molasses according to Dawn (2005) and through interviews, refer to annex-19. In the period of 2018-2019, the country exported 781 million litres of ethanol at trading price of 73 Rs/litre (Pakistan Sugar Mills Association Islamabad,2019).

3.4.2 Ethanol Technology and Processes in the UK

According to ePURE, a European industry body, the UK has a production capacity of 985 million litres of ethanol (European Renewable Ethanol ,2018). Following France and Germany, this has become Europe's third largest production potential. According to a Renewable Energy Association report, the United Kingdom has three bioethanol producers: Vivergo, British Sugar, and Ensus. At the end of 2018, Vivergo have discontinued their production due to low ethanol price and more competition. As per Renewable Transport Fuel Obligation statistics for 2018, transport fuel supplied from renewable was 4%, and of this 33% met sustainability requirements under the RTFO. Of this percentage, bioethanol was 38% that means around 0.5% of transport fuel was from sustainably produced bioethanol supplied in the UK last year (Hinson,2019).

British Sugar's Wissington plant can produce 81 litres of ethanol from thick beet juice and some molasses. Ensus in Teesside, which has a capacity of 400 million litres and uses wheat as a feedstock, is the other major bioethanol producer in the UK. According to the Department for Transport (DfT), the UK consumed 744 million litres of bioethanol from 2017 to 2018. Ethanol derived from crop feedstock supplied in UK totalled 555 million litres, of which 212 million litres from corn, 193 million litres from wheat, 125 million litres from sugar beet and 25 million litres from sugarcane (NFCC,2019). In UK in 2018, 53% of the land of total bioenergy crop was used for biofuel for the transport mark, including both bioethanol and biodiesel(Hinson, 2019).

3.5 Drivers, Factors, and Influences

Sugarcane is a perennial crop, requires tropics and subtropics regions to grow and a significant source of sugar and bioenergy in the world (Hussain,2018). Sugar beet is a significant break crop which has ability to multiply the invested energy (Řezbová,2013). Productivity of these two crops is affected by several drivers and factors, of which main are shown in Figure 3.5 (Hussain,2018; Řezbová,2013; Chandel,2010) discussed the key drivers for successful ethanol production on commercial basis. Main factors for ethanol production are presented in Figure 3.5

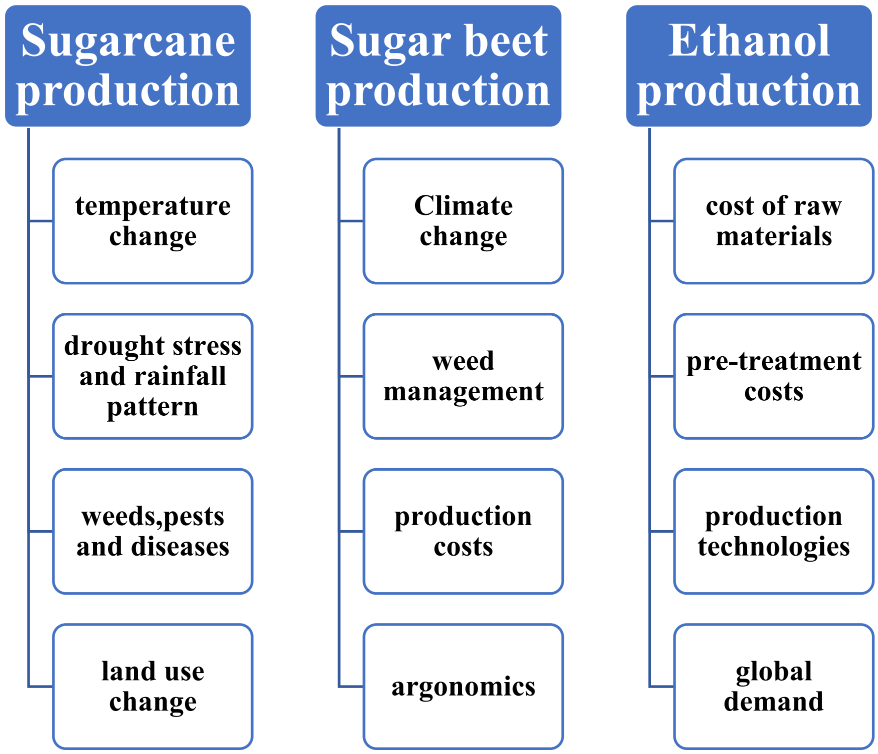


Figure 3.5 Main factors affecting sugarcane, sugar beet and ethanol production (Hussain,2018; Řezbová,2013; Chandel, 2010)

3.5.1. Drivers, factors and influences in Pakistan and UK

Sugarcane is a cash crop in Pakistan, and its production is heavily influenced by climate change. Sugar beet is primarily a temperate zone crop in the United Kingdom. Ethanol is produced from both crops, and key drivers affect its production differently in both countries. Tables 3.2 and 3.3 show some of the drivers and factors influencing sugarcane yield in Pakistan and sugar beet yield in the United Kingdom, as well as ethanol production from both (NFCC, 2019; Afghan, 2013, Arshad, 2019).

Table 3.2 Drivers/factors effects on the yield of sugar beet and ethanol in UK, Source (NFCC, 2019; British Sugar, 2020a; British Sugar, 2020b; ABSugar, 2018)

	Drivers/factors	Effects on yield
Sugar beet	Soil types	• Yields are affected by drought on very light soils • Low soil pH leads to poor beet yields • Beet grows very well on light to medium textured soils.
	Fertilizer requirements	• Boron deficiency results in yield loss and can be overcome by 3kg/Ha of boron • Yield is not affected by nitrogen rate if 119-149 kg N/Ha were included in mineral soil. • High yielding crops suffer from Sulphur deficiency and corrected by 25-50 kg/Ha • Sodium improves efficiency of water use and magnesium maintains green canopy allowing more sugar production
	Weed control	• Weeds do competition with beets for light requirement. • Yield losses because of weed density and length.
	Cultivation and harvest	• Improper cultivation with wrong timing results in loss of yield by 30%. Cultivation at the end of march is ideal. • Harvesting date affects the yield and root quality and should be done in winter starting or late autumn.
Ethanol	Supply and cost of feedstock	• A stable supply of feedstock is necessary for higher yield • Cost of the processes and products involved depends on the local and global markets changes.
	Production technologies	• If sugar beet pulp is utilized, then higher yields of ethanol is possible. • Thin juice is also used for ethanol production which can reduce costs and energy consumption.
	GHG emissions	• Low GHG emissions encourage higher yield by using renewable input fuel for heat and electricity processes.

Table 3.3 Drivers/factors effects on the yield of sugarcane and ethanol in Pakistan, Source: (Arshad, 2019; Securities, 2019; Arif, 2019; Abbassi; Abas et al., 2017; Afghan, 2013; Shahid, 2013)

	Drivers/factors	Effects on yield
Sugarcane	Rainfall pattern	Annual rainfall is in the range if 400mm to 700mm favours sugarcane growing locations between July and August. Only 10% of annual rainfall comes in winter which lowers the production of crop.
	Temperature	Temperature below $15^{0}C$ in winters limited the cultivation and temperature increases in summers between 8-$34^{0}C$ improves the yield.
	Drought	Drought stress decreases the productivity of crop and deficiency of water reduces the production up to 60%
	Price	Sugarcane cultivations decline by 10% due to low purchase price from millers.
Ethanol	Production technologies	Processes of production are labor intensive and not mechanized which results in low yield. Energy output per input ratio can be 1 to 1.5 if by-products of molasses are used. If sugarcane juice is used directly to produce ethanol than energy balance raises to 2 to 4.
	Production Cost	Cost of molasses changes every year due to which ethanol production cost varies accordingly.

Figure 3.5 explains the main factors affecting sugarcane, sugar beet, and ethanol production. Similarly, Tables 3.2 and 3.3 have been derived from the Literature review about the factors that impact on the yield pf sugarcane and ethanol across both the countries. The further discussion based on impact and yield is as followed.

3.5.1.1 Discussion on factors effecting the yield in UK – Sugar Beet

Types: In the United Kingdom, approximately 60% of the sugar beet area is on sandy loam soils, with less than 30% on heavy clay soils, giving growers the opportunity to match soil types to harvest dates (British Sugar, 2020a).

Rain: Year-to-year variation accounted for 20 % of all variation in yield; increasing amounts of rainfall during the growing season appeared to decrease yield (ABSugar, 2018).

Harvest: A field experiment in each year 1963 to 1967 in Suffolk, England, tested the effect on yield of sugar beet of sowing dates ranging from 13 March to 11 May and harvest dates ranging from 20 September to 8 December. Sowings in March or early April gave similar yields of sugar but with later sowings yield decreased progressively faster. Delayed harvest increased sugar yield (Hull, 1970).

Fertilizations: On average, 0.6 cwt./acre of N was more profitable than 1.2 cwt./acre (Tinker, P. B. H., 1965). There was a positive interaction between N and Na, and a lesser one between N and K; in presence of the heavy salt dressing, or the light salt dressing and potassium the optimum rate of nitrogen was 1.0 cwt./acre. (Tinker, P. B. H. (1965). The effects of nitrogen, potassium and sodium fertilizers on sugar beet (Journal of Agricultural Science, 2017).

Weeds: Weeds in beet crops reducing the yield in the field level as well as making the harvesting and processing difficult (British Sugar, 2020a).

3.5.1.2 Discussion on factors effecting the yield in UK – Ethanol

Supply: Almost all ethanol produced on a global scale is derived from starch and sugar-based feedstocks (ABSugar, 2018). Because the sugars in these feedstocks are simple to extract and ferment, large-scale ethanol production is feasible.

Production technology: Sugar beet sucrose produces by-products such as sugar beet pulp and molasses, which are critical in filling energy gaps, particularly as an excellent alternative source of green energy (Journal of Agricultural Science, 2017). In the pursuit of sustainability and economic value, crop utilisation must be maximised for maximum sugar yield, profitable plant operation, and efficient bio-fuel production such as ethanol.

GHG: Biofuels are being promoted as a low-carbon alternative to fossil fuels as they could help to reduce greenhouse gas (GHG) emissions and the related climate change impact from transport (Lynsey, 2019).

3.5.1.3 Discussion on factors effecting the yield in Pakistan – Sugar Cane

Rain: Sugarcane is a tall tropical plant that requires strong sunlight, fertile soil, and plenty of water to thrive. It requires at least 1.5 m of rain per year (Abas et al., 2017). Annual rainfall in Pakistan ranges from 400mm to 700mm, favouring sugarcane growing areas between July and August. Winter receives only 10% of annual rainfall, reducing crop production.

Temperatures: Temperature is critical during the sugarcane growth process. Temperature deviations were as follows at various stages (Ali et al., 2017). Crop photosynthesis and leaf development rate are constrained by stumpy temperature (Tahir et al., 2013). If understood in a restricted range, we can say that if temperature falls below 15°C due to climate change in low temperature zones during its early stages, it limits sugarcane cultivation, but temperature increases, on the other hand, improves sugarcane harvest (Khan et al., 2018). The Handman test was used to statistically analyse data collected from sources.

Harvest: Summer spell is categorized by extraordinary moisture, which in the occurrence of high temperature grow into humid situation and hence friendly atmosphere for production of sugarcane (Saddiq et al., 2014).

Drought: The impact of drought on sugarcane production is determined by the stage of plant growth. The impact of drought on sugarcane production is determined by the plant's growth stage and the duration of the stress (Pakistan Sugar Mills Association, 2019). Drought primarily reduces sucrose yield in the early and mid-growth stages. Moderate drought increases the sucrose content in stalks during the late growth stage.

Prices: Sugarcane growers have historically faced a variety of issues from the country's sole buyer, the sugar mills. For example, in the 1990s, there was a problem with delayed payments, which resulted in late wheat sowing, non-mention of cane prices in the receipt, cuts in the quantities brought for sale at the procurement point or mill-gate and offering prices lower than the announced procurement prices (Bhutta, 2018). The majority of small growers sell their produce at lower prices to middlemen, large growers, or collection centres (known locally as kanda) (Anjum et al., 2016; Sanaullah, 2018).

3.5.1.4 Discussion on factors effecting the yield in Pakistan – Ethanol

Production Cost: Molasses prices fluctuate year after year, causing ethanol production costs to fluctuate accordingly. All costs associated with the fuel production system at each stage of the ethanol production system are included in the detailed cost breakdown analysis for the estimation of ethanol life cycle cost (Pakistan Sugar Mills Association, 2019). These costs are divided into four major cost categories, the most important of which is feedstock cost (CFS) (Bhutta, 2018).

Feedstock cost: The cost of molasses used in ethanol production is included in the feedstock cost. Molasses prices are highly volatile, depending on fluctuations in the local market's demand, seasons, and location, among other factors. Pakistan has been exporting cane molasses to the European Union (EU), Saudi Arabia, the United Arab Emirates (UAE), and Afghanistan (Bhutta, 2018). As a result, fluctuations in demand and price in the international market have a significant impact on molasses prices in the domestic market (Pakistan Sugar Mills Association, 2019).

3.6. Trade-off and Complementarity between Sugar and Bioethanol Production

Tokgoz and Elobeid (2006) studied how price shocks impact three input and output markets directly associated with ethanol production. These markets include corn, gasoline, and sugar. During the investigation, the impact of these shocks was examined on ethanol sectors of Brazil and the United States.

The study developed an international model for ethanol that has relationships with input and output markets of ethanol. A multi-commodity, multi-country system of integrated commodity models was used to estimate the impacts (Tokgoz and Elobeid, 2006). The structure of the model defines behavioural equations for the productivity, consumption, end of stocks, and net trade of ethanol for Brazil, United States and European Union-15. World sugar relates to ethanol model via international sugar model, which comprises of countries with major sugar production and consumption. Raw sugar price of the world is calculated endogenously by comparing surplus supply to surplus demand in the world sugar market. This model is developed on 2005 data with a baseline generated for a 10-year period from 2006 and 2015. The study investigated three scenarios considering shocks to gasoline, corn, and sugar prices which are used exogenously to the baseline.

In the baseline, the world raw sugar price is 14.34 US dollars per pound, and the ethanol price is 1.27 US dollars per gallon. In the scenario with the 20% raw sugar price shock, the sugar price rises to 17.21 US dollars per pound, while the ethanol price rises to 1.35 US dollars per gallon (ABSugar, 2018). This raw sugar price shock has an impact on US and Brazilian production, consumption, exports/imports, and domestic ethanol prices. In the United States, ethanol production rises by 0.99%, consumption falls by 0.5%, net imports fall by 24.9%, and the domestic ethanol price rises by 1.82% (British Sugar, 2020b). In Brazil, however, ethanol production falls by 2.57%, consumption falls by 0.83%, exports fall by 9.99%, and the share of sugarcane in ethanol production falls by 2.57% (Amies-Cull, Briggs and Scarborough, 2019).

The study concluded that with the rise in the raw sugar price globally, the ethanol production and net exports decreases in Brazil whereas in US net imports decreases drastically. The results of the scenario represents that prices of sugar and ethanol competing with one another in Brazil (Tokgoz, 2006).

Trade off analysis was used but in Pakistan, the potential for trade-off between sugar and ethanol may be limited, as ethanol is only produced from the molasses, which is a sugar industry by-product. Pakistan has not produced ethanol from any other feedstock so far. The only use of sugar cane in Pakistan is to produce sugar from it and by-product use it for other products mainly ethanol and co-generation. Pakistan must bring the policies and infrastructure to build distillation columns to have a choice in future to produce more sugar or more ethanol according to the demand and situation. It could be interesting and profitable trade off situation in Pakistan.

In the United Kingdom, ethanol is produced from wheat or sugar beet. Wheat has no trade-off between sugar and ethanol since wheat is not the raw material to make sugar. Sugar beet provides a trade-off route, currently in UK only 5% of the sugar beet production is used in the ethanol production. It would be a trade-off if more sugar is produced from sugar beet or if all or certain land is used to produce ethanol. The trade-off will be influenced by the price of sugar in the local and global markets. Another sugar-ethanol trade-off revealed that some sugar cane can be used to produce ethanol and jaggery. Jaggery is a popular local sugar substitute that is widely produced and consumed. Jaggery is a consumer item that is not linked to the biofuel production chain, but it does represent a trade-off with sugarcane ethanol (Bilal et al. 2010). As the world's largest sugar exporter, this entailed shifting from conventional sugar production to ethanol production. The connection, as well as potential changes in business conditions or other parameters, would make the trade-off analysis more interesting and meaningful. It will aid in understanding the changing trend of ethanol production and how it can or cannot impact the sugar industry in the United Kingdom and Pakistan. Once the potential impacts of the ethanol industry on the sugar industry are known, a better understanding of mitigation measures to eliminate the impacts will be available. However, it should be noted that ethanol is the best alternative because it benefits the economy by providing direct and indirect jobs while also reducing GHG emissions. The optimal trade-off is a sugar-ethanol combination that equals the opportunity cost.

3.7. Business environment and regulation in UK

The two dominant producers of sugar in the UK are British Sugar (mostly beet) and T&L Sugars (mostly imported cane), having a market worth of around £900 million. British Sugar has situated their processing facilities at Newark Bury St Edmunds, Wissington and Cantley. Around 3,000 growers supplied British Sugar (NFCC,2019).

The current sugar industry in the United Kingdom is facing the challenge of monopolisation by the major players in the field. British sugar has long dominated the sugar industry in the United Kingdom, forcing many emerging companies to close. This means that the companies can exclude any competitors in raw material importation if they pose a significant threat (Sekhon and Rahman, 2013). Tate and Lyle are one of the sugar companies that have faced a rough time in the U.K. following the monopolization of the sugar industry, and the policies developed by the EU. British Sugar PLC has ensured that it is the only company that has access to the local market for sugar, and it mainly produces sugar from sugar beet. This means that the development of biofuel production in the nation is a direct competition with the giant company. (U.K Agriculture, 2015).

The Common Agricultural Policy governs the sugar sector in the European Union (CAP). Its primary goals are as follows: 1) to assist growers and ensure an affordable and stable food supply by improving agricultural productivity; and 2) to promote jobs in the agricultural industry and farming to help grow the rural economy. 3) To aid in addressing climate change while maintaining natural resource sustainability. 4) Maintaining landscapes and rural areas 5) To assist farmers in making a living (NFCC,2019).

Under the Renewable Transport Fuel Obligation (RTFO), transport fuel suppliers in UK should be able to give a proportion of the fuel comes from sustainable and renewable sources. Furthermore, EU Fuel Quality Directive (FQD) mandates UK to reduce the GHG emissions by 6% till 2020 from transport fuel. In the petrol industry of UK bioethanol supply is 4.5% and manufacturers of car warrant petrol engines to use 5% ethanol blend. The biofuel market in the UK has been on pressure for the initialization of “E10” biofuel blends to meet the decarbonisation targets. The industry also face strong competition from imports pushes to increase the domestic supply market (NFCC,2019). The market outlook is uncertain, and UK agricultural policies may look different from the EU policies in the future after the Brexit.

3.8. Business environment in Pakistan

In Pakistan, there are currently 89 sugar mills in operation, with owners who are mostly influential people, including politicians from both Punjab and Sindh provinces. Since decades, there have been two lobbying groups: sugar mill owners and sugarcane growers. Every year, the provincial government sets the sugarcane support prices. It has been observed that support prices have increased by 220% over the last ten years, while sugar prices have increased by 100%. This gap has had a negative impact on the sugar industry, resulting in the closure of some mills (Pakistan Sugar Mills Association Islamabad, 2019). Government has control on domestically available sugar and regulate export quotas for surplus sugar exports (Abbasi Securities,2019). The provincial governments of Pakistan regulate the sugar supply, its distribution, and prices under the Sugarcane Act 1934. As per the Sugar Factories Control Rules 1950, the Cane commissioner has given the authority to control sugar mills in terms of purchasing sugarcane and allow them to purchase from the advised areas with fix quantities. Under the Punjab Act 1958, the government of Punjab province has the authority to set the ex-mill price as well as the sale and purchase prices of sugar. The Price Control and Prevention of Profiteering and Hoarding Act of 1977 grants similar powers to the province of Khyber Pakhtunkhwa. Most of the operating units have a crushing potential of less than 6,000 TCD, which is significantly lower than the global crushing potential of 10,000 TCD. Sugar and ethanol export revenues totalled $900 million in 2017-18. (Abbasi Securities, 2019).

In terms of ethanol, Pakistan is succeeding in its molasses-based ethanol production. Due to lower domestic consumption, Pakistan exported 300 million litres of ethanol in 2018. Producing ethanol is advantageous for sugar manufacturers because no government export quotas are required (Abbassi Securities, 2019). Pakistan Ethanol Manufacturers Association (PEMA) was built in the year 2008 to promote the development of ethanol industries with high efficiency and ensure legal protection to ethanol sellers and buyers under the laws of government. The government of Pakistan has provided regulations for 5% blending of ethanol in gasoline for transport purposes in 2006. In 2009 under the government strategy Pakistan state Oil (PSO) has initiated E10 pilot project for 10% blending of ethanol into gasoline (Tariq, 2014).

3.9. The life cycles of biofuel, value chain of Food and sugar production

The information in ISO 14040 describes a lifecycle assessment as the process of gathering information relevant for the evaluation of the inputs, outputs and the expected environmental effects of a given product system throughout its lifetime and stages. All inputs and output data relating to the different stages of the product lifecycle including biofuel production, transportation, and final use are required to ascertain the appropriate lifecycle procedures. The major criteria for a biofuel lifecycle assessment is the analysis of greenhouse gas emissions, balance of energy, water usage in the production process and the impacts at every stage on food and sugar production (Gnansounou, 2009). The following figure 3.6 shows the various phases during a lifecycle assessment process.

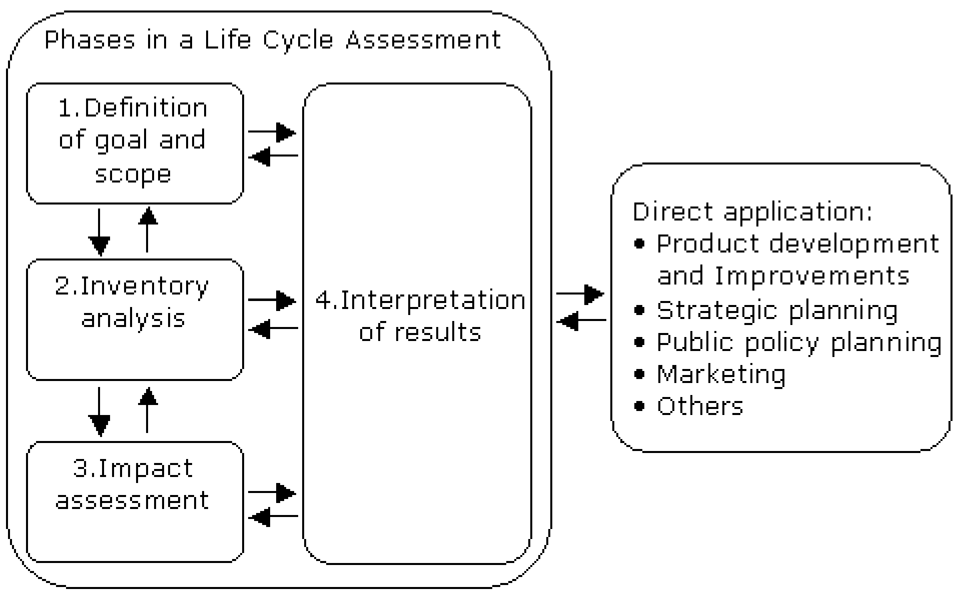


Figure 3.6: Life cycle assessment process (Wenzel, Hauschild and Alting, 2001)

According to the World Watch Institute (2007), most biofuel lifecycle assessments have been found to be ineffective because they fail to recognise certain critical aspects. For example, they rarely consider the other indirect effects of the biofuel industry on the environment. Clearing of vegetation, which results in greenhouse gas emissions before the feedstock is grown, is frequently overlooked. Most of these lifecycle assessments do not consider the effects of converting an entire forest into a palm oil plantation (Worldwatch Institute 2007).

Life cycle analysis of the effects of biofuel production on the environment as well as its consumption has shown that there is a huge variance, which results from the net reduction in greenhouse gas emissions and a consequent net increase in the risks of unanticipated negative effects on the environment. Although beneficial in reducing GHG emissions, there is the possibility of large amounts of nitrous oxide being generated this originates from nitrogen fertilizers and is produced by processes of nitrification and denitrification. The amounts generated do not depend on the amounts of nitrogen fertilizer used but also on soil characteristics and climate conditions, so there can be a very wide range of values for emission factors. It should be noted that when land with a soil such as peat that stores large amounts of organic carbon is developed and cultivated, the carbon accumulated in the soil is released into the atmosphere as carbon dioxide.

This will be determined by the type of raw materials used and the manufacturing methods used in the process. The life cycle assessment also presents several challenges. The process necessitates a wide range of information. Second, it always employs a sophisticated method of combining various quantities, necessitating extensive explanation and interpretation of results. During the examination process, a life cycle assessment study may also combine inputs that are very different from one another (Davis, 2008).

A review of the life cycles of biofuel, value chain of food and sugar production will therefore enable a country such as United Kingdom to identify the critical sustainable factors affecting food and sugar production and further determine whether there is a potential conflict between bio-fuel and value chain of food in developing countries such as Pakistan; Pakistan is a major producer of ethanol hence placing it at a risk of the effects of biofuel production on sugar production in the country. A clear lifecycle system also indicates the conflicts that exist between food and fuel thus helping the country to establish whether there are effects of biofuel production on their food & sugar industry.

3.10. How the life cycle works

Life cycle assessment has been extensively used in the field of biofuels to compare it to its fossil fuel counterparts by evaluating their environmental performance. The government employs GHG calculators. Annex V part C of the Renewable Energy Directive (2009/28/EC), for example, contains the rules for calculating the actual value of greenhouse gas (GHG) emissions. Total GHG emissions from (bio)fuel use to compare environmental aspects of biofuels and fossil fuels to make biofuel policies using the LCA approach. Second, LCA is used to assess biofuel environmental aspects without comparing them to fossil fuels. This method aids in the generation of data on new raw materials and manufacturing technologies. Third, LCA is used to evaluate significant hotspots in the entire chain process, which is relevant not only to biofuel policies but also to biofuel production companies. LCA can also be used to conduct another analysis that determines the contributions of various emissions (Voet, 2010).

The increase in biofuel production will require farmers to significantly increase the production levels of biofuel crops like sugar beet, wheat, and maize for the case of the UK, which could eventually translate to decline in supply of the latter for feeding the nation's population. Following this statement, it is prudent to note that the UK biofuel industry poses no direct threat to the nation's sugar and crop production. Sugar beet shortages as a raw material for the nation's sugar industry could occur because of competition from the biofuel industry. At the same time, increased competition to produce sugar beet for the two industries may result in a reduction in supply. This would have a direct impact on the sugar industry and sugar-based industries in the United Kingdom. Plants that play an important role in feeding the population will eventually become scarce.

In the case where the local demand for sugar increases, the government is forced to import sugar to cater for the local deficit created by the biofuel production. If the total cost of importing sugar is higher than the cost of producing sugar beet locally, the result is increase in the prices of commodities manufactured from sugarcane and sugar beet as well as other food crops whose production at farming level is affected by the biofuel industry. Given this scenario, people's disposable income would decrease due to increase in prices (Olsson, 2007). With biofuel production, it means that more land will be allocated for biofuel production. Forests may be cleared to give room for the plantation of biofuel crops. Therefore, there should be policies to ensure a sustainable balance of the biofuel production in all countries more so developing countries like Brazil and Pakistan.

3.11. Lifecycle of Ethanol manufactured from Sugar beets

In a study conducted by Foteinis et al., (2011) life cycle inventory (LCI) and impact analysis are used. The primary goal of this research was to investigate converting existing sugar units in Northern Greece into modern ethanol units. This is accomplished by investigating the environmental impact of existing sugar beet cultivation on long-term sustainability. SimaPro7.14 tool was used for designing ethanol production model. The results show that transforming old sugar plants into bioethanol plants will reduce the environmental risk by 32.6%.

Furthermore, LCA is used for comparing ethanol production to gasoline and biodiesel. The analysis shows that ethanol has highest environmental effect of 62.1% but the co-product (corn ethanol plants produce distillers' grains and soluble. Soybean crushing plants produce soy meal and soy oil) reduced it by 17.1%. This concluded that existing sugar plants conversion to bioethanol is environmentally feasible. Moreover, the prices of gasoline and depletion of fossil fuel presents bioethanol as an environment friendly alternative fuel (Foteinis2011).

Munoz et al. (2013) has conducted another life cycle analysis for ethanol production from sugar beet and wheat in France, maize grain in USA and sugarcane in Brazil. The main aim of this study is to evaluate the environmental impacts and explore difference between feedstocks. The ethanol from sugar beet shows the lowest GHG emissions from cradle to gate and wheat shows highest. It also considers land use change and with PAS 2050 tool assessed GHG emissions, by which ethanol from sugarcane shows the highest GHG emissions (Muñoz,2013).

3.12. Lifecycle of Ethanol manufactured from Sugarcane

Gopal and Kammen (2009) established a modified version of California's GREET (Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation) model for ethanol in Brazil. It calculates greenhouse gas emissions from the entire process of producing ethanol from fresh sugarcane juice and molasses. The study found that production of ethanol by using molasses has as a lifecycle GHG value of 15.1g CO_2-equivalent MJ^{-1}, It is much lower than the existing California-GREET value of 26.6 1g CO_2-equivalent MJ^{-1}. Their model is feasible for an individual factory as well as for a wide industry (Gopal and Kammen, 2009).

Roberto et al. in (2009) investigates the life cycle assessment of fuel ethanol from sugarcane in Brazil. The method used in the LCA is the Environmental design of Industrial Products. The life cycle impact analysis includes emissions from global warming, acidification, ozone formation, nutrient enrichment, and human toxicity. Results shows that fuel ethanol from sugarcane negatively contributes to these impact categories (Roberto,2009).

3.13. Knowledge Gap Table

The knowledge gap table contains information that highlights research gaps in the current Literature of Pakistani and UK sugar/ethanol production. Table 3.4 depicts some analysis work that has been completed and that must be completed in the future for the Pakistan and UK sugar and ethanol industries.

Table 3.4 Research gap in existing Literature

No.	Subject	Research work done	Weaknesses of the study	Research work needs to be done
1.	Life cycle assessment on ethanol from sugarcane	This study(Ghani, 2018) exhibits a life cycle assessment for sugarcane industry by-products use in Pakistan. It investigates their substantial impact on the environment of the biorefinery unit.	This study does not consider the effect of land use change for sugarcane production. It also lacks the investigation on long-term sustainability of biorefinery in Pakistan	A detailed analysis is required for the sustainability and availability of ethanol in Pakistan. Further analysis also needs for its implementation on land use change.
2.	Life cycle assessment on ethanol from sugar beet	The lifecycle emissions of bio-ethanol (sugarcane, sugar beet, corn) was undertaken using hybrid LCA methodology(Acquaye, 2012)	This study did not investigate the impact of life-cycle emission savings from ethanol on the production potential of sugar beet, sugarcane, and corn.	Life cycle assessment is required to find out the impact of ethanol on the production of sugar beet in UK which eventually affects the sugar industry.
3.	Techno-economic analysis of ethanol in Pakistan	The social, economic and environmental aspects were considered and analysed for the bioethanol production in Pakistan(Arshad, 2019).	The economic analysis in this study did not evaluate pre-treatment cost and recovery cost of ethanol.	A techno-economic analysis is required for ethanol production from sugarcane in Pakistan considering pre-treatment costs and ethanol recovery cost.
4.	Techno-economic analysis of ethanol in UK	Techno-economic analysis was performed for bioethanol production from wheat straw of UK considering five pre-treatment technologies (Littlewood, 2013).	The analysis in this study fails to compare the prices of wheat straw to other feedstocks for ethanol production in UK.	Research is required for techno-economic analysis for bioethanol obtained from UK sugar beet.

5.	Engine performance by blending of ethanol in other fuels	In this paper it has been proved experimentally that the use of Jatropha biodiesel along with bioethanol allow to operate diesel engines (Bannikov, 2016).	This study did not investigate the blending of ethanol in engines separately.	Experimental analysis is required to investigate the engine performance by blending of ethanol in engines with other fuels.
6.	Impact of ethanol on sugarcane production	This research focused on the impact of low sugarcane yield on the sugar industry of Pakistan (Zaidi, 2013).	This research did not focus on the demand of sugar in Pakistan and demand of ethanol in the world.	Research is required to find the impact of ethanol on sugarcane production if the demand of ethanol exceeds in Pakistan.
7.	Technological processes	This research utilizes GTAP model to forecast the effects of policies of biofuels in national and global markets on food prices and agriculture markets in Pakistan (Ali, 2013).	This research did not include production technologies of biofuels and its impact on food prices and agriculture industry.	For implementing full-scale biofuel/ethanol program detailed Literature is required on different production technologies for ethanol
8.	Sugar production from sugar beet	This (Tzilivakis, Lewis, May, Warner, 2005) research evaluated the economic and environmental aspects of production systems for sugar beet in UK.	The analysis in this research did not focus on the impacts of sugar beet production systems on sugar industry of UK.	A broader study is required to assess the sugar production, processing, transportation, and consumption for finding sustainable solutions.
9.	Comparison of sugarcane and sugar beet	An analysis of the input energy and greenhouse gas emissions in sugar beet production is done in the UK (Tzilivakis, Lewis, May, Warner, 2005)	The GHG emissions from sugar beet production in UK did not compare with GHG emissions from sugarcane production.	A comparative study is required to assess the greenhouse gas emissions by the production of sugar from sugarcane and sugar beet.

10.	Sustainability of ethanol market	The study identifies and analyses the variables of feedstock availability and sustainability and their interactions with bio ethanol market(Bhutto, 2015).	For the sustainability of ethanol market this study did not consider socio-political, environmental, and legal aspects.	A PESTLE (political, economic, social, technological, legal, and environmental) analysis is required for the sustainability of ethanol market in Pakistan.

3.14. Research Gaps

The preceding studies conducted extensive research on a variety of issues, including the life cycle of ethanol from sugar cane and the life cycle of ethanol from sugar beet, but this study lacked information on the impact of land use change on sugar cane production. The life cycle of ethanol from sugar beet bioethanol life cycle emissions (sugarcane, sugar beet, maize) were calculated using the hybrid LCA methodology, but the life cycle savings from ethanol emissions on the production potential of sugar cane, sugar beet, and maize were not included in the Literature. An economic analysis was also conducted, but it failed to evaluate the cost of ethanol pre-treatment and recovery. The ethanol blending level in engines was not addressed; research on the impact of ethanol on sugarcane production focused on the sugar industry's low sugar cane yield but lacked research on the demand for sugar and ethanol. Ali's study on technological processes employs the GTAP model to forecast the effects of biofuel policies in national and global markets on food prices and agriculture markets in Pakistan, but it fails to account for the impacts on food prices and agriculture industry. Sugar beet production evaluated the economic and environmental aspects of the sugar beet production system but did not focus on the effects of sugar beet on the sugar industry. In UK studies, GHG emissions from sugar beet production were not compared to GHG emissions from sugarcane production. The research study on the sustainability of ethanol market identifies and analyses the variables of feedstock availability and sustainability, as well as their interactions with the bio ethanol market, but it does not consider socio-political, environmental, or legal aspects.

The research analysed and revealed some clear gaps in the general perception, application, and knowledge (strengths or success and weakness or setbacks). The research gaps were summarised as follows:

a) Sugar – ethanol link explored in the existing Literature but not the reverse link or the trade-off.
    a. potential for expansion of ethanol production in Pakistan not explored adequately and possible effects on sugar industry not well understood.
    b. ethanol route as a possible option for sugar industry viability not explored explicitly.
b) Decrease on sugar demand but potential growth in ethanol market has not been explored –
c) Comparative analysis and potential from learning not exploited sufficiently

3.15. Justification of the need for this Research

The above-mentioned Literature review confirms that the research work conducted evaluated the factors and drivers that affect ethanol production from either sugarcane or sugar beet. Since no research has been conducted to identify the factors that influence both the sugar industry and the production of ethanol. In the case of Pakistan, the Literature declares ethanol to be a beneficial product for sugar manufacturers, but no detailed analysis on techno-economic aspects with quantitative results has been performed. Furthermore, the PESTLE analysis did not consider all six factors.

In case of UK, PESTLE analysis has not been done considering all six factors, therefore it will be opportunity to conduct pestle analysis and TEA techno-economic analysis. Furthermore, long term sustainability of bioethanol has not been explored for both Pakistan and UK based on sugar and ethanol demands in global markets. This research will fill these research gaps by different qualitative and quantitative assessment techniques and determine the relationship between sugar and ethanol, factors affecting sugar industry, how and if ethanol can have impact on sugar sector in UK and Pakistan, how both can be trade off and be sustainable.

According to the SWOT analysis, many factors influence sugar production in Pakistan, including low technology, low yield crop, pricing issues, yield loss due to transportation, political interference, unfavourable policies, and less sugar cane availability for sugar production. In the case of the United Kingdom, it was stated that monopoly, less sugar beet growing area, less sugar beet available to meet local demand, competition with other crops, and health concerns are the main factors affecting sugar production in the United Kingdom. SWOT analysis was extremely useful in determining each country's strengths, weaknesses, opportunities, and threats to provide an appropriate solution. Primary data collection was also critical because it is based on face-to-face interviews.

The PESTLE analysis revealed the primary factors influencing the sugar and ethanol markets. improper policy in Pakistan, export delays, farmer income not protected by policy, in addition, concentrate in two ways. Internal factors address the UK and Pakistan's strengths and weaknesses in sugar production and include internal factors such as the local business environment, support policies, and other internal mechanisms. External factors, on the other hand, address the opportunities and threats to the UK and Pakistan's sugar production capacities. External strategies capitalise on opportunities while addressing emerging threats to the UK and Pakistan's sugar production capabilities.

3.16. Conclusion

This chapter's Literature review concludes that existing studies have primarily focused on the food-fuel relationship. Sugar is a popular food in both Pakistan and the United Kingdom. Pakistan has more sugar mills with integrated ethanol distilleries than the United Kingdom, which has two sugar mills with lower ethanol production potential than Pakistan. Various studies have presented sugar production from sugarcane and sugar beet, as well as factors influencing yield, and then ethanol production from these two feedstocks. Sugar prices and production impacts on ethanol production, consumption, import/export and prices have been analysed. Environmental concerns are a major factor in the production of ethanol from various feedstocks, according to life cycle assessment studies. In the future, environmental and health concerns will be prioritised in the production of ethanol from sugary crops. Research gaps identified areas of research that should be prioritised in the sugar and ethanol sectors in the future. Several impacts must be investigated in terms of ethanol production potential, socioeconomic and environmental perspectives for the sustainability and availability of the ethanol industry in both Pakistan and the United Kingdom.

Chapter 4: Methodology

4.1. Introduction

This section of the research study provides a detailed review of the methodology used to collect relevant information and data for the study. This section will explain the researcher's methodological strategy and plan for this research, as well as justify the use of the methods chosen. Because the data collected is ordinal, qualitative, and quantitative, data analysis will use a combination of qualitative and quantitative methods. This research study considers the use of primary, secondary, and official sources. One of the most important reasons to prioritise primary sources is their authenticity and dependability. Secondary sources will include reputable journals, company websites, and books. Furthermore, official data will be used, which will be obtained directly from Government of Pakistan and UK offices, making the data more reliable and authentic. This chapter also presents the ethical aspects that had been considered in this research while gathering data and information. The basic aim of this study is to address the issue of the relationship between sugar and ethanol industry and how the ethanol industry can impact the sugar industry of Pakistan and the UK currently or in future. The investigation is related to the field of sustainability and is extremely important for researchers, academicians, and managers of various departments in the sugar and ethanol industry, as it reveals a vital impact of developed and developing countries.

4.2. Research Methodology

The research methodology is determined by the topic being studied and the nature of the research. According to the Literature, the research design used is either quantitative or qualitative, or a combination of both (Kothari, 2004). A qualitative approach is effective if the research goal is to explain the situation by relying on the stakeholder's experience in the given condition. It aids researchers in understanding the relationship between various variables (Creswell, 2003). The qualitative research method is used to obtain descriptive responses and to give respondents complete freedom to express their opinions on the questions (Newman and Benz, 1998). Quantitative research is required in research because it uses graphs and numbers to test assumptions and theories, as well as to determine whether the evidence supports the hypothesis in the research. It expanded on the facts and circumstances surrounding the research topic. It is also defined as an organised investigation, like qualitative investigation, of a situation by gathering quantitative data and performing mathematical, economic, financial, and statistical techniques. It gathers information from people in the relevant research area to forecast the future outcome of services and products and how to make changes accordingly.

This study will employ both qualitative and quantitative methods. The following research questions guided the study:

i) What are the factors affecting sugar production in the United Kingdom and Pakistan respectively?

ii) What are the possible impacts of the ethanol production on the sugar industry in the UK and Pakistan? And how changed level of ethanol production will have or will not have any impact on the sugar industry in the United Kingdom and Pakistan?

iii) What are the available mitigation alternatives to reduce or eliminate the impact of Ethanol industry on the sugar industry in the UK and Pakistan and how Ethanol production and sugar production can be made sustainable and viable?

The quantitative approach is an effective method of analysis in this research, as financial analysis will be performed to understand the complex financial situation and modelling (Kothari, 2004). This methodological approach was effective in investigating the relationship between the sugar industry and the ethanol industry in the United Kingdom and Pakistan, how ethanol can have an impact, and how ethanol production levels can change. Interviews were used in this study. The survey questions were designed to be open-ended, allowing respondents to express themselves freely. The preceding explanatory research seeks to develop an authentic and dependable research methodology based on appropriate input sources from the ethanol and sugar industries in the United Kingdom and Pakistan. That is, the main reason this design is preferred is that it minimises bias while increasing reliability (Prasara and Gheewala, 2019).

The research framework is a tool used in the research to answer the research questions. Finally, the qualitative and quantitative research methods were considered as the methodology for this research because the qualitative approach builds the methodological understandings required for the interviewers and the quantitative approach is used to perform the statistical/mathematical calculations.

4.3. Primary and secondary data collection

Primary data was gathered by conducting personal interviews and contacting people on various social media platforms related to the sugar and ethanol industries to inquire about data that is relevant to the study and can provide an edge to the research. Interviews were conducted on various social media platforms with mutual consent. Secondary data was obtained from government websites, and they were contacted personally via email if any data was missing online or for clarifications. These data were required test the theory and examine the effects of ethanol production on the sugar industry, the factors affecting the sugar industry, and how to eliminate the impacts. The methodology used to analyse the data and factors is explained below for each question.

4.4. Methodology approaches for the individual Questions

Methodology for Question 1: Analysing Factors affecting sugar production in the United Kingdom and Pakistan, respectively.

SWOT, demand and supply, PESTLE, and Thematic analysis will be used to answer the question of factors affecting sugar production in Pakistan and the United Kingdom. SWOT analysis can help you learn more about the sugar industry in Pakistan and the United Kingdom by examining the industry's strengths, weaknesses, opportunities, and threats (Abas et al., 2017). Secondary and primary data will be used to extract the strength, weakness, opportunities and threats related to sugar industry in Pakistan and UK. SWOT analysis will lay the groundwork for a thorough answer to the question. It will highlight the benefits and drawbacks of the sugar industry in Pakistan and the United Kingdom: this will aid in understanding the overall factors affecting the sugar industry in Pakistan and the United Kingdom.

The demand supply analysis is concerned with the product demand/service, as well as the maximum production and supply capacities. Gaps in market requirements are highlighted to facilitate the fulfilment of goods and services. This analysis is based on the laws of demand and supply. According to the law of demand, the demand for goods is inversely related to the price.

According to the law of supply, the supply of goods is directly related to their price. Therefore, demand and supply analysis will be applied to predict the future forecast for sugar production by assuming if sugar demand is increased in future and if ethanol production or demand of ethanol to increases. The assumption is that if there is an increase in sugar demand and ethanol production or demand, how much will it impact the sugar industry in the future and how to eliminate the impacts on sugar production in Pakistan and the United Kingdom. Secondary data will be used to analyse demand and supply.

PESTLE analysis (formerly known as PEST analysis) is a tool used to analyse various factors that may have a significant impact on any organisation, such as political, economic, social, technological, legal, and environmental. Pestle analysis is a tool for evaluating external factors affecting businesses, in this case the sugar industry in the United Kingdom and Pakistan. Pestle analysis can be simplified in three steps: Data collection, deciding which factors to discuss and analysis. For the data collection: Primary data has been collected using semi-structured interviews and secondary data has been obtained from the Government officials in Pakistan and the UK. These will be used for the analysis. To analyse the impact based on each dimension, all Six Dimensions of Drivers (PESTLE) will be used. Through secondary sources, PESTLE analysis will assess both internal and external factors affecting Pakistan and UK sugar production. The output of the SWOT analysis and demand supply analysis aided in the generation of the pestle analysis.

Since secondary source analysis is always limited and does not always provide the true picture or desired result, thematic analysis was chosen. Thematic analysis was used, as suggested by Braun and Clarke (2006), to investigate how stakeholders in the sugar and ethanol industries perceive ethanol and whether it has an impact on the sugar industry. For this research, the familiarization with the interviews data was done by reading vigorously, then coding was done to take out the main phrases, codes with pattern identification and themes were generated, then re- review was conducted, defining of themes to understand the data with regards to sugar data, and finally analyzation of the data was done. Semi-structured interviews were conducted with sugar industry stakeholders in various positions to confirm the results of the SWOT, demand and supply analysis, and pestle analysis. Thematic analysis will validate the results, allowing us to finally understand the factors affecting the sugar industry in Pakistan and the United Kingdom.

Methodology for Question 2: Analysis of Possible Impacts of Ethanol Production on the Sugar Industries of UK and Pakistan

Thematic analysis is a qualitative data method that was used again for this question because themes, patterns, and coding were identified in the previous question, but this time thematic analysis was done to understand if ethanol production has any impacts on the sugar industry in Pakistan and the United Kingdom through primary sources (Creswell, 2003). This approach and method are a good way to understand people's perspectives and opinions on whether the ethanol industry is waging a trade war or having an impact on sugar production in Pakistan and the United Kingdom. Thematic analysis will have informed the possible factor of ethanol impacting the sugar industry and have informed about the trade-off. Trade off analysis is a decision based on the situation that involves in losing one product for another in return for having one product. In simple meaning where one thing is produced more, and another is decreasing. Its purpose is to find best suitable alternative options. Secondary sources will be used in trade off analysis and aim is to identify the trade-offs between sugar and ethanol and what other valuable products can be produced. It will help stakeholders to understand what the available alternate product to sugar production and what value it is can bring to the industry and economy.

Thematic analysis through primary research will inform the results of the possible impacts of ethanol production on the sugar industry. Trade off analysis informed what other valuable products can be produced (Goldemberg, J., 2010). SWOT analysis will be done to understand the ethanol markets Strength, weakness, opportunities and threats. The SWOT analysis will help to understand the value of ethanol. To understand if Ethanol is financially feasible in countries like Pakistan and UK. Life cycle costing such as Techno economic analysis will be conducted on the data which will be gathered through primary sources mainly.

Techno-Economic Assessment (TEA) is a framework for determining the technical and economic capabilities of a product or service (Kishita, Mizuno, and Umeda, 2016). Process modelling, engineering designs, and economic evaluations are all used in TEA. Techno-economic analysis is critical for determining the economic viability of sugar production. Techno-economic analysis (TEA) could aid in determining the economic viability of ethanol production in both the United Kingdom and Pakistan. The Techno-Economical analysis will assist in determining how profitable the ethanol industry is and whether it has an impact on the sugar industry or helps the sugar industry and governments generate good income, save millions in foreign reserves, and reduce greenhouse gas emissions.

Once the credibility of ethanol was established through Technoeconomic analysis, all other analyses were articulated with each other to understand and develop an answer to this specific question about the potential ethanol impacts on the sugar industry in Pakistan and the United Kingdom. It is also necessary to comprehend the potential future outcome. Each study must look at a variety of factors to predict possible future outcomes. As a result, future scenario analysis was chosen, with primary and secondary sources used. Future scenario analysis is an examination of potential future outcomes. It is carried out to analyse potential future events by considering possible outcomes: scenarios, and to present various options for future development. Future scenario analysis will be used to address long-term challenges confronting sugarcane farmers, the sugar and ethanol industries in Pakistan and the United Kingdom. Future scenario analysis will identify key issues and questions, brainstorm factors that can affect, outline internal and external factors that will impact the sugar and ethanol industries in Pakistan and the United Kingdom, forecast uncertainties, and explain the scenarios for each chosen scenario.

Methodology for Question 3: Mitigation measures to manage the potential impacts and suggestions

This would follow from the analysis and would attempt to identify potential measures to ensure the sugar industry's resilience. The activities associated with ethanol and their potential impact on sugar will be described, as will the measures that could be taken to eliminate or reduce the impact of ethanol on the sugar industry. Two separate tables will be created: one for the United Kingdom and one for Pakistan, and comparative analysis will be performed to present the results.

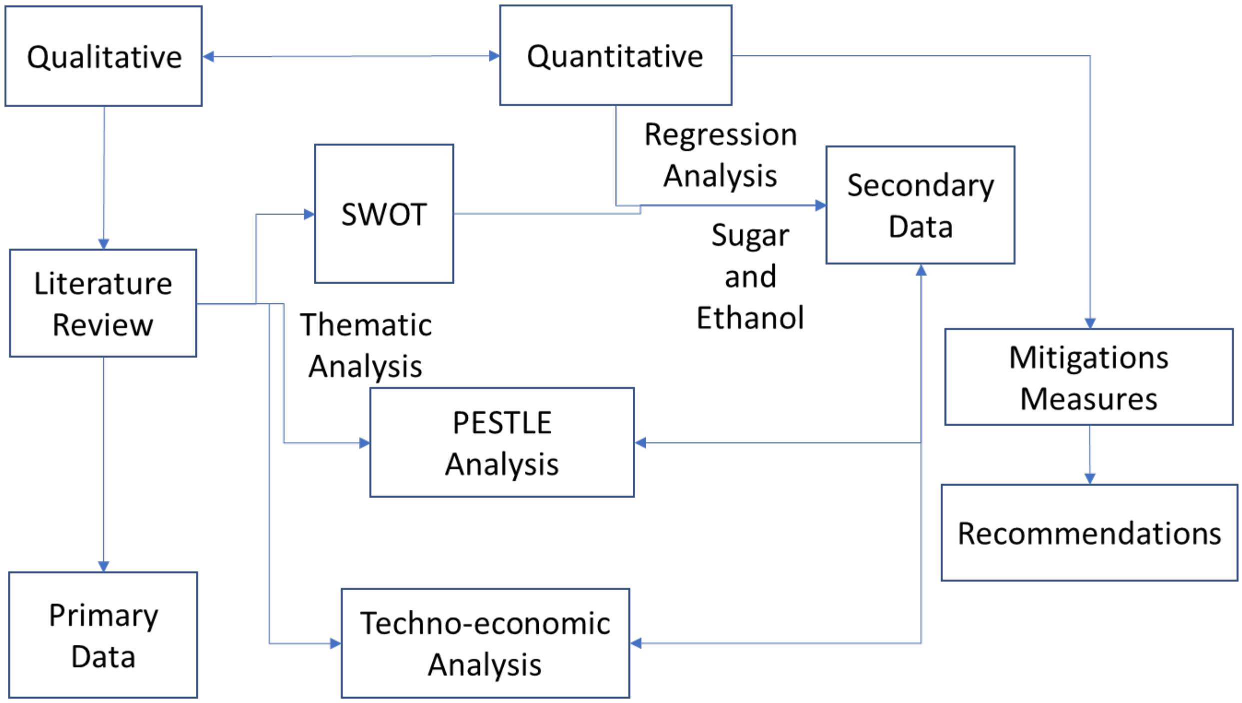


Figure 4.1 Study framework

4.5. Data Collection Method

The Literature suggests that data collection methods are based on primary and secondary collection methods (Harell and Bradley, 2009). Most researchers believe that a combination of secondary and primary methods is best for gathering relevant data for the study. The researcher used both data collection methods in this study. To obtain raw data from respondents, primary sources are used. Secondary sources are used in the research's Literature review, which is based on previous studies on the topic. Therefore, the data used in this methodological section are drawn from various classes of stakeholders. This includes stakeholders such as sugarcane farm owners, sugar producers, and ethanol producers**.** This study established methodological partnering with farmers, ethanol and sugar factories based in the UK and Pakistan for this research project. Sugar cane farmers were approached through personal contacts in the various regions of Pakistan and many sugar mill managers directed me to their sugar cane farmers, who supply them with sugar cane. Other private farm owners were given the opportunity to verify the inputs drawn from them and other players in the sugar industry to avoid receiving biased opinions and contributions. These farmers were approached through personal referrals, contacts, and by utilising other farmers' contacts, as well as using the Facebook group Pakistan agriculture forum to reach out to a larger number of sugar cane farmers to collect data and connect with sugar and ethanol distillery personnel.

4.5.1. Primary Data

Primary data is also known as "raw" or "original" data as it is used for the first time in the research (Johnson and Turner, 2004). Focus groups, face-to-face interviews, discussions, and open-ended questions are examples of primary data sources used in research studies. In this research study, the researcher concentrated on collecting primary data through open-ended questions on a semi-structured questionnaire and then critically discussing the results considering the Literature review. To develop a comparative analysis, interviews were conducted with sugar mills in Pakistan and sugar producers in the United Kingdom. Furthermore, semi-structured questionnaires were distributed to experienced professionals from both countries involved in sugar and ethanol production. The primary goal of conducting interviews is to evaluate and compare the responses of individuals associated with the sugar industry and ethanol production in Pakistan and the United Kingdom. The following procedures are used to collect primary data:

“In May, November 2019, and May, November 2020, data on farm owners were collected from the sugarcane farming field via face-to-face and telephonic conversations. After the ethics committee granted permission, a total of 250 participants from Punjab areas such as Sargodha, Mailsi, Jhang, Faislabad, Rahim yar khan, Multan, and Sindh areas such as Badin, Thatta, and others in Pakistan and the National Farmers Union in the United Kingdom participated in September 2018. The interviews with the workers were conducted to vet the inputs provided by other stakeholders to improve the survey results' verification, validity, authenticity, and reliability. Face-to-face interviews with farm owners and sugar cane mill owners, on the other hand, were conducted, while those farmer owners and sugar cane mill owners were interviewed by senior staff representing them. The senior management of the sugarcane farms is a collaborator in the data collection processes for this study. Finally, data were collected in this group of interviewers through the staff of the sugar factory because contacts with most farm owners and factory owners were established through the factory employees. This means that the face-to-face interviews were successful in establishing contacts with sugar factory owners, casual farm workers, and other senior management personnel”.

4.5.2. Secondary Data

Secondary data can also be referred to as "used" or "existing" data (Johnson and Turner, 2003). Because the data obtained through secondary sources has already been used in previous studies by scholars. Secondary data was required to employ the analytical framework, which identified the key drivers of sugarcane production in Pakistan and the United Kingdom. Secondary data is regarded as having a lower level of authenticity and reliability than primary data. However, for this study, researchers used secondary sources such as published articles, peer-reviewed journals, and registered financial websites in the United Kingdom (Sugar industry) to present a critical review of the Literature. The comparison of primary and secondary is shown in table 4.1, and the framework for the analysis is shown in figure 4.2.

Table 4.1: Comparison between primary and secondary data, Source: (Creswell, 2003)

Primary data	**Secondary data**
• Focus groups, face-to-face interviews, discussions, and open-ended questions are examples of primary data sources used in research studies. • It can be explaining the SWOT analysis's strength and weakness factors.	• The data is gathered from previous data and used to forecast the future using demand and supply analysis.

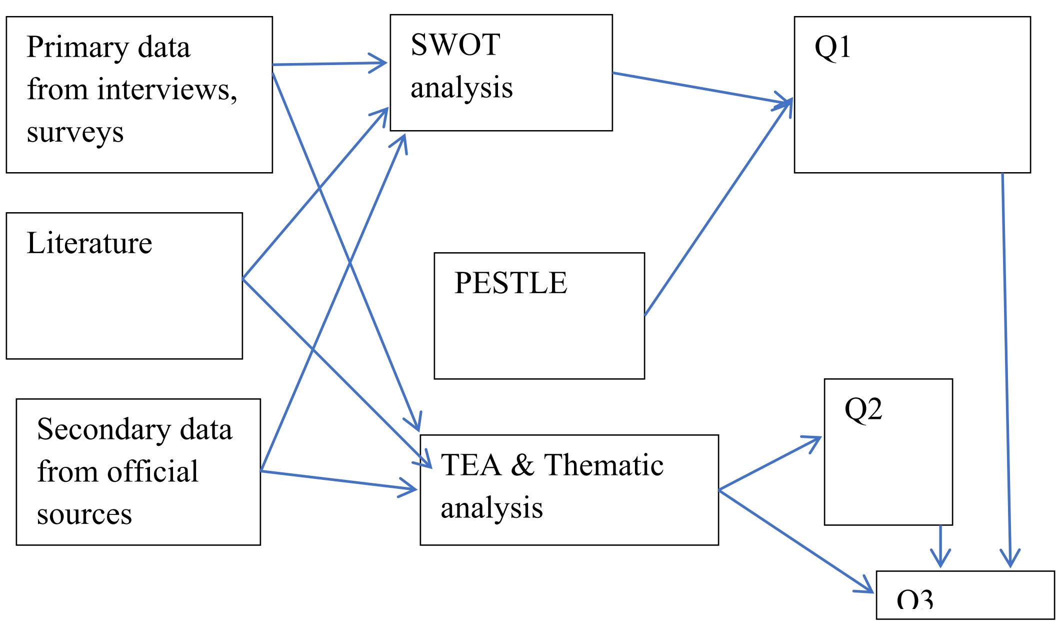


Figure 4.2 Methodological Framework

4.5.3. Official Data

Government official data is a type of official data. It can also be considered secondary data, but to distinguish it from secondary data, it is mentioned separately here. This source's data is derived solely from the Ministries of Business, Energy, and Government departments. The authenticity and dependability of official data are regarded as extremely competitive. Based on the official data, many assumptions and analyses can be made. Furthermore, official data will be gathered from Ministries and Government departments in the United Kingdom and Pakistan.

4.6. Research Instrument

The main research instrument for this study was the annex-1 questionnaires (both printed and distributed face-to-face and online) (Table 4.2). The research is geographically limited to the study areas.

Guide to the Interviews: The semi-structured interviews were conducted in a language that the participants could easily understand to obtain descriptive responses. It was made certain that the questions were as short as possible and that they were not phrased negatively. It was also made that indeed pertinent questions were asked first.

Table 4.2: Characteristics of the Study Participants, Source: (Creswell, 2003; Kothari, 2004)

Bases of the questionnaire	The primary goal of conducting interviews is to evaluate and compare the responses of individuals associated with the sugar industry and ethanol production in Pakistan and the United Kingdom.
Types of data	Interviews and Questionnaires.
How it used	The primary goal of data collection is to collect information in a measured and systematic manner to ensure accuracy and facilitate data analysis. It was also used in a Techno-Economical analysis to determine how profitable the ethanol industry is and whether it has an impact on the sugar industry or helps the sugar industry and governments generate good income, save millions in foreign reserves, and reduce greenhouse gas emissions.
The interview	Each interviewee took 15 minutes and asked the same questions.

Because this study recognised the importance of generating accurate information, the use of complex English language was avoided. The questionnaires are intended to be distributed personally to stakeholders in the Pakistani and UK ethanol industries, where mixed sampling methods are permitted. There were farmers in Pakistan and workers in ethanol and sugar mills who did not speak English, so interviews and discussions were conducted and completed in Urdu. The main goal was to base the research on facts rather than information from newspapers and magazines. More than 250 interviews were recorded in an excel sheet in preparation for data processing, gathering, and collation. Respondents were chosen from various sugar cane areas and through referrals. They were first contacted by phone, followed by a personal interview and discussion on the subject. Informed consent was obtained; they were informed of their rights and ethical concerns before being asked if they were willing to proceed. They provided all the information in person, and it was all recorded on the excel sheet. The collected data was converted to Excel so that it could be analysed. Further interviews and friendly discussions with sugar cane growers, sugar mill and ethanol distillery managers and personnel confirmed the data once more.

4.7. Validity

Validity is a test that determines the accuracy of any result or outcome obtained from samples. Validity refers to repeating a check or test on a group of people to determine the authenticity of the outcome or results obtained. The questionnaires were thoroughly investigated, with details confirmed with other stakeholders and compared to data published by the Pakistan Sugar Mills Association, AMIS, and Ministry of Agriculture.

4.8. The Respondents Profile

This section discusses the respondents' profiles compiled for this study. Respondents were those who had been involved in sugar/ethanol production in the UK and Pakistan for more than two years. The respondents' profile is a graphical representation of genuine survey participants (Tomei, 2015). Table 4.3 depicts the study participants' characteristics.

Table 4.3: Characteristics of the Study Participants, Source: Author

	Pakistan	United Kingdom
Farmers	250 Sugar cane farmers	1 (National farmer Union)
Ethanol Producers	14 (Total 18)	3 (Total 3)
Sugar Producers	47 (Total 84)	2 (Total 2 mainly)

According to Table 4.3, there were 250 sugar cane farmers respondents from the Punjab and Sindh selected sugar cane region in Pakistan, while in UK, National farmers union provided the information on behalf of the farmers. Fourteen ethanol mills responded in Pakistan, while three ethanol producers responded in the UK. Total forty-seven sugar mills participated in Pakistan and total two sugar producers participated in the UK. All the participants were from the sugar cane & sugar beet industry, ethanol industry and sugar industry of Pakistan and UK. The response rate and sample size of the interview was good enough to carry further analysis. The initial data of the sugar cane farmers, sugar beet farmers, ethanol producers and sugar producers in UK and Pakistan was collected in 2019.

4.9. Targeted Population/ Sampling Criteria

The study's target population included all users and stakeholders in sugar and ethanol production in the United Kingdom and Pakistan. They are primarily the consumers who supported the production of sugar and the use of ethanol as an alternative energy source in the United Kingdom and Pakistan. Because this study focuses on the impact of ethanol production on the sugar industry through a comparative analysis of the UK and Pakistan, sugar industries in both countries were targeted to collect primary data. Furthermore, the ethanol production departments of both companies were targeted, as were employees with extensive experience in these production departments. Each company's production manager was interviewed and was either in front of the managing director or any of the CEO to obtain relevant information from each factory. Interview IDs was assigned and mentioned in the annex 11-23. Interviews were conducted with the following UK and Pakistani companies:

- The UK based Ethanol Industries: UKEthanol
- The UK based Sugar Industry: UKSugar
- Pakistan Sugar Mills: PKSugar
- Pakistan Ethanol Distilleries: PKEthanol
- PEMA - Pakistan Ethanol Manufacturers Association: PEMA1
- PSMA- Pakistan Sugar mills association: PSMA1
- NFU- National farmers union the UK: UKFarmer1
- Farmers of Pakistan: PKFarmer

4.10. Problems and Challenges

The global sugar and ethanol industries are highly politicised. The sugar and ethanol industries in Pakistan and the United Kingdom were also highly politicised and monopolised. It was extremely difficult to approach the sugar and ethanol industries in both countries. It took three times as long as normal data collection. Because the sugar and ethanol industries are highly politicised and monopolised around the world, it was difficult to approach them and obtain data without risking information being leaked for tax purposes. Even when the data was rough, it was necessary to re-connect to interview different people from the same mills to gain insight. In addition to the foregoing, I was denied a UK tier 4 visa in November 2015, which resulted in a 10-year UK ban. I decided to appeal the decision, and it was overturned in September 2018 via Judicial Review, allowing me to finally come to the UK to conduct my research, meet my supervisors and colleagues, and discuss the results of my research.

Another significant challenge was Covid-19, which began in November 2019 and then experienced rapid growth in the UK and Pakistan, which slowed the research process, verifications, and even trips to the UK were limited due to lock down and Pakistan being placed on the red list. Covid caused the pandemic, and health was also impacted, affecting travel and research plans.

4.11. Ethical Considerations

This study ensured that proper procedures were followed, beginning with the distribution of questionnaires, followed by the collation of questionnaires, the collation process, and the statistical preparation and analysis presentation. Notably, ethical approval was obtained in DMU prior to collecting field data. The University's ethical guidelines were strictly followed. The researcher would consider the following ethical considerations while gathering data for the research study:

1. The interviewee scheduled formal appointments to avoid disrupting their working hours.

2. Each respondent was given adequate time to answer the questions to express their ideas openly.

3. All the data attained through the interviewees were kept confidential, Consent was recorded and kept in safe records.

Chapter 5: Analysing Factors affecting sugar production in the United Kingdom and Pakistan

The purpose of this chapter is to analyse the overall factors, which are affecting sugar production in general in Pakistan and in the UK. The chapter analysed the factors affecting sugar production from the perspective of sugar cane grower, sugar beet grower and sugar producers. This chapter focused on the SWOT analysis of sugar industry, demand and supply analysis, regression, PESTLE analysis and finally thematic analysis of the semi-structured interview to see what are the factors which are affecting sugar production. This analysis will help to understand the factors affecting sugar production in Pakistan and UK.

5.1. SWOT Analysis

SWOT is Strength, Weakness, Opportunities, and Threats (Abbassi Securities,2019). Swot analysis is useful in finding the facts about the company or industry to look at the strength, weakness, opportunity and threats of a company or industry (Guevara, Silva, Hasegawa, and Venanzi, (2017). It helps companies and industries to understand the current situation before making new strategies. As a result, this study utilizes the SWOT analysis for evaluation as followed. Notably, the SWOT analysis was conducted through the Literature review considering the articles, annual reports, policies published in last 10 years for both the countries.

5.1.1. SWOT Analysis of sugar industry in Pakistan

Pakistan sugar industry is one of the top ten producers of sugar cane and sugar. It is one of the backbone industries of Pakistan economy and provides much of the employment directly and indirectly. It can be shown in figure 5.2 about the strength, weakness, opportunities and threats facing by the Pakistan sugar industry. SWOT analysis will be done on the sugar industry in Pakistan from the secondary and official sources. The data was gathered from the government sources and other online Literature, which was sorted and from which strength, weakness, opportunities and threats were defined for the sugar industry of Pakistan.

Strength: Pakistan is the major producer of sugar cane and sugar in the world. Sugar mills pay sales tax, which generates billion of rupees as revenue for the government. It also pays over 3 trillion Rupees to the sugarcane growers. It directly or indirectly employs millions of people (PSMA, 2020). It is a strong point as it contributes to income and creates job opportunities. It is also a source of energy, contributes to energy crisis of the country. Through its job creation, it helps in people standard of living. Lastly it contributes to the taxes significantly and to states economy.

It is protected by the government for the sugarcane price and for the selling of sugar to protect the sugar industry. It produces many by-products such as bagasse: which is useful for the electricity generation, Molasses: which is the raw material for the ethanol industry and feed industry and mud: which works as fertilizer for the sugar cane fields.

Weakness: Most of the sugar mills are more than 20-30 years old and are using the same old technology, while some have upgraded, and some new ones are with new technology. There is a lack of professionalism and efficiency in terms of number of people, administration of inputs and outputs and are non-cooperative in payments and negotiations. Sugar cane is a water intensive crop and requires too much of water as compared to other crops. Transportation is another weakness which can decrease the yield of sugar from the sugar cane. Due to lack of good varieties, there is low sugar yield.

Opportunities: More transparent policies for the sugar industry and sugar cane growers must be in place to protect the rights of both parties. It is also noted from the interviews through thematic analysis that all respondent of sugar cane growers unanimously agrees to setup research and development centres in every province to test new varieties for a better yield crop. There is also a need to educate the farmers about the soil and water use and to be more effective. There is a need to upgrade the technology which will result in higher sugar yield. The by-products of the sugar cane molasses are very high value products and fetch revenues for the sugar mills. There is also a need to have an integrated sugar plants to have make sugar and ethanol at same place. It is displayed in figure 5.1 where from sugar cane direct processing, sugar can be produced, and molasses will be used to make ethanol directly. Also, it gives an opportunity to make ethanol from sugar cane juice directly as well.

Threats: one of the main threats to sugar industry is that it is controlled by the strong businesspersons who are politicians and sugar industry is highly controlled by the government.

Water scarcity might push the sugar cane farmers to divert to other crops. Crop competition in terms of income can put the sugar cane behind other crops. There is a need to ensure the sugar cane crop like many western countries do, to protect if the crop is destroyed due to flooding or global warming. Lastly, there are large numbers of people who are now becoming health conscious, although there was no effect on demand, but this factor might put a threat to sugar industry in Pakistan. Figure 5.2 briefs about the strength, weakness, opportunities and threats facing by the Pakistan sugar industry.

Integrated Sugar Manufacturing Model for Pakistan

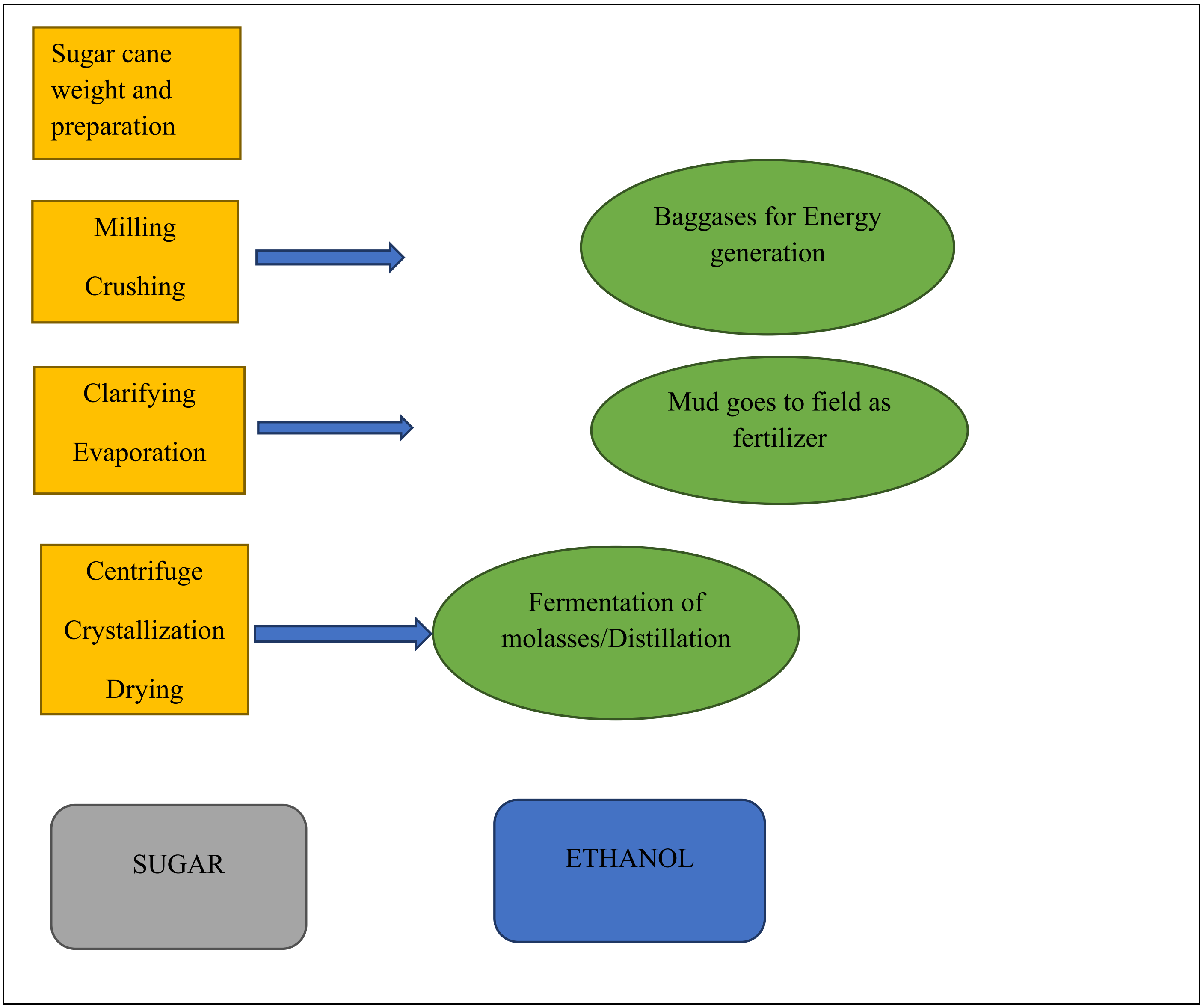


Figure 5.1 Sugar cane to sugar production or ethanol production model, Source: Author

SWOT Analysis of Sugar industry in Pakistan

Figure 5.2 SWOT Analysis of Pakistan sugar industry, Sources: (Author derived and analyzed from, Pakistan Sugar Mills Association, 2019; Ali, A., 2019; Abbassi Securities, 2019; Abas et al., 2017; Pakistan Sugar Mills Association, 2018; Bannikov., Gillani., 2016; Pakistan Bureau of Statistics, 2015)

5.1.2. SWOT Analysis of UK

UK sugar industry is one of top producer of sugar from sugar beet in the EU. UK produces half of its sugar from sugar beet and rest comes from abroad. It partners with 3000 sugar beet growers and supports up to 9500 local jobs (British sugar, 2020). Figure 5.3 indicates the strength, weakness, opportunities and threats facing by the UK sugar industry.

Strength: UK is top producer of sugar from sugar beet in the UK. It provides jobs to more than 10,000 people. It contributes to the UK tax system and have invested heavily in last few years.

Sugar beet prices are set between national farmers union and British sugar to protect sugar beet growers and British sugar. Sugar beet processing generates by-products such as pulp, leaves and molasses. Leaves are used in the fertilizer making, pulp is used for animals and molasses is used for feed and ethanol production.

Weakness: There are only 3 sugar mills, one is based on sugar beet and other two are based on raw sugar. British Sugar and American Sugar refinery have the market share of 98%. There is a huge monopoly in terms of prices and supply for sugar from sugar beet from the British sugar. UK revenue will fall as it will try to align its prices with the international market, while previously it was with the EU, where prices were higher under its sugar regime. Sugar beet area is not increasing from last decade and many people prefer to divert to other cash crops.

Opportunities: Brexit gives opportunity to American Sugar refinery to import raw sugar without heavy duties so that it can produce less expensive sugar and contribute to the demand of sugar. The abolition of European Union sugar quota will help other refinery to import cheap sugar and provide cheap white sugar. Brexit will allow more businesses to enter sugar market to produce sugar from beet or to import raw sugar and refine it locally. Molasses from the sugar mill can be used to make ethanol either in the sugar mill or can be sold to ethanol producers. Similar model as shown in figure 5.1 can be adopted where sugar beet to use to make sugar and by product molasses to make ethanol on site.

Threats: Demand of sugar to weaken due to health-conscious people to reduce their intake on sugary drinks and food. Crop competition can put sugar beet behind other crops, which generates more income.

Swot Analysis of sugar industry in UK

Figure 5.3 SWOT Analysis of Pakistan sugar industry, Sources: (Author derived and analyzed from, British Sugar, 2020; Ceres, 2017; Duraisam., Salelgn, and Berekete, 2017); Chillrud, 2016; Roberts, M., 2016)

5.1.3. Conclusion

SWOT analysis was derived from the verified governmental sources. All the data mentioned was either from the government sources or from the thematic analysis, which was presented at the later stage of the research. The primary data collected from the interview which explained the strengths and weaknesses from their point of view also secondary data collected and depended on previous data.

SWOT analysis indicated that there are many factors which affects the sugar production in Pakistan such as low technology, low yield crop, pricing issues, loss of yield due to transportation, political interference, unfavorable policies, and less sugar cane availability for sugar production. In case of UK, it stated that monopoly, less sugar beet growing area, less sugar beet available to fulfil local demand, competition with other crops and health concerns are the main factors which are affecting sugar production in UK.

5.2. Demand and supply analysis

Demand and supply analysis is from the microeconomics of the economic subject (Silalertruksa., Pongpat, Gheewala, 2016). It is the study of how the seller and buyers interact with each other determine the quantities and prices. Prices at the same time shows the buyers value (Marginal unit) and the cost to the unit of the seller. The relationship between demand and supply outcomes in many decisions such as the items price and how it will be produced by using the sources in most cost effective and efficient way (Stake, 2010). Changes in demand and supply of any industry can be due to many factors such as: government policies, change in governments, recession, boom, prices, logistics and demand (World Bank, 2019). For the demand and supply analysis, secondary sources will be used which are from yearly generated reports from the government, ministry of finance, Pakistan sugar mills association, DEFRA, Department of Transport and other available secondary sources such as Bureau of Statistics of Pakistan, Economic Survey of Pakistan etc. SWOT analysis was done to understand the Strength, weakness, opportunities and threats related to the sugar industry, but demand and supply was necessary to understand the current level of demand for sugar and the supply of sugar in Pakistan and UK. The purpose of this research analysis and other analysis such as SWOT, PESTLE was checking the factors affecting sugar industry in general, from the government of point of view and official reports before doing thematic analysis of the interviews to match the result to have more authentic answer. The potential benefits of this analysis include understanding the relationship between supply and demand and how it affects sugar production.

5.2.1. Demand and Supply Analysis for Pakistan

Though the sugar supply has faced many ups and down since 2004, 2.92 million metric ton in 2004 to a peak of 7 million metric ton in 2017 to 4.82 million metric ton in 2020. There is an overall positive linear trend in sugar demand in the Pakistan sugar market (Figure 5.4). Since

2017, Sugar supply has decreased even though a significant increase in price in retail market because of decrease in the sugarcane plantation area and the total sugarcane production (Figure 5.4). Sugar prices fluctuated between as low as PKR 27.9 ($ 0.42) in 2007-2008 to as high as PKR 75.89 ($ 0.48) in 2019-2020 (Table 5.1). Though sugar price in the last 15 years has gone through peak and trough, sugar consumption per capita did not experience any significant fluctuation (Figure 5.5).

Table 5.1: Overall Sugar Related Data Source: (Author's Construction from PSMA, 2020)

Year	Total Sugar Supply	Sugar retail price (kg)	Sugarcane Plantation area in hectares	Reserves of refined sugar (MT)	Total Sugar cane production (MT)
2004-2005	2,922,126	23.45	966,600	577653	43,533,000
2005-2006	2,588,177	31.16	906,980	1310862	44,292,000
2006-2007	3,516,218	31.85	1,029,000	986160	54,871,000
2007-2008	4,740,913	27.92	1,241,300	1188689	63,920,000
2008-2009	3,134,145	38.72	1,029,400	866557	50,045,400
2009-2010	3,133,494	57.11	942,870	100000	49,372,900
2010-2011	4,172,729	72.72	987,700	1109321	55,442,100
2011-2012	4,670,380	60.99	1,046,600	1394013	58,038,200
2012-2013	5,030,129	53.25	1,128,098	844171	63,718,523
2013-2014	5,587,568	53.82	1,171,687	1197128	67,427,975
2014-2015	5,139,566	57.14	1,113,161	1344421	62,794,827
2015-2016	5,082,110	62.60	1,130,820	950,000	65,450,704
2016-2017	7,005,480	64.94	1,216,894	2473476	75,450,620
2017-2018	6,580,111	53.70	1,340,926	2424707	83,289,340
2018-2019	5,210,744	59.84	1,101,073	1812137	67,129,645
2019-2020	4,819,793	75.89	1,038,879	825387	67,105,218

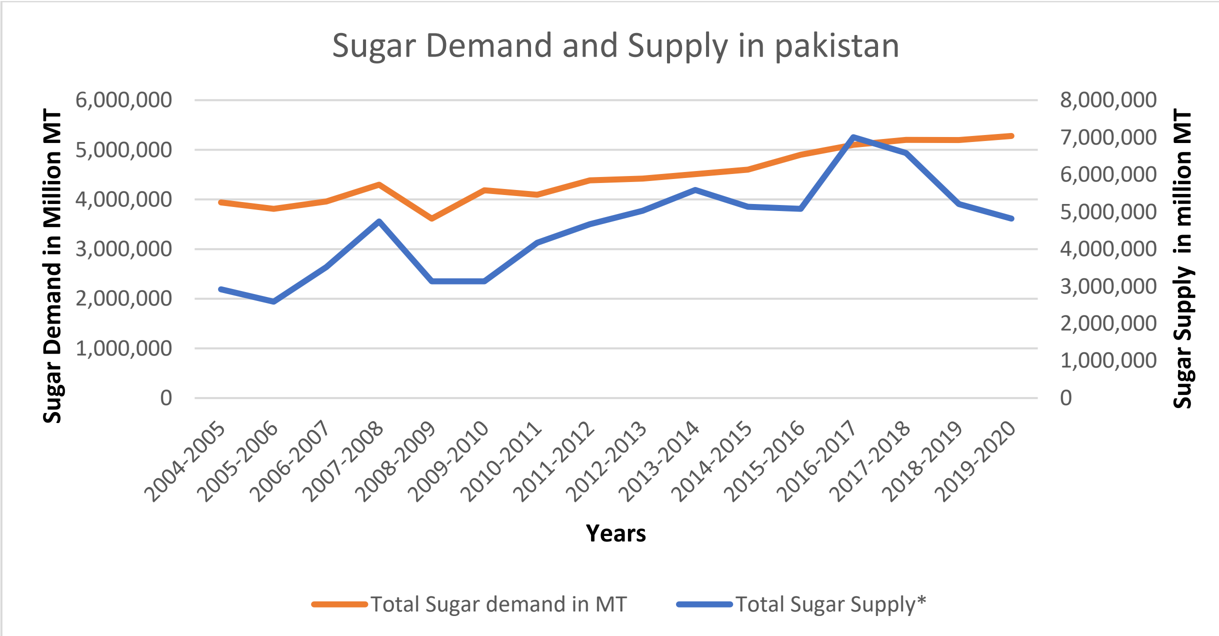


Figure 5.4: Demand and Supply in Pakistan (yearly basis) (Author's Construction from PSMA, 2020)

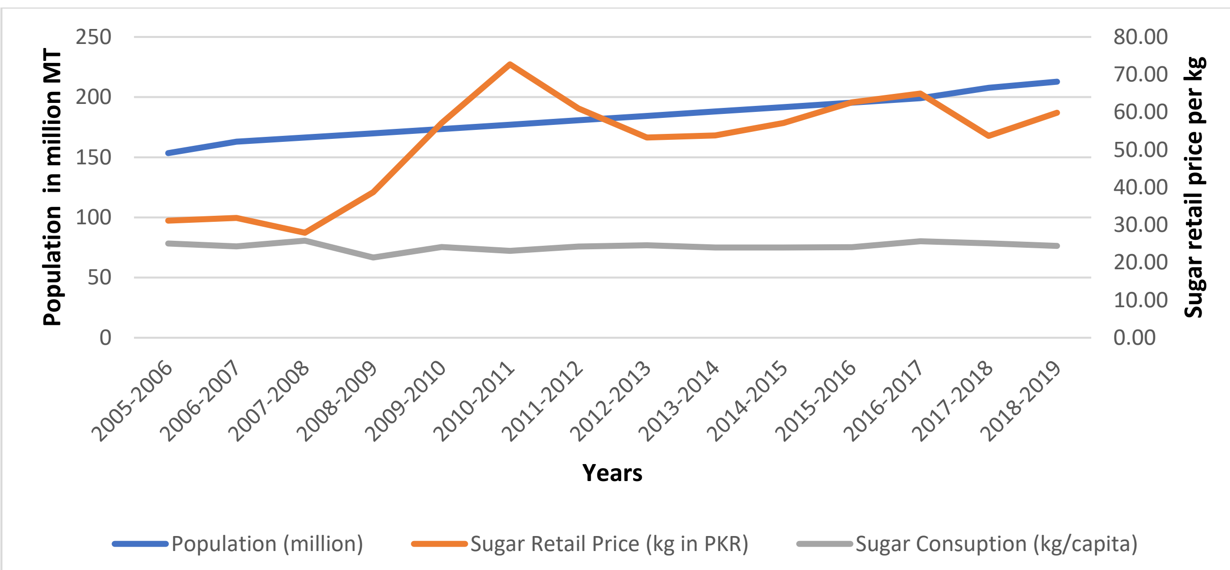


Figure 5.5: Population, Retail Price and Per Capita Consumption Sources; Author's Construction from PSMA, 2020)

Though demand curve has a positive shift, the degree of change in demand is not linear to the change in price (Figure 5.6). On the other hand, supply curve shows a negative shift even the massive increase in price (Figure 5.7). Data from 2004 to 2020 shows that sugar demand increases even if the price increases (Figure 5.8).

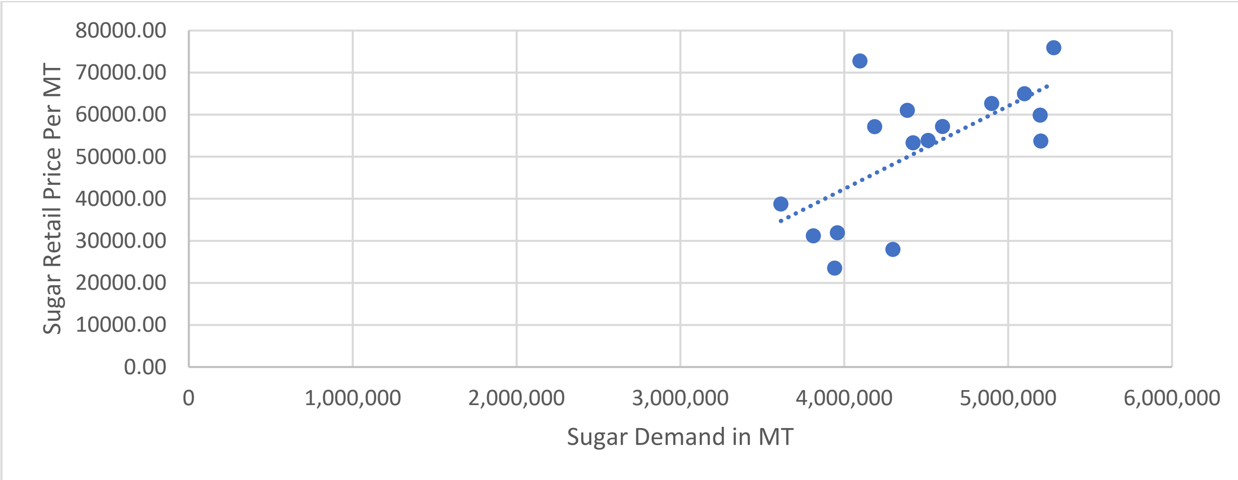


Figure 5.6: Demand Curve Source: Author derived and analyzed from PSMA, 2020

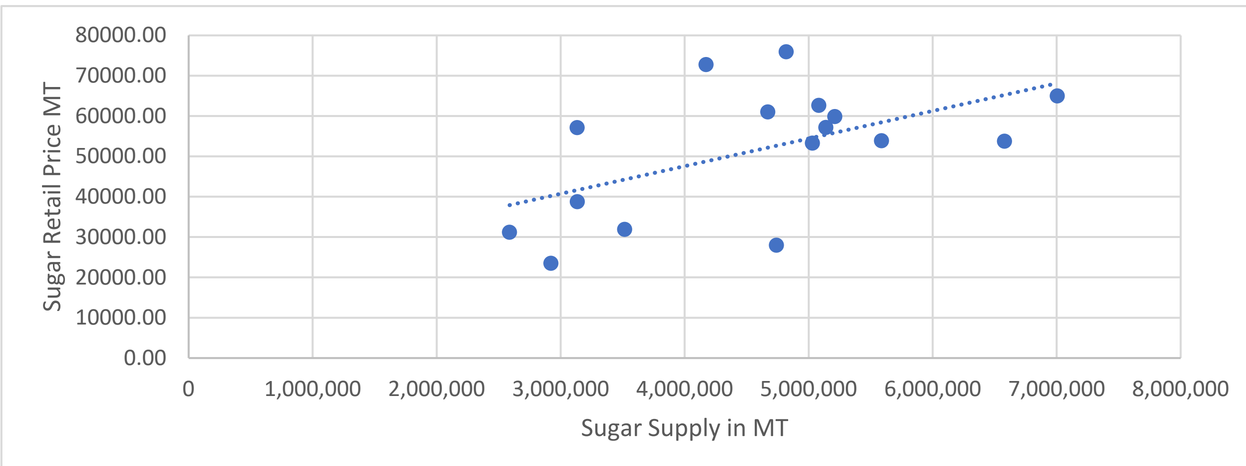


Figure 5.7: Supply Curve Source: Author derived and analyzed from PSMA, 2020

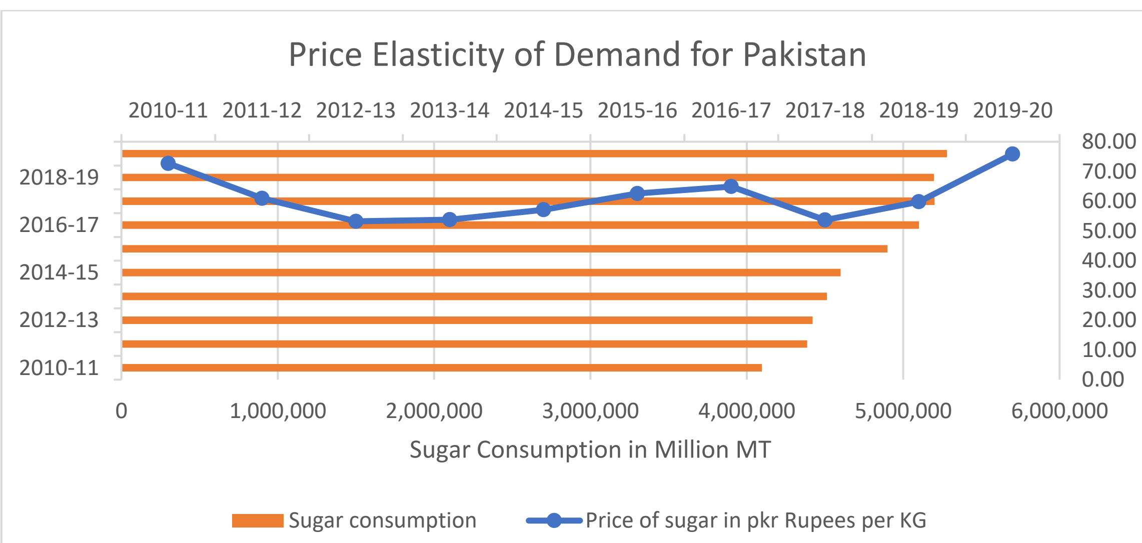


Figure 5.8: Price Elasticity of Demand Source: Author data collected from the PSMA, 2020

Data from 2010 to 2020 shows that sugar demand increases even if the price increases (Figure 5.8). Any commodity which is considered as necessity is considered to inelastic to demand such as wheat flour, corn, sugar and rice. Sugar is considered as necessity products and it has no to weak or expensive alternative, therefore is considered as inelastic demand. Secondly, we spend very small amount on the daily sugar intake from our income, and even the price goes high: it affects only a very little percentage on the income. Thus, sugar is an inelastic demand. The figure 5.8 is derived from the economy data of the country through PSMA (2020) and it was calculated through formula as below:

$$PED = \frac{(Q1-Q0)/[Q1+Q0)/2]}{(P1-P0)/[P1+P0)/2]}$$

Where,
P0 is the initial products price
P1 is the final products price
Q0 is the initial demand
Q1 is the demand after the change in price
Notably, PED is the price elasticity of demand.

The demand for sugar is inelastic as irrespective of the change in price, the demand for sugar remains the same. As observed, (figure 5.8), the prices of the sugar increases however the consumption kept on increasing.

Sugar is mostly used as sweetener in the local market. Sweetener demand per capita was 29.24 kg in 2005, with a population of 153 million people (PSMA, 2020) However, after 13 years and nearly 213 million people, sweetener consumption fell to 25.60 kg per capita (Pakistan Sugar Mills Association, 2020). Figure 5.9 gives the synopsis of the sugar consumption and sweetener kg per capita.

Sweetener Consumption in Pakistan
Sugar plus Gur Equivalent

Qty: Mln. Metric Tonne

Sugar Year	Population Millions	Sugar Consumption		Gur Equivalent	Total Sweetener	Sweetener kg / capita
		Year's	Kg Per Capita			
2006-07	162.91	3.958	24.29	0.523	4.481	27.50
2007-08	166.41	4.297	25.82	0.132	4.429	26.16
2008-09	169.94	3.628	21.34	0.789	4.410	25.95
2009-10	173.51	4.186	24.12	0.625	4.810	27.72
2010-11	177.10	4.096	23.12	0.169	4.265	24.08
2011-12	180.71	4.385	24.27	0.240	4.625	25.59
2012-13	184.35	4.420	24.60	0.270	4.690	25.44
2013-14	188.02	4.512	24.00	0.390	4.902	26.07
2014-15	191.71	4.600	24.00	0.342	4.942	25.78
2015-16	195.40	4.904	25.10	0.395	5.299	25.12
2016-17	199.1	5.100	25.65	0.219	5.310	26.80
2017-18	207.77	5.200	25.10	0.200	5.400	26.00
2018-19	212.82	5.196	24.42	0.250	5.446	25.60
2019-20	211.17	5.279	25.00	0.300	5.600	26.52

Source: - Pop: Economic Survey 20019-20
Sweetener: - Sugar + Gur

Figure 5.9: Sugar consumption per capita, Source: PSMA, 2020

“Gurr” is a natural sugar cane product. In English and Latin America, it is referred to as "jaggery" and "panela" (Limb, 2004). It is traditional non-centrifugal and non-refined sugar (Duraisam, Salelgn, and Berekete, 2017). It is prepared by boiling of sugar cane juice, then evaporating and finally drying. It is mostly consumed in southeast Asia and in the south American countries. Figure 5.9 depicts population growth from 2006 to 2020; sugar consumption rises year after year, as does jaggery consumption. Jaggery is mostly consumed in Pakistan's rural areas. Although consumption fluctuated from 2005 to 2019, sugar consumption kg per capita decreased from 25 to 24.42 and overall sweetener kg per capita decreased from 29.24 to 25.60. That sharp decrease proves consumption might continue to decrease or remain stable over the next few years. To support this assessment, it is necessary to examine sugar export figures. Figure 5.10 shows that sugar export peaked in 2017-2018 before declining in 2018-2019 and 2019-2020.

2006-2020

Qty: MT
Value: '000' Rs.
Avg. Price: Rs/MT

*Year	Quantity	Value	Avg. Price
2006-07	12	330	27,500
2007-08	260,840	5,738,856	22,015
2008-09	23,980	639,677	26,675
2009-10	-	-	-
2010-11	-	-	-
2011-12	48,672	2,575,403	52,913
2012-13	1,064,215	51,692,066	48,573
2013-14	647,333	29,638,230	45,785
2014-15	708,356	32,685,502	46,143
2015-16	293,541	13,817,628	47,072
2016-17	307,348	16,867,358	54,880
2017-18	1,469,802	56,379,067	38,358
2018-19	691,994	31,147,250	45,011
2019-20	181,447	11,063,348	60,973

Figure 5.10: Sugar export data 2006-2020, Source: PSMA, 2020

Whenever there is a peak in production, means extra sugar and export has peaked as well- this may be due to manage of stocks within reasonable limits. There are different factors influencing and driving sugar production such as decrease in crop area, decrease in yield of sugar and due to vulnerable price supply of sugar was affected. Whenever there was increase in sugar cane growing area there was increase of sugar in Pakistan, which means more molasses available for ethanol production.

But when the trend on ethanol production and bio-mass fuel sources began to increase, export of Molasses went down, through years with increase in prices too. That means rise in demand for molasses causes prices to go up. In 2009-2010, Pakistan exported highest volume of molasses, 961,000 Mt molasses with an average price of 8,000 PKR, but the price increased by 66% in 2018-2019. In this year Pakistan exported 117,000 MT. molasses with average price of 14,407. (Figure 5.11). The volume of export is falling continuously due to increasing local demand as a feedstock in ethanol production. Over the years, with more ethanol distilleries and more utilization of capacity, molasses available for export has reduced. If number of ethanol plants or production of ethanol increases in the market, there shall be more need of feedstock.

In 2019, Pakistan ethanol production capacity (annual) is approximately 600,000 Mt, while molasses production is 2.3 million MT (PSMA, 2020).

Export of Molasses
2005-2019

*Year	Quantity	Value	Avg. Price
2005-06	497,161	2,612,342	5,255.00
2006-07	373,177	1,704,034	4,566.00
2007-08	780,807	3,490,864	4,471.00
2008-09	936,338	7,486,584	7,996.00
2009-10	961,300	7,784,000	8,097.36
2010-11	86,437	892,087	10,321.00
2011-12	55,608	577,981	10,394.00
2012-13	225,221	2,747,341	12,198.00
2013-14	197,342	2,510,421	12,721.00
2014-15	83,229	1,010,347	12,139.00
2015-16	73,067	874,398	11,967.00
2016-17	101,410	1,217,122	12,001.00
2017-18	168,962	2,114,533	12,515.00
2018-19	117,909	1,698,719	14,407.00

Figure 5.11 Molasses export data Source: PSMA, 2020

Main finding of the analysis

Overall sugar production in Pakistan is decreasing due to a decrease in raw material supply in mills caused by a decrease in sugar-cane plantation area. Price of sugar is inelastic as it has no impact on the demand or production of sugar as shown in the figure 5.8. If the supply of sugar cane increases, then there can be more sugar and more molasses will be available for ethanol production.

5.2.2. Demand and Supply Analysis for UK

In UK, the total demand of the sugar fluctuates between 1,900,000 MT and 2,100,000 MT from 2014 to 2018. There has been a lot of variation in sugar pricing though. Figure 5.12 shows the fluctuation in demand and price. The demand of sugar is highly dependent on the price of sugar and availability of sugar substitutes which are equivalent in tastes, availability in the market and price. Another, factor that could hit the sugar demand. Although the substitutes of sugar are not in excess and do not compete with sugar demand but still the fitness and health-conscious people tend to use less sugar, but this is not making any huge difference in the demand of sugar.

In UK, the demand of sugar continued to grow at moderate level, with the change in prices. Only in 2015-16 the demand has fallen with the increase in prices.

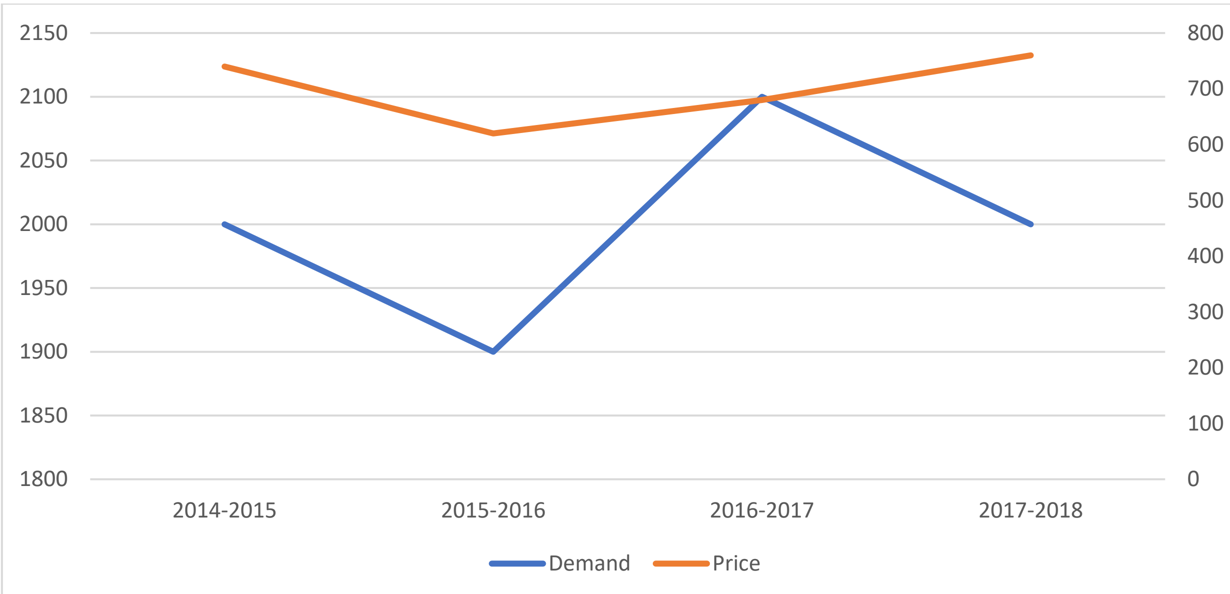


Figure 5.12: Fluctuation in Demand and Price (UK) Source: Author derived and analyzed from Department for Environment, Food and Rural Affairs, 2019.

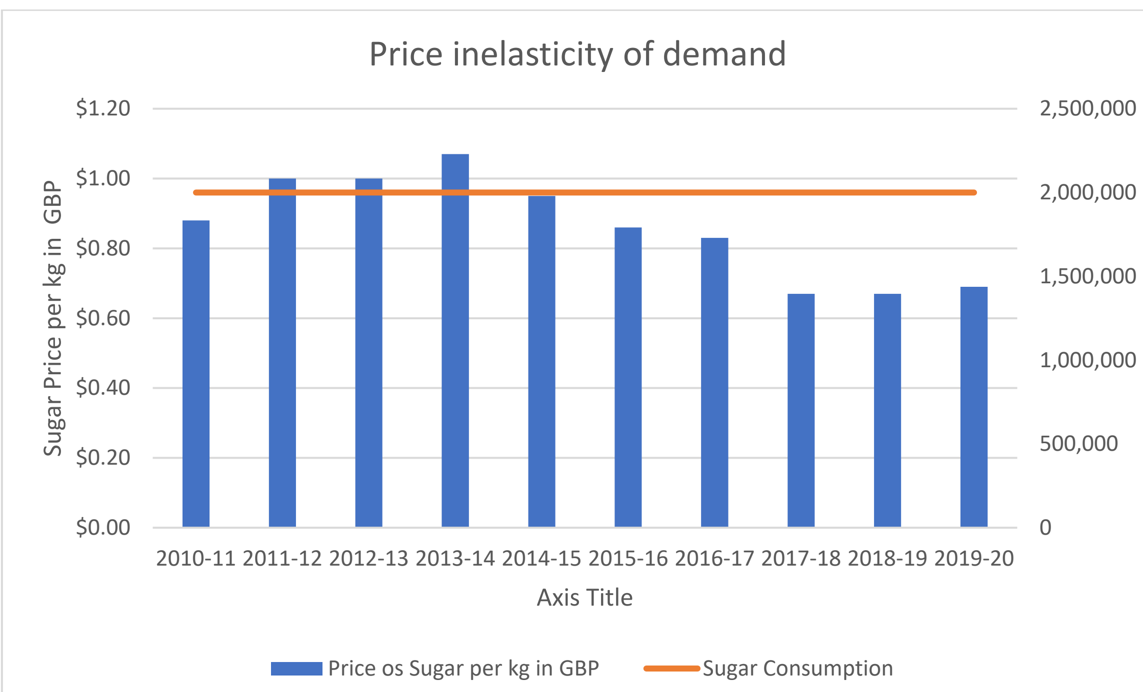


Figure 5.13: Price Elasticity of Demand (UK) Source: D Author derived and analyzed from apartment for Environment, Food and Rural Affairs, (2019).

In UK, the demand of sugar continued to grow steadily, even with the change in prices. As discussed previously that sugar is a necessity product and is inelastic to demand and we only spent very little portion of our income towards buying sugar. Thus, sugar is an inelastic demand. The figure 5.13 is derived from the economy data of the country through DEFRA (2019) and it was calculated through this formula:

$$PED = \frac{(Q1-Q0)/[Q1+Q0)/2]}{(P1-P0)/[P1+P0)/2]}$$

Where:
P0 is the initial products price
P1 is the final products price
Q0 is the initial demand
Q1 is the demand after the change in price
PED is the price elasticity of demand

The current sugar production in the UK ranges from 1 million tonnes (MT) to 1.2 million tonnes and is produced by two major companies: British Sugar and American Refinery (Diabetes Research & Wellness Foundation, 2018). Every year, the UK has approximately 2,000,000 MT of sugar demand, with locally grown sugar beets meeting approximately 50% of the demand and the remainder imported from the EU/rest of the world. Raw sugar is imported and then refined in refinery. The main factor in the supply of sugar in UK is the government import policy and policies regarding production of sugar locally. It is shown in table 5.2 that area for growing sugar beet is constant and have not increased significantly in last few years which has affected the sugar production in UK.

Another factor could be, if sugar beet is grown less, less yield and over supply of sugar from the EU might affect sugar production in UK. After Brexit, it will give opportunity to UK local sugar producers to sell more. Sugar tax is another factor which can play a role as many companies are decreasing their level of sugar in their products but in terms of cost, it will save less as sugar makes up only small amount in overall price of the goods. The price of sugar could also affect the sugar demand considering its use in the beverage industry. Table 5.3 illustrates the UK sugar related data including sugar product, consumption, retail price and amount of import-export.

Table 5.2 Sugar beet area, sugar production, sugar beet price and sugar price per kg in UK Source: Author data taken from Defra, 2019; Office for national statistics UK, 2020.

Years	Sugar beet growing area in ha	Sugar production from sugar beet locally in MT	Sugar beet price Avg per MT	Sugar price per Kg in UK on 1st Jan of each year
2009	114,000	1,280,000	29.1	0.88 GBP
2010	122,000	995,000	30.1	1.00 GBP
2011	113,000	1,315,000	29.6	1.00 GBP
2012	117,000	1,144,000	31.2	1.07 GBP
2013	121,000	1,324,000	32.0	0.95 GBP
2014	117,000	1,446,000	33.9	0.86 GBP
2015	84,000	978,000	27.8	0.83 GBP
2016	80,000	897,000	26.3	0.67 GBP
2017	107,000	1,364,000	25.7	0.67 GBP
2018	110,000	1,080,000	32.3	0.69 GBP
2019	108,000	1,180,000 Est	No data	0.73 GBP

Table 5.3: Source of Sugar in UK Source: Author derived and analysed from Defra, 2019; Office for national statistics UK, 2020.

Years	Sugar production from sugar beet locally in MT	Total Sugar Consumption in UK per MT Avg estimated	Sugar price per in GBP	Sugar Imports in MT	Sugar Exports in MT	Percentage of sugar produced in UK
2009	1,280,000	2,000,000	0.88	1,337,000	536,000	62%
2010	995,000	2,000,000	1.00	1,330,000	510,000	55%
2011	1,315,000	2,000,000	1.00	1,228,000	308,000	59%
2012	1,144,000	2,000,000	1.07	1,054,000	256,000	59%
2013	1,324,000	2,000,000	0.95	1,114,000	233,000	60%
2014	1,446,000	2,000,000	0.86	1,175,000	326,000	63%
2015	978,000	2,000,000	0.83	1,132,000	333,000	55%
2016	897,000	2,000,000	0.67	1,003,000	270,000	55%
2017	1,364,000	2,000,000	0.67	988,000	203,000	64%
2018	1,080,000	2,000,000	0.69	948,000	361,000	65%
2019	1,180,000	2,000,000	0.73	960,000	370,000	65%

Summary of the findings

Sugar production in UK increasing even though price decreasing. However, increase in import is a great motivating factor in increasing sugar production in UK. Due to Brexit demand can be fulfilled by imported sugar. Health concerns are on the rise and can have impact on sugar production.

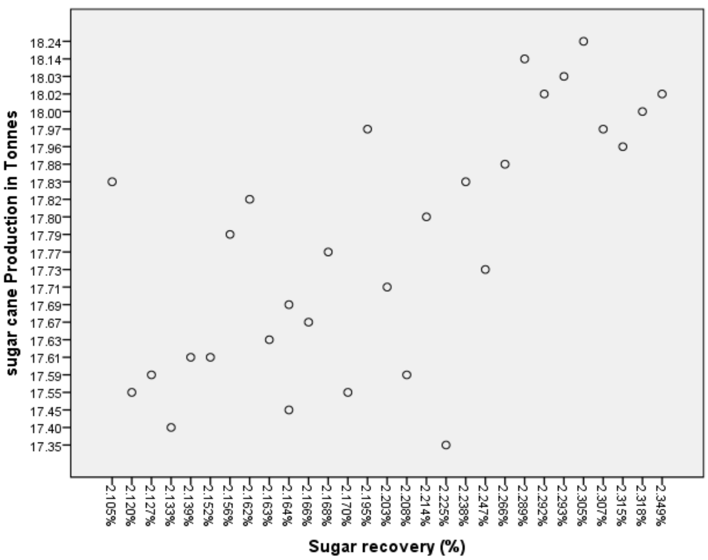
5.2.3. Overall conclusion

According to OECD/FAO (2019), the average world sugar consumption per capita is between 22.7 kg and 24.2 kg. According to FAO (2016), UK sugar consumption per capita in 2013 was 34.2 kg per year (in comparison, in Pakistan it was 24.4). Public debate about the higher intake of sugar, fat and obesity has sparked the government to introduce sugar tax. Pakistan Current demand is 5,196,000 MT and current production is 5,267,572 in 2019-2020, But current production is lower in last few years. The production is decreasing due to lack of support from the government in terms of policies for farmers and late payments if subsidies. Overall, Pakistan has ability to produce 7 million tonnes of sugar considering last 10 years production. Even if the demand increases by 10%, 20% and 30% with proper government policies sugar demand can be met by local sugar cane production. While in UK overall sugar production is 1,180,000 MT of sugar from sugar beet and rest is being imported and refined in the country. UK does not have the capacity to fulfil its local need through locally grown sugar beet. Only certain share can be increased by converting the sugar beet completely to sugar by taking that 5% from ethanol (DEFRA, 2019). It is clear from the table 5.3 that the consumption rate is higher than the production rate and UK depends on imports from abroad to fill this deficit, but it is possible to take a quantity of ethanol and direct it to sugar to fill this deficit to some extent (DEFRA, 2019). Ethanol is not dependent on the sugar beet and increase in sugar demand will leave no impact on ethanol industry. However, more sugar needs to be imported to fulfil local demand in coming years.

5.3. Regression

5.3.1. Regression Analysis for Pakistan of sugar production

Regression analysis is a reliable method for determining which variables have an impact on a given topic. The process of running a regression allows to determine which factors are important, which can be ignored, and how these factors interact with one another. Further, Regression models help to prevent spurious correlations and isolate the role of each variable. In this investigation, “sugar production” is the *dependent variable*, and the *independent variables* are “factories sugarcane own field wide”, “farmer sugarcane field wide”, “sugarcane sucrose content average from factories sugarcane field”, “sugarcane sucrose content average from farmer sugarcane field”, “factories efficiency”, “truck unit”, “yesterday sugarcane remnant”, “sugar milling day amount” and “milling capacity”.


sugar cane Production in Tonnes
18.24
18.14
18.03
18.02
18.00
17.97
17.96
17.88
17.83
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17.80
17.79
17.77
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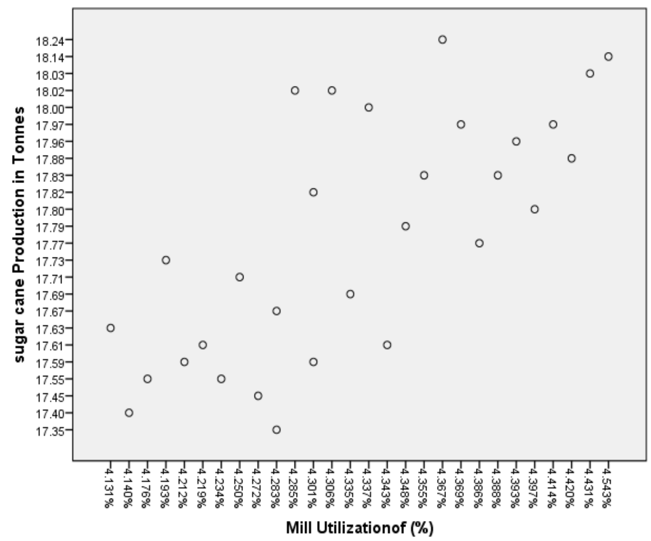
17.59
17.55
17.45
17.40
17.35
2.105% 2.120% 2.127% 2.133% 2.139% 2.152% 2.156% 2.162% 2.163% 2.164% 2.166% 2.168% 2.170% 2.195% 2.203% 2.208% 2.214% 2.225% 2.238% 2.247% 2.266% 2.289% 2.292% 2.293% 2.305% 2.307% 2.315% 2.318% 2.349%
Sugar recovery (%)


sugar cane Production in Tonnes
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17.79
17.77
17.73
17.71
17.69
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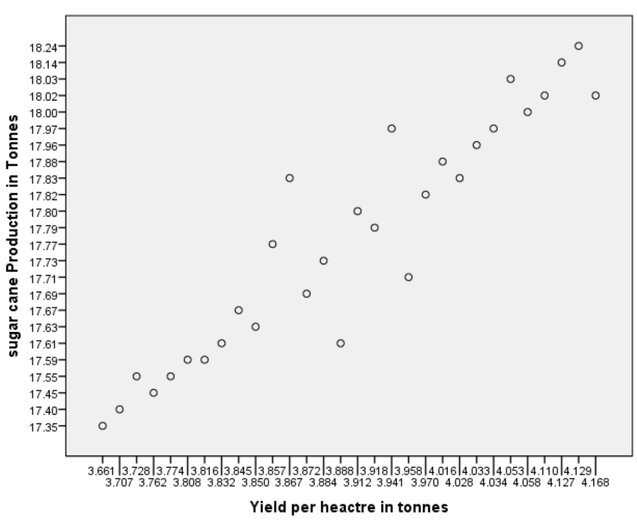
17.59
17.55
17.45
17.40
17.35
4.131% 4.140% 4.176% 4.193% 4.212% 4.219% 4.234% 4.250% 4.272% 4.283% 4.285% 4.301% 4.306% 4.335% 4.337% 4.343% 4.348% 4.355% 4.367% 4.369% 4.386% 4.388% 4.393% 4.397% 4.414% 4.420% 4.431% 4.543%
Mill Utilizationof (%)


sugar cane Production in Tonnes
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17.61
17.59
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17.45
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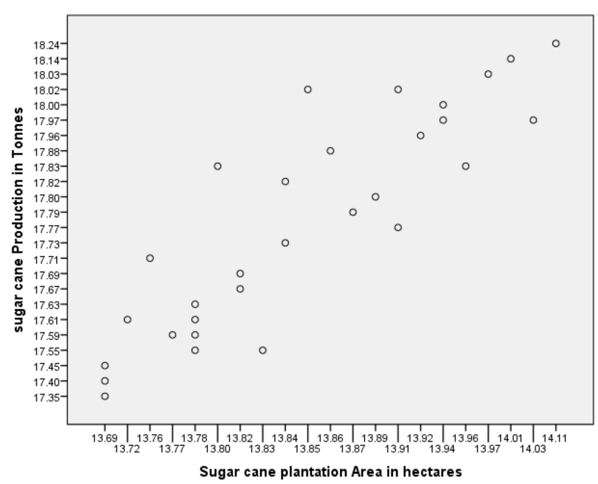
17.35
3.661 3.728 3.774 3.816 3.845 3.857 3.872 3.888 3.918 3.958 4.016 4.033 4.053 4.110 4.129
3.707 3.762 3.808 3.832 3.850 3.867 3.884 3.912 3.941 3.970 4.028 4.034 4.058 4.127 4.168
Yield per heactre in tonnes


sugar cane Production in Tonnes
18.24
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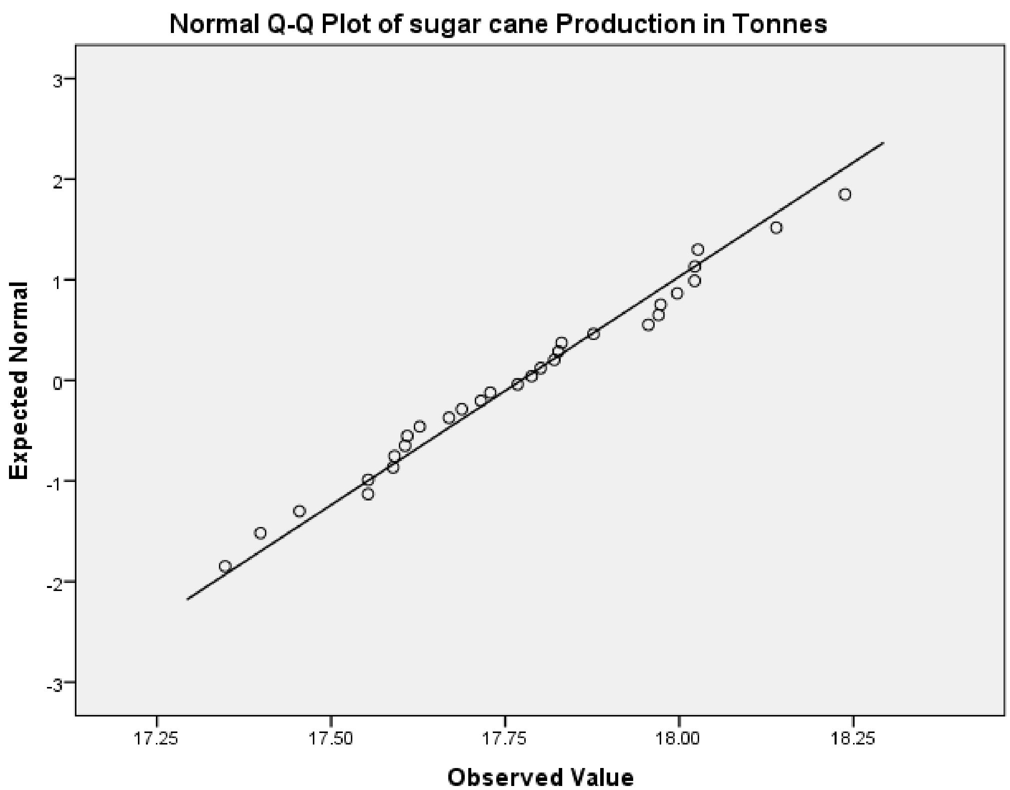
17.59
17.55
17.45
17.40
17.35
13.69 13.76 13.78 13.82 13.84 13.86 13.89 13.92 13.96 14.01 14.11
13.72 13.77 13.80 13.83 13.85 13.87 13.91 13.94 13.97 14.03
Sugar cane plantation Area in hectares

Checking Normality for the Dependent Variable

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
sugar cane Production in Tonnes	.097	30	.200*	.983	30	.891
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Sources; Author's Own

Interpretation: The P-value for both Kolmogorov and Shapiro are greater than the significance level .05, which is an indication that the dependent variable follows normal distribution.



Interpretation: As all values lies on the centre line which depicts strong linear association among the values. This proves that the data follows normality condition fully. Again, the test statistics Shapiro-wilk gives insignificant results which indicates that the dependent variable follows the normality condition.

Regression Model

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000[a]	1.000	1.000	.00116
a. Predictors: (Constant), Sugar recovery (%), Mill Utilization of (%), Sugar cane plantation Area in hectares, Yield per hectare in tonnes				
b. Dependent Variable: sugar cane Production in Tonnes				

Sources; Author's Own

Interpretation: The overall goodness of fit of the model is excellent. The value of R is 1, which indicates that the model is perfectly fitted.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1.406	4	.351	262912.477	.000[b]
	Residual	.000	25	.000		
	Total	1.406	29			
a. Dependent Variable: sugar cane Production in Tonnes						
b. Predictors: (Constant), Sugar recovery (%), Mill Utilization of (%), Sugar cane plantation Area in hectares, Yield per hectare in tonnes						

Sources; Author's Own

Interpretation: Overall model predicts a significant value which indicates that there is significant relationship between the dependent and independent variables. The decision has been made based on the significance P-value. As the P-value is less than 0.05 which indicates significance level.

Table 5.4 Coefficients

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.021	.036		.571	.573
	Area	.999	.003	.474	302.651	.000
	Yield	1.006	.003	.612	328.113	.000
	Mill Utilization	.000	.003	.000	-.115	.909
	Sugar recovery	-.010	.005	-.003	-2.012	.055
a. Dependent Variable: sugar cane Production in Tonnes						

Sources; Author's Own

Interpretation: The above table 5.4 shows significant relationship between dependent variable and independent variables. It is apparent from the above analysis that "Area" has significant (β=.999, P-value= .000) positive relationship with Sugar Production. This means that one unit change in Area will increase sugar production by 9.99% on average. Similarly, the relationship is significant (β=1.006, P-value= .000) for Yield. It tells us that one unit change in Yield will increase the sugar production by almost 1.006%. There is insignificant relationship is being predicted in this model with dependent variable and independent variable Mill Utilization. Again, Sugar Recovery has also a weak significant relationship with dependent variable.

Residuals Statistics					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	17.3474	18.2379	17.7728	.22016	30
Residual	-.00129	.00508	.00000	.00107	30
Std. Predicted Value	-1.932	2.113	.000	1.000	30
Std. Residual	-1.119	4.398	.000	.928	30
a. Dependent Variable: sugar cane Production in Tones					

Sources; Author's Own

5.3.2. Regression Analysis for UK

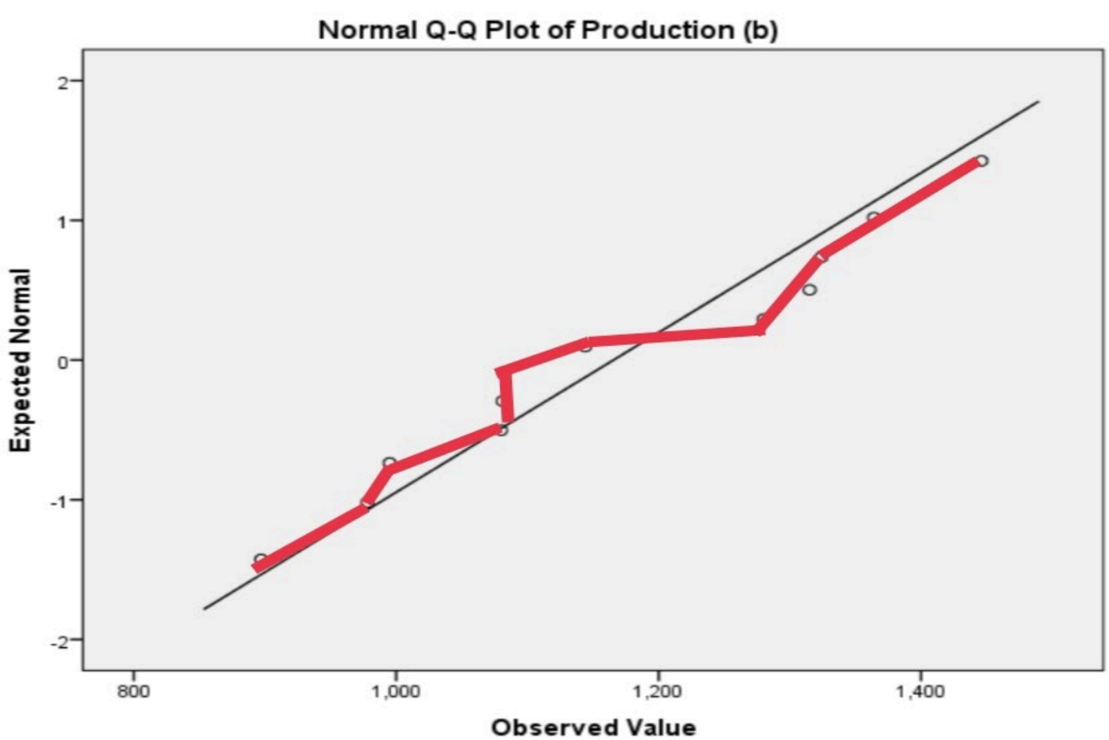
Checking Normality for Dependent Variable

To check normality of our dependent variable Sugar Production, we shall use Shapiro-Wilk test. The test handles the sample size less than 50 perfectly. The below results illustrate the Shapiro-Wilk test.

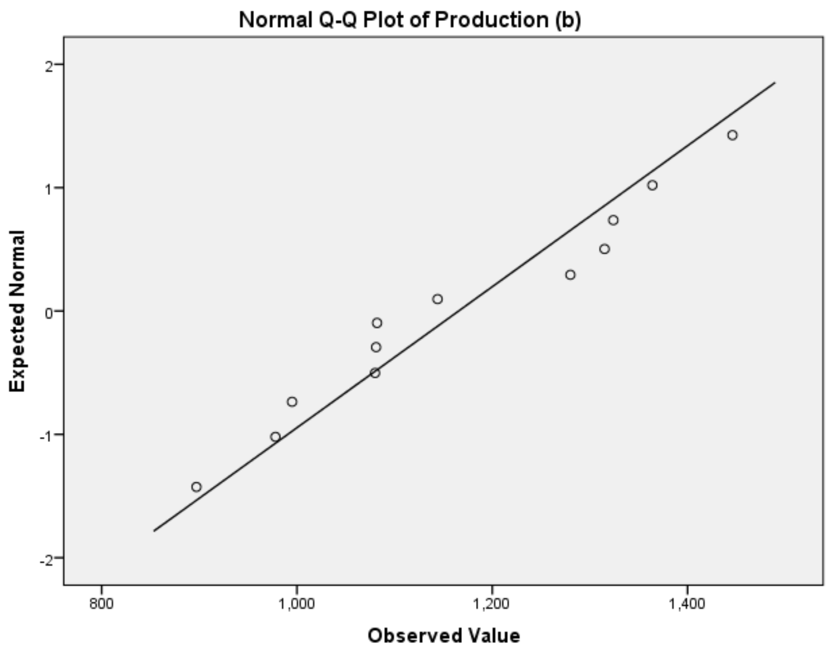
Table 5.5 Test of Normality

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Production (b)	.171	12	.200*	.946	12	.586
*. This is a lower bound of the true significance.						
a. Lilliefors Significance Correction						

Sources; Author's Own



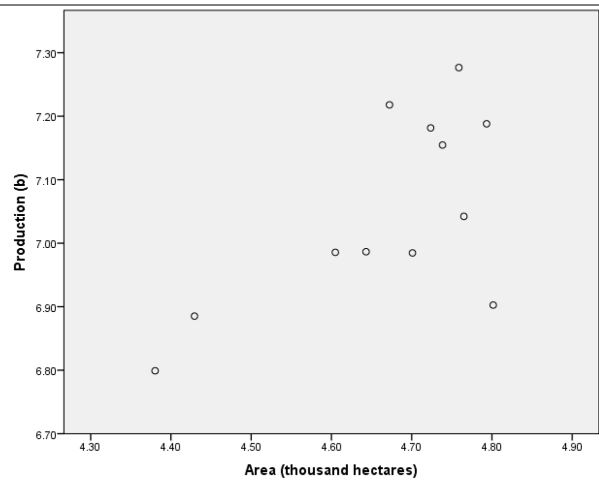
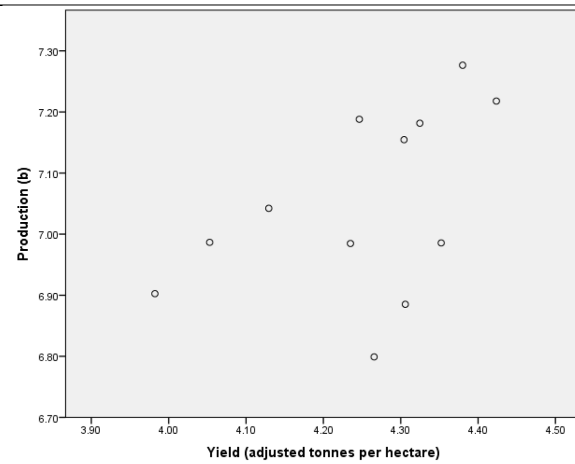
The above table 5.5 illustrates that the significant value (P-value is greater than .05) is greater than the significant P-value. Therefore, it can be stated that the dependent variable follows the normality.

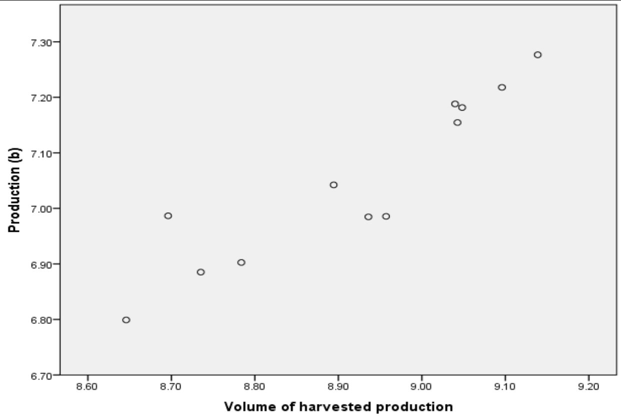


This can be illustrating through QQ-Plot as well. It can be seen from the plot that all the values are around the centre line. This indicates that the dependent variable follows the condition of normality.

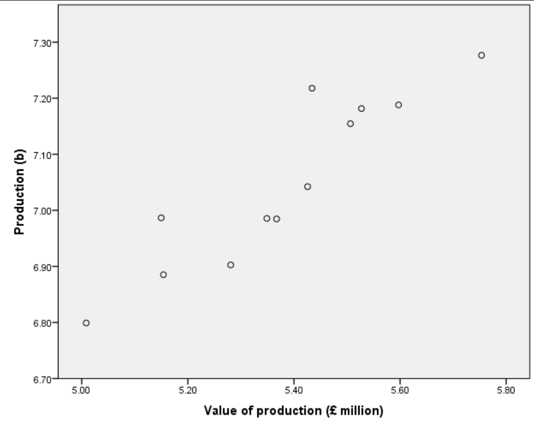
Further, the plot also illustrates that there is not any value which is away from the line which indicates no outlier in this case.

Checking for linear correlation

 Linear Positive relationship	 Linear Positive relationship



Linear Positive relationship



Linear Positive relationship

Variation in the data

Based on the variance of the obtained data, the variation was estimated as 0.023 which indicates that the closeness of the data points to the mean showing the linear relation between the set of variables.

Regression Model: For regression model, this study involved the logarithmic regression instead of linear regression. This study used logarithmic regression instead of linear regression for the regression model. The basic logic behind selecting logarithmic is to have the smallest error possible while also ensuring that data is not overfitting. Overfitting occurs when there are too many dependent variables in play, as in this case, and the dataset lacks sufficient generalisation to make a valid prediction. Using the logarithm of one or more variables improves model fit by transforming the feature distribution to a more normally shaped bell curve. The equation utilized follows as, Ln (Sugar Prod) = Intercept $+\beta_1 * \ln(A) + \beta_2 \ln(\text{Yield}) + \beta_3 * \ln(\text{Volume of Harvest}) + \beta_4 \text{Ln}(\text{Value})$

Table 5.6 ANOVA

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.220	3	.073	18.700	.001[b]
	Residual	.031	8	.004		
	Total	.251	11			
a. Dependent Variable: Production (b)						
b. Predictors: (Constant), Value of production (£ million), Yield (adjusted tonnes per hectare), Area (thousand hectares)						

The overall significant result for the model is shown in table 5.6 above. Since the P-value for F statistics is less than the significant value. 05. Recognizing that the dependent variable "sugar production" has a significant influence on the independent variables "production volume," "its value," and "yield area." As a result, it validates that the overall model is significant.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	.936[a]	.875	.828	.06260

Sources; Author's Own

The above table illustrates the goodness of fit of the model. The value of both R- and Adjusted R is close to 1. This indicates that the model is perfectly good fitted.

Table 5.7 Coefficients

Table 2. Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.061	1.895		.560	.591
	Area (thousand hectares)	.496	.456	.448	1.088	.308
	Yield (adjusted tonnes per hectare)	.494	.332	.435	1.486	.176
	Value of production (£ million)	.293	.314	.406	.934	.378
a. Dependent Variable: Production (b)						

Sources; Author's Own

The tables 5.7 above show the effect of dependent variables on independent variables. All the independent variables influence the dependent variable in a positive but insignificant way. As shown in the table, the significance P-value is greater than the significance level.05, indicating insignificant results.

The regression models used the different variables for the Pakistan and UK because the independent variables affecting each country are different as well as using various variables to support the comparison between Pakistan and UK.

Conclusion:

In the preceding tables, regression models depict the relationship between "sugar production" (dependent variable) and dependent variable such as "area", "yield", "mill utilization", and "sugar recovery" in the case of Pakistan. A significant relationship was discovered between sugar production, area, yield, and sugar recovery. In the case of the UK, the relationship between "mill utilization" and "sugar production" was estimated as insignificant in the regression model. The regression model will offer opportunities for analysing the intervention options in the sugar industry. since Sugar production follows a normal condition because independent variables have a positive but insignificant effect on production.

5.4. PESTLE Analysis

This section deals with a strategic analysis and comparison of the sugar production capacity in the UK and Pakistan using a PESTLE analysis. This strategic analysis comprises of both internal and external factors that affect the UK and Pakistan sugar production. The internal factors deal with the strengths and weakness within the UK and Pakistan for sugar production and include internal factors such as local business environment, support policies and other internal mechanisms. On the other hand, the external factors deal with the opportunities and threats facing the UK and Pakistan sugar production capacities. The external strategies exploit the opportunities while taking measures against emerging threats mediating against the UK and Pakistan sugar production capabilities.

In terms of internal influences, the sugar industry plays a non-essential role in the UK economy other than job creation. Although the industry is growing, operating, and offering high-quality sugar to approximately 50% of British market and exporting global market, however, it has a small share of the country's GDP (Diabetes Research & Wellness Foundation, 2018). The industry supports up to 9,500 jobs in the country. Those jobs are mostly created in production facilities and farms. As the service demand increases in parallel with sugar production and production processes, suppliers coming to factories create more employment. In addition, the British Sugar supply chain includes about seven thousand different businesses and has largest customers in the UK. In this respect, the respondent UKFarmer1 quoted that *"Most of the farmers sell their products to the British Sugar Company" (Refer to appendix 20).*

But for Pakistan, on the contrary, sugar cane is a significant cash crop in the country and plays a critical role in improving the socioeconomic conditions of farmers. The rapid growth of the sugar industry has contributed to the economic improvement and development of Pakistan. Sugarcane is the one of the government's good sources of income, as this crop brings billions of rupees in the form of fees, taxes and its ability to support with energy need of the country (Pakistan Sugar Mills Association, 2019). In recent industrial progress, sugarcane is not only limited to sugar production, but binary products such as alcohol, fibreboard and dozens of other industrial chemical compounds can be produced during sugarcane processing. Pakistan ranks fifth in sugarcane production, seventh in sugar production, and eighth in sugar consumption worldwide (PSMA, 2020). Pakistan devotes 1,120,000 hectares of land to sugar cane, while the UK sugar industry uses 100,000 hectares for sugar beets (Agriculture in the UK, 2020).

However, the sugar industry is mostly affected by global political developments, global demand, and global environmental impacts. For example, extra sugar was produced due to better weather conditions for growing sugar cane. It was also noted that for the first time in many years the price was dropped to $0.10 per lb. Furthermore, the top 20 global sugar manufacturers reduced their output in 2018-2019, and global output is expected to fall to 187.3 million tonnes in 2019-2020, down from 201.2 million tonnes in 2018-2019 (National Statistic, 2019). While falling sugar prices naturally affect the profitability of producers, it leads production factories to loss and increased debt levels. On the other hand, EU manufacturers including UK, have agreements with the farmers of sugar beet, which means they are bound to sell their crops to them only. This approach in the market help sugar beet production to shall remain high, while keeping the price of sugar low and impacting on manufacturer's margins (Office for National Statistics, 2020). Since the lifting of quotas of sugar in EU in 2017, the European sugar industry has experienced unprecedented change. Britain's EU Sugar has suffered too from the profitability and this blow was reduced somewhat by a weak GBP. The low price of sugar, coupled with a continued restriction on insecticide use, saw 6% reduction in beet cultivation in Europe in 2020 (Mintec, 2021).

In short, it can be right to state that external factors that have effects on the sugar industry are mostly global prices, decisions of supranational organizations such as the EU, the ECOWAS. These influences have an impact on prices and production volume (external factors), while internal factors have a direct impact on production quality. However, as the world transitions to low-carbon energy, technology has become a critical factor for both external and internal factors on the sugar industry (Mintec, 2021). The search for a new reliable and cost-effective energy source has led to the development of biomass fuel plants. The governments are revising their renewable energy directive to shift their energy sources to new fields, which highlights the significance of ethanol production. The impact of ethanol production investments can be seen on sugar industry. As result, global sugar production is expected to increase after falling since 2017 (Rodrigue, 2020).

Recently, the increasing depletion of fossil fuels, the destruction of ecosystems, and efforts to reduce external energy dependency have heightened the importance of sustainable fuels such as ethanol (Institute for energy research, 2019). The production of bioethanol from sugar beet molasses will provide new opportunities for beet producers, as will crop rotation and the formation and spread of energy agriculture culture. Bioethanol also benefits the environment by diversifying agricultural production, providing a sustainable structure for agriculture, and developing rural economies.

Overview of Sustainability Structure

The results of the PESTLE analysis are summarized in Table 5.8 and 5.9. The collected factors will be correlated to the different production technologies, depending on the ethanol, feedstock, and conversion technology. PESTLE themes are shown in figure 5.14 and 5.15, respectively for the UK and Pakistan.

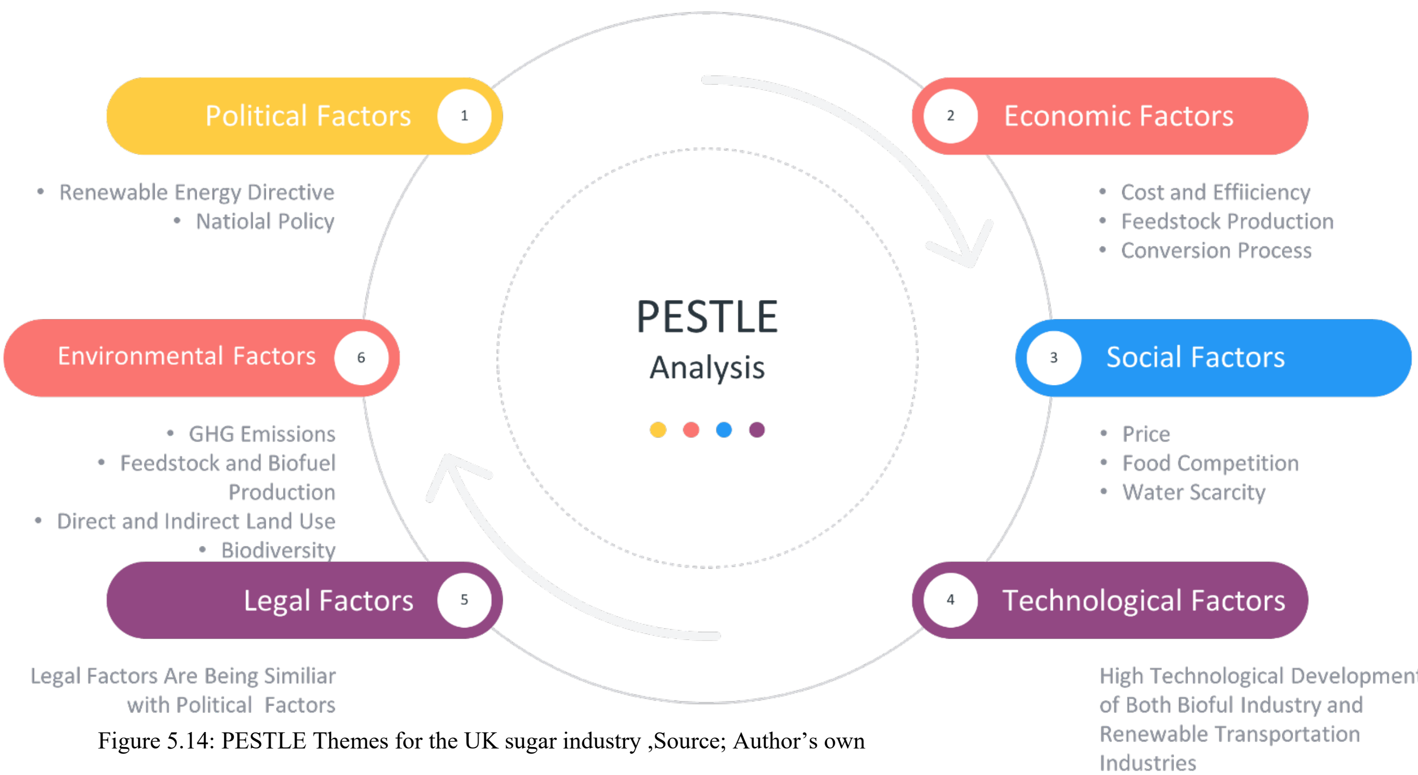


Figure 5.14: PESTLE Themes for the UK sugar industry ,Source; Author’s own

PESTLE analysis for the UK provides a good ground for long-term sustainability. Transportation industry and infrastructure provides sustainable reach to feedstocks as well as climate of UK provides a suitable environment to meet conditions against water scarcity.

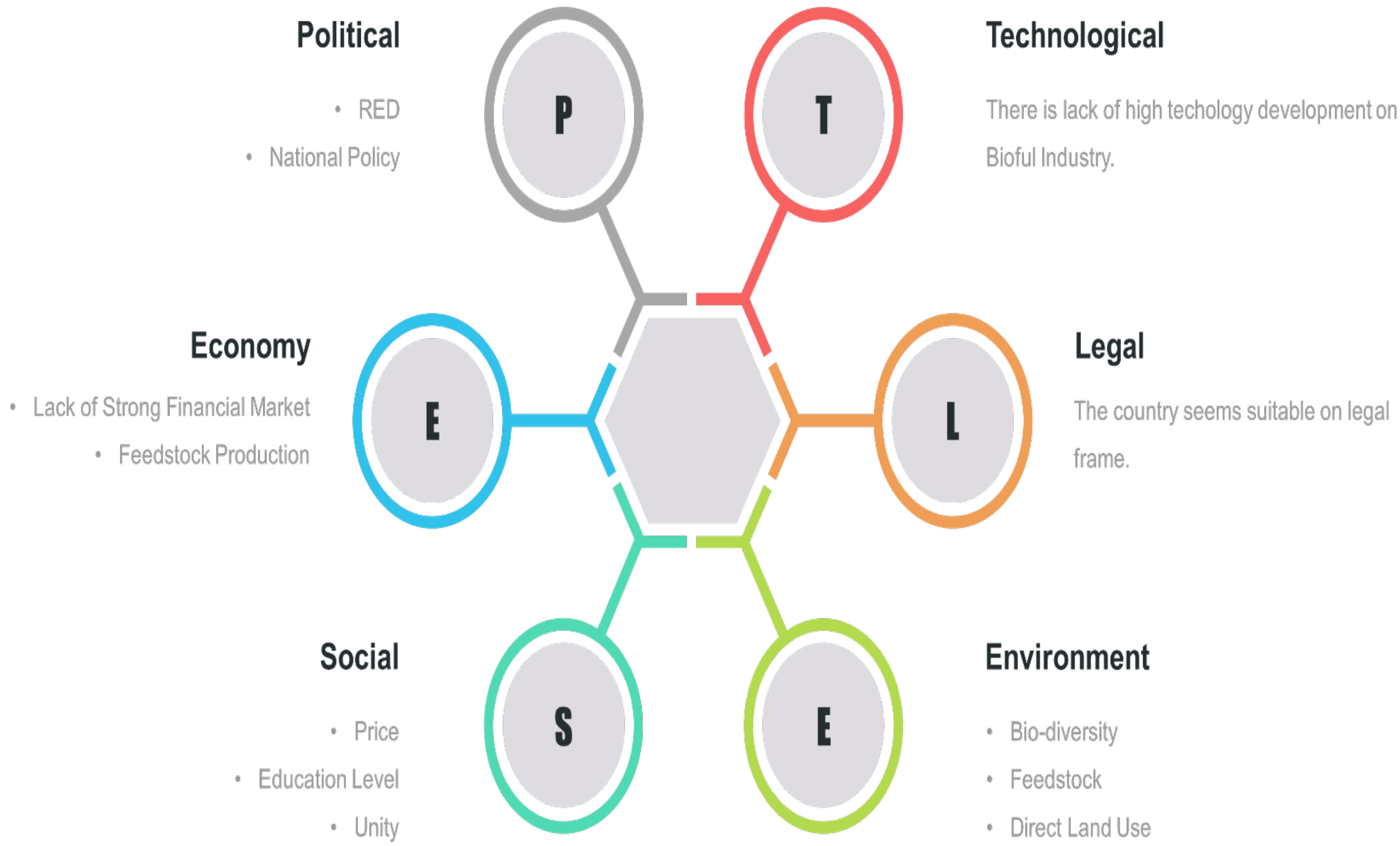


Figure 5.15: PESTLE Themes for Source: (Author derived and analysed from Pakistan Sugar Mills Association, 2020)

On the other hand, the PESTLE analysis for Pakistan, although legal and political factors as well as a well-educated workforce are favourable for investment, biodiversity, technological, and economic factors increase risk on long-term sustainability, particularly on the efficiency of financial markets, which does not inspire confidence to invest. In addition, reaching feedstock seems problematic at Pakistan due to lack of developed road and railway infrastructure. Despite all those, low labour cost, low cost of regulations on biomass industry, biodiversity, water sources, offer an advantage on the price and cost competitiveness. The PESTLE analysis has resulted the main factors that affect the sugar and ethanol markets in UK and Pakistan. Table

5.8 summarizes the key findings obtained from the analysis comparing UK and Pakistan sugar and ethanol industry.

5.4.1. The PESTLE Analysis for the UK and Pakistan Sugar Production

The PESTLE analysis is a structured approach to examine the external environment of the entity (sugar production industries in the UK and Pakistan). There are six categories of environmental influences: P – Political Environment, E – Economic Environment, S – Social Environment and T – Technological Environment and, L – Legal Environment and E – Ecological Environment This framework of analysis will be utilised to analyse the sugar industry in the UK and Pakistan in the subsequent sections.

Political Environment

UK: The political environment for the sugar industry in the UK has several elements (Littlewood, Murphy, and Wang, 2013). These include UK and EU policy influence, health concerns, decarbonisation of transport, and Brexit. The sugar sector in UK is operated under the European Union's (EU) Common Agricultural Policy. The policy focuses on farmers income and living and food supply. It does not contain any support policy for public health. There was also a quota system for sugar production and price, but the system ended in 2017. The quota abolition resulted in increase in EU sugar beet production to 142 million tonnes in 2017-18 which is 27% more than average of last five years white sugar production increased to 21.1 million tonnes which is 26% more than in 2016-17 (European commission, 2019). Following the abolition of the quota system, the EU Commission established the Sugar Market Observatory to assist farmers and processors in making business decisions by providing up-to-date price and production statistics. Because the UK is a net importer of sugar, the EU has developed appropriate policies for sugar import and trade.

In UK, the biofuel policies with sustainability criteria are set by Renewable Energy Directive (RED). The biofuel industry has been lobbying for the launch of 'E10' blending of biofuel to RED decarbonisation targets. The industry also had pressure to increase the market headroom for domestic production due to import competition (NNFCC, 2019). The lobby for biofuel not only includes farmers and biofuel producers but oil companies, seed manufacturers and agribusiness are also part of it. Furthermore, food and beverage companies, producers of poultry and livestock and restaurant chains are in opposition to support biofuels (Bailey, 2013).

In UK, many things changed after the Brexit (British Sugar, 2019). This means no more quotas, no more dependent on EU rules for sugar beet prices, export, import and prices of sugar. It will allow the government of UK to have favourable and balanced policies for sugar beet and sugar cane-based sugar producers in UK. But there are concerns raised by the National Farmers Union that cheap imports can affect the sugar beet farmers. Sugar beet prices in UK fell before the Brexit deal; also due to new restrictions on the use of pesticide, many growers want to move to other crops. The new tariff-free quota will help the sugar refiners in UK to produce sugar locally more freely than before. There are health concerns on the rise in the UK and sugar tax has been imposed to tackle the level of sugar being added into drinks and sugar products.

Pakistan: The political environment for the sugar industry in Pakistan is directly influenced by two main factors: lobbies and a weak policy environment. In Pakistan 89 sugar mills are currently operating whose owners are mostly influential people including politicians of both Punjab and Sindh provinces (Abbassi Securities, 2019). Pricing of sugarcane is the responsibility of provincial governments to set the sugarcane procurement price from cane growers for the sugar mills. Government has control on domestically available sugar and regulate export quotas for surplus sugar exports. Politically connected mill owners lobby for maintaining a low sugarcane procurement price. They also put pressures on government to allow higher export quotas. The sugarcane growers on the other hand lobby for a fair procurement price for them. Sugar cane growers' union tried to put their motive in front of government and let the government to decide what is best for the farmers and to tackle sugar mill owner to suggest a suitable price for both. The sugarcane cultivation area has decreased by 12% for 2019 and sugar production by 16% because of delays in payment from sugar mill owners (PSMA, 2020).

The pricing of sugar is basically dependent upon the dynamics of the international market prices. This fixed policy for sugarcane and uncertainty in sugar prices results in scuffle between sugarcane growers and millers of sugar. Government policy appears to have failed in managing excess sugar exports as well, particularly between October 2016 and December 2018

(Abbasi Securities, 2019). Government lost foreign exchange in this period due to time delay between request and approval of export without considering international price dynamics.

The industry is also harmed by the country's ineffective policy framework. The government directed Pakistan State Oil (PSO) and the Hydrocarbon Development Institute of Pakistan (HDIP) to begin blending fuel in 2006. They started a pilot project with ethanol blending in gasoline at a 10:90 ratio in three PSO petrol stations (Asian Development Bank, 2017). However, the government's policy support for this was not properly established. The government enlisted the Ministry of Petroleum and Natural Resources to promote bioethanol, demonstrating the power of the oil lobby within official circles (Khan,2007). The conflict between different lobbies, the corruption link, and power politics all play a role in shaping Pakistan's sugar industry.

Economic Environment

UK: The economic environment for sugar and ethanol industry in the UK is directly influenced by trade policies and biofuel obligation policy as well as the sugar tax. As mentioned in political analysis, abolition of EU sugar production quota resulted in more sugar production. The excess supply reduced the world sugar prices from € 540 per tonne in 2016 to € 274 per tonne in 2018 (European Association of Sugar Manufacturers, 2019). According to European Association of Sugar Manufacturers, the sugar price in EU is not sustainable for sugar and sugar beet production. As sugar prices tend to decrease in the EU market due to low world sugar prices, this in turn makes beet prices lower. British Sugar and National Farmers Union negotiations over the beet contract of 2016-17 resulted in £20.30 per tonne price which is the lowest price ever (NFU, 2016). The sugar tax factor is another factor which leaves an impact on the economy in the UK. Sugar tax will impact in discouraging people from the sugar products, which can eventually decrease the demand and leads to oversupply.

Due to this price volatility UK emphasizes on producing bioethanol and other biobased chemicals. The use of biofuels in UK is prescribed by RTFO targets. Ethanol is advantageous for the mills, as it can produce ethanol which can be blended into petrol. It will create more jobs, and revenue for the government.

Pakistan: As described in political analysis that government is responsible for sugarcane support prices and export quotas, the economics of the sugar industry is affected by these policies.

1) The price control had an impact on the viability of sugar mills because the sugarcane support price was kept high while the retail sugar selling price was kept low. Sugar retail price was Rs.57.71/kg in 2017, but it was reduced to Rs.53.85/kg in 2018, while production cost was Rs.63.52/kg. Sugarcane support prices in Punjab and KPK in 2018-19 were Rs.180 per 40kg, and Rs.182 per 40kg in Sindh (PSMA, 2019). the sugar millers incurred losses. However, the price structure was improved in 2019 after export and average retail price rose to Rs.68.4/kg. When prices of sugar are controlled by the government or fixed in the beginning, it helps the sugar mills to produce more effectively. It allows them to crush all available sugar cane to produce sugar as it protects their right of profit. Ethanol prices in Pakistan were stable during this time but with increased price of sugar cane, the price of sugar went high, so did the molasses.
2) Furthermore, when the export quota is reduced, the revenue potential from exports for sugar mills is reduced (PSMA, 2019). For example, the 2019 sugar export quota was reduced from 2 million tons to 1.1 million tons without any federal freight support or subsidy announcement. Instead, the province of Punjab declared a subsidy of Rs.5.35/kg, which raises sugar prices. However, due to delays in quota request and approval, as well as international sugar price dynamics, the export was still only 0.712 million tons (Ministry of Finance, 2019).
3) Molasses being used for bioethanol production implies that the alternative route for using excess sugar is limited. This further affects economic viability of mills.

However, the export market for ethanol has emerged in recent years as an attractive option. Due to its low domestic use, it is exported to earn foreign exchange. In 2019, 0.35 million tons of ethanol were exported. There is export quota from the government for ethanol export and it became a good source of foreign exchange.

Social Environment

UK: In 2005, there were 7,300 sugar beet holdings with an average size of 20 hectares, but by 2014, there were only 4,300 holdings with an average size of 35 hectares and 3,400 growers (Agriculture in the UK, 2019). This reflects fewer farmers working on a larger scale in the UK. As noted, subsidies are provided to farmers as part of the Common Agricultural Policy (CAP) (BBC, 2013). Harvesting of sugar beet is preferable in early winter or late autumn, however, wet weather harvesting results in soil loss, consequently, farmers may leave sugar beet farming behind. In addition, due to low beet prices mentioned in economic analysis, farmers will tend to shift towards farming of other crops (Richardson, 2016). Biofuel policies and mandates set in UK create pressure on food prices by increasing sugar demand. It also increases volatility in food prices. Since ethanol is mainly produced by corn and wheat in UK, the prices of these spike, creating food security concerns (AB Sugar, 2016).

Pakistan: In Pakistan, agricultural land distribution is insufficient, with farmers receiving an average of 5 acres (i.e., 2 hectares) of farmland, which is quite small (Pakistan Bureau of Statistics, 2015). Most farmers did not receive adequate government support prices for sugarcane due to sugar mill owners' demand discounts based on sugar quality and demand. For this reason, farmers involve middleman for selling their outputs which saves their transportation charges. The middleman exploits the farmers by charging higher prices. This results in higher sugar production prices than sugar retail prices (Abbasi Securitoes,2019) Ethanol production from molasses is feasible for Pakistan in terms of food security as molasses is a by-product of sugarcane processing and it is not a food crop. In addition, according to respondent #PKEthanol10*, "a single ethanol distillery has the capacity to accommodate 200-250 skilled and unskilled workers and labourers".* Therefore, mills' social role in supporting education, roads, and hospitals is also critical for rural development. This means that rural residents will have more job opportunities. On the other hand, sugarcane cultivation and molasses production employ 70% of the rural population (Pakistan Bureau of Statistics, 2015). As a result, farmers' income can be effectively increased through molasses export. Currently, Pakistan has no policy regarding the socioeconomic benefits of ethanol production for farmers (Arshad, 2019).

Technological Environment

UK: In the United Kingdom, the British Beet Research Organisation (BBRO) has established very effective knowledge exchange and research and development programmes with the goal of developing and implementing efficient methods for sugar beet production (Thornton, 2018). Sugar beet yield in the United Kingdom has increased by 25% in the last ten years because of their efforts and collaboration. Using modern crop varieties in conjunction with best agronomic application in suitable soil and weather conditions, yields can reach 70 tonnes per hectare (NNFCC, 2019). Government of UK has established National Non-Food Crops Centre, NNFCC in 2003. It is a bio-economy consultancy serving internationally covering bioenergy and bio-based products. NNFCC focused on the research for designing more sustainable feedstocks and processes for biofuel production to further minimize GHG emissions and impacts on land use change. The government has also expanded research and development budgets for bioenergy, novel, and advanced biofuels. R & D has been working on advanced processes for using lignocellulose for ethanol production. In addition, R & D focusses on providing finer conversion efficiencies by investigating innovative pre-treatment technologies and new enzymatic techniques. Furthermore, in 2008 "Integrated Biorefining Research and Technology Club" was launched to strengthen the research in technologies used for bio-refining (FAO, 2008).

Pakistan: In Pakistan, all sugarcane cultivation processes, including planting, weed management, fertiliser application, and harvesting, are manual and labour-intensive (Abbassi Securities, 2019). This is because farmers have limited access to modern technology and financial assistance. Furthermore, research and development organisations are not doing enough to raise awareness about the use of advanced technologies. Furthermore, low yielding crop varieties are used in practise, while high yielding crop varieties for sugarcane require research (Bezerraand Ragauskas, (2016). Water scarcity is another reason for low sugarcane yield and drip irrigation system has not been widely applied which decreases the requirement of water and increases the yield (Abbasi Securities,2019)**.** There are 89 sugar mills in the country producing ethanol from molasses. Most of the mills using simple molecular sieve technology for ethanol production. This production technology is a low-tech approach which limits the process and yield, thereby limiting obtaining maximum benefits (Mirza,2017). The low profitability may be a factor affecting introduction of modern technologies.

Legal Environment

UK: The EU's Renewable Energy Directive (RED) drives UK policy on transport sector decarbonization. By 2020, RED has set a mandatory target of extracting 10% of the energy consumed in the transportation sector from renewable sources (British Sugar, 2019). This condition was introduced by Renewable Transport Fuel Obligation in 2008 in the UK law. Furthermore, Fuel Quality Directive (FQD) by EU was introduced by Motor Fuel Greenhouse Gas Emissions Reporting Regulation 2012 in the UK law. According to this the average GHG emissions from transport fuels should be reduced by 6% by the year 2020 and is mandatory requirement for Fuel suppliers in UK. To meet the RTFO requirement, sugar beet contributed only 10% compared to other renewable feedstock fuels in 2017-18. Due to the concerns related to land use change impacts linked with crop derived biofuels and new legislation by RED II, UK has put a crop cap of 4% which will reduce to 2% by 2032. (NNFCC, 2019).

Pakistan: The provincial governments of Pakistan regulate the sugar supply, its distribution, and prices under the Sugarcane Act 1934 (Pakistan Sugar Mills Association, 2019). As per the Sugar Factories Control Rules 1950, the Cane commissioner was given the authority to control sugar mills in terms of purchasing sugarcane and allow them to purchase from the advised areas with fix quantities. The government of Punjab province enjoys the power of deciding the ex-mill price and sugar sale and purchase prices under the Punjab Act 1958. The Price Control and Prevention of Profiteering and Hoarding Act of 1977 grants similar powers to the province of Khyber Pakhtunkhwa. The federal government initiated the sugar export arrangement under the Export Policy Order 2016, which restricted sugar export. The Competition Commission of Pakistan under the Competition Act 2010 has the power to observe the decisions and agreements of governmental and other regulatory bodies. In addition, courts are also involved in monitoring government actions. However, this spread-out legal control on sugar industry of Pakistan appears to be ineffective and inefficient. Due to high oil prices, the government directed in 2006 that 5% ethanol be blended into motor gasoline. Through pilot projects, Pakistan State Oil (PSO) introduced 10% ethanol blending in gasoline (Pakistan State Oil, 2019). Following the success of pilot projects described in political analysis, PSO officially launched E10 fuel blending in 2010. The government has allocated PKR 4 billion to oil companies for the establishment of 200 E10 fuel stations across the country (Ali, 2019). Currently, proper blending programmes are required by law to promote ethanol production. (Banikov, 2014).

Ecological Environment

UK: RED and FQD have set criteria for sustainability of consumption of biofuels in EU. Requirements include savings of greenhouse gases, biodiversity, and appropriate use of land. For environmental sustainability savings from GHG should be 50% compared to fossil fuels, land from where raw materials is derived can have low biodiversity value and low carbon stock. Typical GHG savings according to RED from sugar beet ethanol are 61% with no emissions from land use change (biofuel annual). As per RED II, the savings from GHG emissions are 79% from sugar beet ethanol of a plant which utilizes by-products for producing natural gas and biogas. Emissions arise from cultivation stage during land preparation by machinery using diesel as a fuel. However, cultivation emissions from sugar beet are lower than wheat because of less fertilizer requirements and higher yield. For the sugar beet drilling and harvesting, required energy is higher than cereals due to specific harvesting equipment and weight of beet. The processing of beet juices to ethanol has emissions from 7.6 to 27.4 gCO_2e/MJ (Juan & Ramirez, 2017). Water footprint of ethanol from beet is very less compared to other feedstocks for ethanol in EU. In 2017-18, ethanol from sugar beet consumed in transport sector of UK had a carbon footprint of 34-40 gCO_2e/MJ of ethanol, having GHG savings of 52-60%. (NNFCC, 2019).

Pakistan: Sugarcane cultivation in Pakistan utilizes diesel and electricity for preparation of land, maintenance of crop and irrigation. Mineral fertilizers are used in soil and agrochemicals are used for pest control. After harvesting of sugarcane its trash is mostly burned. Diesel is also used in transportation of sugarcane to sugar mills. The use of diesel, fertilizers, agrochemicals, and cane trash burning contributes to air pollution and GHG emissions. In addition, in sugar mills the wastewater is discharged in the surface water creating water pollution. Ethanol production is a closed cycle utilizes energy from sugarcane residue i.e., bagasse for the processes of refinery and distillery. From the ethanol plant wastewater is utilized to produce biogas which is another source of energy for the plant. Moreover, the wastewater from biogas unit moves through by pond and discarded for evaporation (Ghani, 2018) Almost 80% of the emissions and air pollution are caused by sugarcane production chain due to inefficient irrigation system and fossil- based fertilisers while negligible emissions are from ethanol production process. Also, water scarcity footprint is 98% due to cane farming in whole sugarcane to ethanol production chain. The carbon footprint for molasses-based ethanol is 26 gCO_2e /MJ of ethanol (which is lower than UK as sugar beet emit more CO2) with GHG savings of 70% compared to gasoline (Ghani,2019). The carbon footprint of ethanol based in molasses is lower in Pakistan than the one produced in the UK with sugar beet because the co2 which released in the air when ethanol is used in the cars is offset by the carbon dioxide is captured when crops are grown with the use of ethanol. Sugar beets emit more co2 emission than sugar cane molasses.

Table 5.8: Comparative Analysis sugar and ethanol industry of UK and Pakistan , source: Author derived from the results of the pestle analysis

PESTLE	PAKISTAN	UK
Political	* Two lobbies including sugarcane growers and sugar millers * Failed policy of government for managing surplus sugar export * Scuffle between cane growers and sugar millers due to pricing policy of sugarcane * Oil companies lobby for bioethanol production * There is RED but applying in the market is at low rate.	* No lobbies in sugar sector * Proper policies for sugar import and trade are defined * No scuffle between growers and millers as they are supported by EU commission policies * Biofuel industry lobbies for new fuel blending. The lobby include farmers, biofuel manufacturers, oil and seed companies. * Strong and reliable RED
Economic	* Export of sugar improves retail sugar prices * Delay in export quota request and approval results in less export of sugar * No subsidies for farmers and for export * Ethanol is exported mostly * Ineffective financial market	* Low world sugar prices decrease EU sugar prices which in turn dropped beet prices * Import tariff and free trade tariff properly defined for raw sugar and white sugar * Subsidies provided to farmers * Ethanol used to meet RTFO, no export of ethanol * Strong financial market
Social	* Average farm size is very small * Farmers income are not protected by proper policy * No food security concerns for sugarcane and sugar * Low entrepreneurship * Low management skills * Education among farmers is very low	* Average farm size is large * Farmers income supported by subsidies under government policy * No food security concerns for sugar beet and sugar * High entrepreneurship among youth * Innovated management skills * Strong education among farmers
Technological	* Lack of adequate research and development for sugarcane production * Lack of proper knowledge for using modern crop varieties, agronomics and soil condition resulted in low sugarcane yield * Processes are not mechanized and lack of technology awareness * Old technology used for ethanol production * R & D needs to focus on new and advanced technologies	* Adequate research and development for sugar beet production * Proper knowledge of crop varieties, soil conditions and agronomics resulted in high beet yield * Advance/improved technology usage for biofuel production * R & D focusses on new technologies for biofuel production
Legal	* No regulations defined for GHG emissions and land use change impacts * Legal control over sugar sector is ineffective * Fuel blending has set without any proper law	* GHG emissions target regulations are defined * Blending of fuel described under transport obligation
Ecologic	* GHG emissions savings of around 70% * Emissions from cultivation and harvesting stage are higher * Negligible emissions from ethanol production process * Water scarcity footprint is high	* GHG emissions savings of around 52-60% * Emissions from cultivation stage are less than harvesting stage * High emissions from ethanol production processes * Water scarcity footprint is less

5.4.2. Comparative Analysis sugar and ethanol industry of UK and Pakistan

The PESTLE analysis has resulted the main factors that affect the sugar and ethanol markets in UK and Pakistan. Table 5.9 summarizes the key findings obtained from the analysis comparing UK and Pakistan sugar and ethanol industry.

Table 5.9 Comparative Pestle analysis of UK and Pakistan, Source: Author, derived from the analysis

	Political Environment	Economic Environment	Social Environment	Technological Environment	Legal Environment	Ecological Environment
PAKISTAN	Two lobbies including sugarcane growers and sugar millers	Export of sugar improves retail sugar prices	Average farm size is very small	Lack of adequate research and development for sugarcane production	Fuel blending has set without any proper law	GHG emissions savings of around 70%
	Failed policy of government for managing surplus sugar export	Delay in export quota request and approval results in less export of sugar	Farmer's incomes are not protected by proper policy	Lack of proper knowledge for using modern crop varieties, agronomics and soil condition resulted in low sugarcane yield	Legal control over sugar sector is ineffective	Emissions from cultivation and harvesting stage are higher
	Scuffle between cane growers and sugar millers due to pricing policy of sugarcane	No subsidies for farmers	Farmers exploited by middleman with high charges, due to which sugar prices increases	Processes are not mechanized and lack of technology awareness	No regulations defined for GHG emissions and land use change impacts	Negligible emissions from ethanol production process
	Oil companies lobby for bioethanol production	Ethanol is exported mostly and earn foreign exchange	No food security concerns for sugarcane and sugar	Old technology used for ethanol production		Water scarcity footprint is high
				R & D needs to focus on new and advanced technologies		
UK	No lobbies in sugar sector from government	Low world sugar prices decrease EU sugar prices which in turn dropped	Average farm size is large	Adequate research and development for sugar beet production	Blending of fuel described under transport obligation	GHG emissions savings of around 52-60%

		beet prices				
	Proper policies for sugar import and trade are defined	Import tariff and free trade tariff properly defined for raw sugar and white sugar	Farmer's income supported by subsidies under government policy	Proper knowledge of crop varieties, soil conditions and agronomics resulted in high beet yield	GHG emissions target regulations are defined	Emissions from cultivation stage are less than harvesting stage
	No scuffle between growers and millers as they are supported by EU commission policies	Subsidies provided to farmers	Farmers shift towards other crops due to low beet prices and changes in climate	Advance/improved technology usage for biofuel production		High emissions from ethanol production processes
	Biofuel industry lobbies for new fuel blending. The lobby include farmers, biofuel manufacturers, oil, and seed companies.	Ethanol used to meet RTFO, no export of ethanol to earn foreign exchange	food security concerns for sugar beet and sugar if more sugar beet is used for ethanol	R & D focusses on new technologies for biofuel production		Water scarcity footprint is less

5.4.3. Summary of PESTLE analysis

According to the PESTLE analysis, Pakistan has a high potential for sugar cane cultivation; however, the government of Pakistan has failed to manage surplus sugar export and there has been a scuffle between cane growers and sugar millers due to sugarcane pricing policy. Also there exists a lack of adequate research and development for sugarcane production, as there are no food security concerns for the sugarcane and sugar industry. As a result, R&D must focus on new and advanced technologies, and farmer income may be protected through government policy. Furthermore, biofuel industry lobbying for new fuel blending must be limited. In the United Kingdom, on the other hand, there are no sugar lobbies, and the government provides subsidies to farmers. R&D focuses on new biofuel production technologies. As a result of proper knowledge of crop varieties, soil conditions, and agronomics, beet yield was high. Notably, until the EU splits up, the sugar and ethanol markets are heavily protected, but this is expected to change. The use of sugar beet and wheat for ethanol raises food security concerns. Even though the wheat used is of feed grade quality. Much research is being conducted to increase sugar beet yield to increase the proportion of local sugar production. New research and technologies are also being developed for producing ethanol from non-food and oil crops. Finally, a mandate and regulations are in place to reduce GHG emissions. Many organisations support ethanol because of its low GHG emissions.

5.5. Thematic Analysis

Braun and Clarke (2006) proposed using thematic analysis to investigate how participants think about the factors affecting the sugar industry in Pakistan and the United Kingdom. Semi-structured interviews were conducted with sugar industry stakeholders in various positions, and the same questions were asked on both sides with no differences in the interview guide. The ethical approval was obtained from the De Montfort university ethic committee. All the participants agreed and provided consent with it. They were informed that they could withdraw at any time and that no information about them would be released. The password-protected excel sheets were used to record interview. The responses form the interviews were coded to generate the sub-themes followed by finalizing the core themes as shown in TABLE 5.10. Interview was conducted either in the sugar mill office or at a mutually agreed, time, day, and place. It was a semi structured interview. Participation in this study was completely voluntary. There were no foreseeable risks associated with this project. However, it has been reported that he did not have to answer any question if he didn't feel comfortable. It was very important for us to know all the opinions. The answers were strictly confidential and the data from this research would be reported in aggregate only as agreed in the consent form. To strengthen the process of analysis and gather the most appropriate data, researcher reviewed the interviewed and reflected on the procedures. The data which was collected was transformed to excel to use them for the analysis. The data was verified again by conducting further interviews and friendly discussions with sugar mill and ethanol distillery managers and personals.

The main objective was to identify the themes from the interviews to interlink the research objectives. Therefore, six-stage process of analysis presented by the Clarke and Braun (2014) based on framework was utilized in stages to obtain the thematic analysis as follows:

1. Familiarizing with the data of interviews and identifying the interested items

This qualitative data thematic analysis identifies the factors influencing the sugar industry in Pakistan and the United Kingdom by recording the results of semi-structured interviews (held with sugar industry experts). The notes for the discussion were recorded for coding purposes, which aided the researcher in gaining a better understanding of the data pattern.

2. Themes searching: codes examining and identifying the pattern

Table 5.10 shows how the interview data was transcribed and coded to produce the themes and sub-themes. Thematic analysis necessitated transcription of the interview recordings and subsequent coding. Initially, the transcript was read several times to become acquainted with potential themes. As a result, the analysis becomes more robust. For example, sugar cane is regarded as one of the most important cash crops grown in Pakistan. Several factors are currently affecting the sugar industry and production in Pakistan. Traditional farming practises used by sugarcane farmers may be one of the main causes of insufficient production. It states that less sugar cane and lower sugar yield results for the factors that are directly affecting. In comparison to Pakistan, the UK has a reasonable sugar beet production of around 7,620,000 MT for a low sugar beet cultivation area. Despite this significant amount of sugar produced, the current sugar beet crop remains insufficient to meet total demand, with the majority of the sold product aimed at the British Sugar market.

3. Themes review

It was necessary to review the themes as it helped to apply the themes of the given data in analysing whether the story is correct which is coherent with the thematic area. Themes were defined, written, split and re-defined. This process helped in organizing the given information.

Therefore, this stage 4 of the analysis was involved in re-reading of the information to make sure that it flows with the identified themes.

4. Naming and defining the themes

The researcher was able to develop the table to analyse each theme at all stages by defining the themes with the information. At the stage 5, it was identified if there are any sub themes. This process helped to revise the completed part and for the themes identification to explain the factors which are affecting sugar production in Pakistan and UK in accordance with sugar farmers and sugar millers as shown in the table 5.10. In Pakistan lack government support lead to degradation of sugar industry, Transportation of the sugar cane is difficult due to poor infrastructure in PK, Yield issues represent in Agriculture department doesn't help in providing guidance and for introducing a suitable variety , Degradation of the sugar cane farmers because of there is no proper policies to support the price of sugar cane, farmer can shift to other crops in PK, Price of sugar the final price of the sugar should be announced by the government after consultation with the sugar mills. In UK, according to ASR, Poor Policies, Monopolization, and Eu quota regime are the factors affecting sugar production in UK. If sugar beet is grown less, less yield and Over supply of sugar from the Eu might affect sugar production in UK. Otherwise after the quota is ended, it will give opportunity to UK local sugar producers to sell more. When asked if a sugar tax would increase sugar production or if the government would encourage voluntary reductions in sugar content in food and beverages, he replied, "No." No, the effect on sugary products, such as cola and sponge cake, will be more muted, because the cost of sugar is only a small portion of the overall price of those goods)). No government support, low profit, low sugar yield, and low yield crops in Pakistan, as well as less sugar beet and farmers unable to convert to sugar beet, have all contributed to the factors affecting sugar production in Pakistan and the United Kingdom. Table 5.10 presents a summary of the coding process for the sugar cane industry and the sugar industry, which assisted in identifying the factors affecting the sugar industry.

Table 5.10 Coding process to understand the factors which are affecting sugar production in Pakistan and UK according to sugar farmers and sugar millers. The factors affecting sugar production according to sugar mills and sugar cane/beet farmers' opinions such as government support, sugar mills owner, cost of sugar cane, agriculture guidance and taxes

Question	**Example of quotes**	**Example of codes**	**Sub Themes**	**Themes mapping against the data**
Describe the factors affecting sugar production in Pakistan according to sugar mills and sugar cane/beet farmers' opinions.	Pakistan sugar cane farmers			
	Government has not supported us (PK)	Lack of government support.	Degradation of sugar industry in PK	Weak law
	Sugar mills are exploiting sugar cane growers in PK	Exploitation		
	Late payments are paid by the sugar mill owners in PK	Late payments	Low level of protection	Law not able to fully support the farmers
	Brokers are exploiting in between for the price mechanism	Brokers exploitation		
	Transportation of the sugar cane is difficult due to poor infrastructure in PK	Transportation issues		
	If no proper policies to support the price of sugar cane, farmer can shift to other crops in PK	Price protection	Degradation of the sugar cane farmers	
	Agriculture department doesn't help in providing guidance and for introducing a suitable variety which can give better yield	Yield issues	Degradation of resources	Coordination among stakeholders

	<u>Pakistan sugar mills</u>			
	The cost of sugar cane is high, which makes the production cost to go high and finally sugar price will be higher	High cost of raw material	Subsidy	PSMA and government to work together
	The sugar cane variety doesn't give more than 9-10% sugar yield which is far less as compared to other countries	Low yield	Lack of research	
	The tax rate on the sugar industry is high, which results in expensive sugar and can affect the sugar production.	Tax issues		Sugar tax act
	The final price of the sugar should be announced by the government after consultation with the sugar mills.	Price of sugar	Lack of communication	
	<u>UK Farmers</u>			
	National farmers union is the voice of British farming, which protects the sugar beet growers	Protection	Support from government	

	in UK. What are the usages of sugar beet in UK and UKFarmer1 declared that sugar beet is used in sugar and ethanol production in UK. Half of the UK sugar is produced from the sugar beet and is backbone of the sugar industry According to UKFarmer1, farmers are happy to grow this crop There is no subsidy on growing sugar beet According to farmers, people are not growing more sugar beet because income is less <u>UK Sugar mill</u> Home grown sugar beets are not enough to produce all needed sugar in UK There is no subsidy from government for producing sugar Sugar production demand will increase with the increase of	Uses if sugar beet Backbone Happy No subsidy Less income Not enough beets No subsidy Increase of demand	Homegrown sugar Protection with payments Incentives for farmers Balance of demand	

	population according to UKSugar2		Monitor of prices	
	According to UKSugar2, sugar industry prospect will be great if EU quotas are removed, and cheap raw sugar is allowed to import into UK	Cheap sugar	Better political policies	
	According to UKSugar2, Poor Policies, Monopolization, and Eu quota regime are the factors affecting sugar production in UK	Political factors	Better political policies	
	According to UKSugar1if sugar beet is grown less, less yield and Over supply of sugar from the Eu might affect sugar production in UK. Otherwise after the quota is ended, it will give opportunity to UK local sugar producers to sell more	Political factors		
	When asked, Will the Sugar production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in			

	food and beverages? UKSugar1: No UKSugar2: The effect on sugary products, like cola and sponge cake, will be more muted, because the cost of sugar only makes up a small part of the overall price of those goods. For example, if the cost of sugar fell by 40%, that might lead to a saving of less than 1% on the price of a Victoria sponge cake.			

6. Report generation

The final stage of the thematic analysis was to create the report by incorporating all the data segments. The emerging codes and meanings were thoroughly examined and presented. According to data analysis, the Pakistan sugar industry believes, and all agreed, that there is a lack of government policies. The government is not encouraging farmers to grow more sugar cane to produce more sugar. Sugar yields must be increased by introducing new varieties. According to SWOT analysis, despite significant growth in sugarcane incomes, it remains low in comparison to the average evolution in the sugar industry; the national average cane production is 750 pounds per Maund (one Maund in Pakistan is equal to 40 kilogrammes), which is very low in comparison to its potential (it can reach 1400 in case of future farming with better variety). According to farmers polled, sugar cane production is profitable: small farmers earn PKR 50,000-75,000 per acre, medium-sized farmers earn 75,000-100,000, and large-scale farmers earn 100,000-150,000. Sugarcane production is currently constrained by a variety of factors. However, these earnings can be increased further. The main constraints of low production could be due to traditional farming practices adopted by sugarcane farmers. The other constraints could be higher input costs, lack of government support, exploitation from sugar mills in terms of late payment, and Broker Mafia. Constraints are those hinders that come in the way of the adoption of the latest production technology.

In comparison, the UK has a significant sugar beet production of approximately 7,620,000 MT for only 110,000 Hectares of sugar beet cultivation area, resulting in a sugar beet yield of approximately 69 Tonnes per Hectare. The percentage of sugar produced from beets ranges between 50% and 60%, whereas the percentage of sugar produced from cane raw sugar ranges only between 40% and 50%. The sugar beet in UK is used for not only sugar production but also for Ethanol and Animal feed production. The current sugar beet remains insufficient for complete demand, where most of the sold product is oriented to British Sugar market. The factors impacting the British sugar industry are different from those of Pakistani ones, they are: Poor Policies, Monopolization, EU quota regime, less sugar beet. sugar beet is less income crop as compared to other crops and health concerns.

5.6. Conclusion of the chapter

Several studies on the factors influencing sugar cane and sugar beet production have been conducted (Table 3.4). There have been extensive studies on the food vs fuel, but none could cover sugar vs ethanol. The scope of study on the factors affecting the sugar industry itself was limited. These studies focused on this domain and identified several factors that influenced sugar production in Pakistan and the United Kingdom. SWOT analysis was carried out to understand the strength, weaknesses, opportunities, and threats related to sugar industry and for this secondary data was used from the official sources. In the case of Pakistan, strength and opportunities were top ten producer of sugar cane, produces many by products, employment, and utilization of byproducts for energy generation and ethanol production, and weaknesses and threats were: low sugar cane yield, politicized industry, and unfavorable policies for the farmers. In the case of UK, strength and opportunities were top ten producer of sugar beet in the EU, provides direct employment, and opportunities for the refiners to fill the demand and supply gap, and weaknesses and threats were: only two major players, decreases in sugar beet cultivation in recent years, health issues and competition with other crops.

As per the demand and supply analysis, Pakistan and UK sugar demand are stable or will continue to grow very slowly. If the demand of sugar increases in next few years in Pakistan, it can overcome the local demand by cutting on its exports and supplying more sugar locally. If the sugar demand increases in UK, they would need to import more sugar (As it was explained in the analysis, Pakistan is one of the largest sugar-exporting countries. If the demand for sugar increases, it can reduce exports to address this problem. As for UK, only half of the sugar is produced in the UK and rest is imported. There is a downward trend if demand decreases due to obesity issue otherwise if demand increases, they will have to import more sugar from abroad. If the supply of the sugar increases in Pakistan, it will give them great opportunity to export surplus. According to data from the previous decade, Pakistan's demand and supply will remain stable, and with the right policies, the country will be able to export more sugar in the coming years. If the supply of sugar in the UK increases, they will be able to meet local demand and save a lot of reserves. The data suggest that UK demand is more, and supply is less, if supply decreases more than current production, they will need to bring more sugar into the country and if supply increases, they can meet demand (Table 5.3). As can be seen, the rate of consumption exceeds the rate of production; % of the domestic demand for sugar is met by locally grown sugar beets, while the remainder is imported from the EU/rest of the world; the increase in import is a significant stimulus factor in increasing sugar production in UK.

Thus, if the rate of supply increases, the UK will reach self-sufficiency and increase the rate of inventor Thus, if the rate of supply increases, the UK will reach self-sufficiency and increase the rate of inventory their local demand first. Pakistan has a great potential for sugar cane cultivation for sugar production, but a lack of appropriate policies and a government unwilling to confront the mafia are undermining the case. If farmers can sell their product directly to mills without the use of a middleman and receive their payments on time and firsthand, things will improve up for the sugar industry. Pakistan is also one of the top ten countries in terms of sugar both production and exportation, and if it can produce well, it can easily export and earn millions of dollars. It should also be noted that the ethanol industry in Pakistan is linked to the sugar industry, so an increase in sugar cane or sugar production in Pakistan will benefit the ethanol industry as well. There has been a lack of proper research for the better sugar cane variety to extract more yield, which could aid in the increase in sugar production (Figure 5.2).

Once SWOT analysis was done. It helped to carry the demand and supply analysis to understand the demand and supply market of sugar in both countries. The need of the PESTLE analysis was emerged, there was it was decided to do the PESTLE analysis. According to PESTLE analysis (Table 5.9), there are no regularities in terms of GHG emissions control, waste control from sugar and ethanol mills in Pakistan. In UK, sugar is produced from sugar beet only and that also only fulfils half of its demand. The other half is fulfilled through imported raw sugar which then is refined in UK. Policies are in place to protect local farmers and sugar industry. There is a strong lobby to implement higher mandate of ethanol in UK. Subsidies are provided to sugar beet farmers. The sugar and ethanol market are heavily protected till EU split over, but it is expected to change. There is a food security concern for using sugar beet and wheat for ethanol. Although the wheat which is being used is feed grade quality. There is lot of research going on to increase the yield of sugar beet to have higher proportionate of local sugar production. New research and technologies are being developed to produced ethanol from non-food and oil crops. There is a mandate in place in UK and regulations for GHG emissions. Many organizations work for the favour of ethanol due to its low GHG emission. Table 5.7 of the PESTLE analysis compares between both countries about all five factors of PESTLE.

To confirm all the above analysis, such as SWOT, demand and supply, and PESTLE analysis, it was decided to do the thematic analysis to confirm the results with the analysis which were based on the secondary sources. Thematic analysis (Table 5.10) explains the result of the answer of the stakeholders, and it was concluded that, government policies, late payments to the farmers, low variety crop can have impact on the sugar industry in Pakistan. In the case of UK, if more sugar beet is used for the ethanol production, will have an impact on the sugar industry.

The main factors influencing the sugar industry in Pakistan and UK are,

1. Price and market control in Pakistan is heavily concentrated in the hands of the government and sugar mill owners, who control supply and prices of sugar. In the United Kingdom, the NFU acts as an intermediary to settle sugar beet prices, and the price of sugar is set by the government to protect sugar millers. In comparison to the United Kingdom, Pakistan has a poor agricultural policy. Current government is

working to improve farmer policies to revitalize the agriculture industry, which has been neglected for the past 30 years. Sugar cane farmers in Pakistan have received the highest price in the last 30 years. In the United Kingdom, agricultural policies are in place to protect sugar beet farmers from low crop prices and crop insurance. (Figure 5.2 and Figure 5.3)

2. In Pakistan, there are technological issues since most sugar mills use old technology, which results in less sugar yield and more molasses. On the other hand, the United Kingdom uses cutting-edge technology to process sugar beets into sugar or to refine raw sugar into white sugar. It is a learning experience for Pakistan sugar mills to work on the technology side to reduce processing costs and increase yield. (Table 5.8 and 5.9)
3. Policy weakness is a major issue in Pakistan, but the new government is attempting to address it by focusing on renewable energy. Because there are no official biofuel targets in Pakistan, much of the ethanol produced in the country is exported to Europe. On the other hand, the United Kingdom has a mandate for biofuels, which is a boost for the ethanol industry in addressing environmental issues. (Figure 5.2 and 5.3) (Thematic analysis)
4. Environmental issues are also a major concern, as many sugar mills in Pakistan do not comply with international standards for releasing gases into the air and water. However, the United Kingdom has a proper policy in place to protect the air and environment from the dangerous gases and water released by sugar mills. Pakistan must impose strict regulations to control the environmental damage caused by sugar mills. (Table 5.9)
5. Pakistan used to export a significant amount of molasses, but that has decreased in recent years due to an increase in global demand for ethanol. Recently, an export duty was imposed to deter people from exporting molasses from Pakistan. Pakistan imports fossil fuels while ignoring the need to mandate biofuels and regulate the transportation industry to reduce GHG emissions. However, in the UK, a car checkup is required every year to control emissions, but progress with RTFO is slow. (Demand and supply analysis, Pestle analysis)

Chapter 6: Analysis of possible impacts of ethanol production on the sugar industries of UK and Pakistan

The goal of this chapter is to answer the second research question, which is to examine the potential impacts of ethanol production on the sugar industry in Pakistan and the United Kingdom. Overall, thematic analysis will be applied to data collected from sugar and ethanol producers in Pakistan and the United Kingdom to determine whether ethanol has any impact on the sugar industry in Pakistan and the United Kingdom in particular. A trade-off analysis in which one product is foregone in exchange for another. Ethanol was chosen as our alternative in our paper because of its ability to improve economics while also contributing to environmental control. After understanding and analysing the context, it will be possible to consider some alternative options that may be more beneficial to Pakistan and the United Kingdom. Sugar cane is primarily used to produce sugar, ethanol, cane juice preservation, syrups, and jaggery. According to previous research and recent interviews, ethanol was selected as our alternative due to its ability to improve economics while also contributing to environmental control. As a result, additional trade-off analysis will be performed to determine what alternative products to sugar production are available and what value they can bring to the industry. The ethanol industry will undergo a quick swot analysis to determine its strengths, weaknesses, opportunities, and threats. It will be followed by a "techno-economic analysis" to determine whether producing ethanol is beneficial and commercially viable. Finally, future scenario analysis will be performed to generate various scenarios for sugar and ethanol production that will describe various outcomes.

The interviews

It was done from the ethanol industry people from the UK and Pakistan. Thematic analysis will be applied to extract the data from the semi structured questionnaire to analyse the qualitative data. The thematic analysis was done to understand if ethanol production has any impacts on sugar industry in Pakistan and UK. This approach allows the researcher to understand the views of the participants regarding the trade-off and impacts between the ethanol industry and the sugar production in Pakistan and UK. This will lead to trade off analysis to understand what the trade-off of sugar production is. SWOT analysis and TEA will use primary data and official data to understand various factors and financial stability of ethanol production. Finally future scenarios will be predicted based on historical data taken from Pakistan sugar mills association, Pakistan ethanol manufacturing association, and from the UK government specifically from the department for Environment, Food & Rural Affairs.

6.1. Thematic analysis

The main objective was to identify the main themes from the interviews to interlink the research objectives. Therefore, six-stage process of analysis presented by the Clarke and Braun (2014) based on framework was utilized in stages to obtain the thematic analysis. The details of the stages involved has been presented in the previous chapter. Table 6.1 summarises the coding process for the ethanol industries in Pakistan and the United Kingdom, which aided in understanding whether ethanol has any impact on the sugar industry. Notably all the sub-themes and the themes have been derived through interviews.

Table 6.1 Coding process to understand possible impacts of ethanol production on sugar industry in Pakistan and UK according to Sugar and ethanol industry

Question	Example of quotes	Example of codes	Sub Themes	Themes mapping against the data
Possible impacts of ethanol production on the sugar industries of UK and Pakistan	**Pakistan sugar mills** Ethanol production has no impact as it is using molasses which is a byproduct of sugar industry	byproduct	Utilization of resources	Positive Trade-off
	Currently Pakistan distilleries are using only one feedstock which is molasses and thus no direct or indirect impact	No Impact	Better off	More Revenue
	Ethanol distilleries are providing revenues for the sugar industry since it is buying molasses from the sugar industry	Revenue generation	Financial benefit	
	Ethanol Industry Pakistan Ethanol industry is not impacting the sugar industry	No impact		

	Pakistan ethanol industry does not really compete with the Sugar industry as sugar is being produced by sugar cane and ethanol is being produced by Molasses which is a by-product of Sugar industry	Byproduct		
	Currently Pakistan is producing all its ethanol from molasses, if extra sugar is available, it is profitable to convert to ethanol	Trade-off		
	Ethanol industry works on molasses, and molasses is related to sugar production, if more sugar production, means more molasses and if sugar production is decreased then ethanol production will decrease too.	More production		
	If ethanol can be made from extra sugar, which is being exported (export subsidy is given to sugar mils) then it can save the subsidy and fulfil the local and international demand.	Better-off		
	UK Sugar mills Ethanol production from wheat will have no impact on sugar production	No impact		
	Ethanol production will have low impact if sugar beet is used to make ethanol or more sugar beet is utilized to make ethanol	Low impact		

	Ethanol can use non sugar feedstock such as by products, second and third generation feedstocks	Alternative feedstock		
	Ethanol Industry UK UKEthanol2 states that it doesn't compete with sugar industry in terms of feedstock. Ensus produces enough biofuel to meet one third of the UK's bioethanol demand under the UK's Renewable Transport Fuel Obligation (RTFO). they export to Europe and there is a great potential to increase production with subject to availability of feedstock and no crop cap.	Beneficial		
	UKEthanol1 believes that, if more sugar beet to be used for ethanol production rather than Sugar, it will decrease the quantity of sugar being produced in UK and which eventually will have impact on sugar industry and sugar-based food industries.	Might impact		
	UKEthanol2 believes that ethanol which is produced from the same feedstock such as sugar beet in UK can have impact if more beet to be used for ethanol production.	Will impact		

	UKEthanol3 believes that sugar beet ethanol plants, as well as cane sugar, have some flexibility over how much sugar or ethanol they produce. Depending on the prices of ethanol and sugar, this can cause plants to increase or decrease the supply of sugar / ethanol which affects prices	Flexibility		

Aspects and Impacts

It has been determined that the ethanol industry is very important for Pakistan and is dependent on the sugar industry because it uses sugar industry by-products such as molasses. Because it uses a by-product of the sugar industry, the Pakistan ethanol industry has no impact. If sugar production increases, so will molasses and ethanol production. More molasses means more sugar cane needed to produce the sugar and from which by product of molasses will be available for the ethanol production. None of the distillery is based on sugar cane, all are from molasses based. However, there is no trade-off with this, but if direct sugar cane is used, it can be used to produce sugar, ethanol, or both products in integrated mills, but there will be a trade-off based on economic and data gathered from previous data that shows that ethanol is the viable option available.

In contrast, the United Kingdom, which produces ethanol from sugar beets and feed grade wheat. Because it uses sugar beets, it has little effect on sugar production. If more sugar beet is used for ethanol, less sugar is produced, and the impact is higher. In the United Kingdom, wheat accounts for 95% of ethanol production, with sugar beets accounting for the remaining 5%. According to data, ethanol produced from sugar beets will have little impact on the sugar industry because sugar beets are the primary raw material used to make sugar in the United Kingdom. However, if more sugar beets are used, the impact will be greater. According to respondent UK ethan1, % of local demand is met by locally grown sugar beet, with the remainder imported; thus, if the use of sugar beet increases in the ethanol industry, the impact will be significant.

To summarise, ethanol has no impact on the sugar industry in Pakistan because it is a by-product of the sugar industry and thus does not compete directly or indirectly with the sugar industry; however, ethanol production from sugar beet has an impact on sugar production in the UK because sugar beet is used for sugar production. Since the UK only produces half of its sugar from sugar beets, it will have an impact on the sugar industry as well as sugar-based food industries. Lastly, Table 6.2 is to present all the analysis results in table format, along with the impact factor. It will provide clear guidance to decision makers when evaluating ethanol in Pakistan and the United Kingdom. Impact factor has been categorised to None, Medium, and high. None referring to: no impact at all, Medium referring to: will have little impact and High referring to: will have impact.

Table 6.2 Thematic result (Which shows the impacts that all farmers agreed on)

Country	**Industry**	**Raw material**	**Scenario**	**Impact factor**
Pakistan	Sugar	Sugar cane	Sugar cane is used for sugar production	None
Pakistan	Ethanol	Molasses	Molasses is a by-product of sugar industry	None
Pakistan	Ethanol	Sugar cane	By assuming if sugar cane is used for the ethanol production	Medium
Pakistan	Ethanol	Grains	Wheat, corn etc.	None

Pakistan	Sugar & Ethanol	Sugar cane	If excessive sugar cane or sugar to be used to make ethanol	None
UK	Sugar	Sugar beet	Sugar beet is used for sugar production	None
UK	Ethanol	Sugar beet	5% Sugar beet is used for producing ethanol	Medium
UK	Ethanol	Wheat	95%. Feed grade wheat is used to make ethanol	None
UK	Ethanol	Sugar beet	If more sugar beet is used to make ethanol	High
Recommendation: It is better to use 2nd and 3rd generation raw materials to produce to avoid any kind of conflict with sugar industry in Pakistan and UK. It is also recommended to use extra sugar to ethanol to generate more revenue rather than export in which government must pay subsidy to compete with the international prices in Pakistan. It is recommended in UK to rely on wheat, corn, and cellulosic based raw materials to produce ethanol and not to use sugar beet at all, because UK only produces half of its sugar from sugar beet. If more sugar beet is used means less sugar and more sugar will be imported.				

6.2. Trade off Analysis

A trade off analysis is a decision based on a situation in which one product is sacrificed for another in exchange for having one product. In simple terms, where one thing is increasing, and another is decreasing. Its goal is to find the best alternative options. Recognizing the context (it is not directly related to the PESTLE analysis but is a pre-analysis clarification). Pakistan manufactures sugar from sugar cane. Pakistan is meeting its current sugar demand and exporting excess sugar through a government quota system. Because local sugar in Pakistan is more expensive than on the international market, the government of Pakistan provides subsidies for export. Sugar cane farmers reduced the number of hectares for a few years due to a lack of government support for payment and payment delays from sugar mills. In contrast, the United Kingdom produces sugar from sugar beets. The UK can only meet half of its demand from locally produced sugar beets; the rest is imported in the form of raw sugar, which is refined in the UK. Sugar beet hectares have not increased in recent years due to low income and better alternative crop availability. Following Brexit, sugar refineries will have the opportunity to import cheap raw sugar, refine it, sell cheap sugar, and export it.

Defining the alternatives

After understanding and analysing the context, it will be possible to consider some alternative options that may be more beneficial to Pakistan and the United Kingdom. Sugar cane is primarily used to produce sugar, ethanol, cane juice preservation, syrups, and jaggery. According to previous studies and recent interviews, ethanol was chosen as our alternative due to its ability to have better economics and contribute to environmental control.

Defining criteria

Following the selection of ethanol as an alternative to sugar production. It was chosen because it contributes financially to the industry, creates jobs, reduces GHG emissions, and saves millions of dollars in extra fossil fuel because ethanol can be blended into gasoline.

Setting the Criteria weight

A weighted scoring model generates a one-of-a-kind value-weighted numerical score for potential projects (Silalertruksa, Pongpat, Gheewala, (2016). If the criteria are of unequal importance, the measures of success can be improved by weighting the relative importance of the criteria, and when assigning weights, the contribution to sustainability achieved from the worst likely outcome to the best likely outcome for one criterion should be compared to anomalous. The weighted scoring model for ethanol creates a weighted numerical score, and the relative importance of the ethanol selection criterion compared to other choices, each selection criterion is given a positive weight. The weighted scoring model for ethanol creates a weighted numerical score, and the relative importance of the ethanol selection criterion compared to other choices, each selection criterion is given a positive weight.

For Weights, these weights are summed up to one. If the criteria are of unequal importance, the success measures can be improved by weighting the relative importance of ethanol as well as other criteria when assigning weights, and the contribution to sustainability achieved from the worst likely outcome to the best likely outcome of Ethanol should be compared to another. This is one of the most important factors in trade off analysis because it influences the decision making. The table 6.3 explains the criteria and have mentioned the metrics to help in decision making

Table 6.3 Criteria and metrics, Source: Author

Criteria	Metrics (explained in detail in SWOT analysis which showed the strength and weaknesses)
Financial	It contributes heavily to the country foreign reserves, save lots of dollar.
Environmental	Ethanol releases less GHG emission as compared to the fossil fuel
Better market	Ethanol has a better market than rest of the products (As explained in SWOT analysis which showed the opportunities for ethanol plus TEA showed that demand in the market both domestic and global are increasing for renewable energy sources.)
Socio economic	It gives employment to many people. Many of the rural industry can be employed in this sector
Mandate	It is recommended by the governments in UK and Pakistan to use certain percentage of ethanol to save the GHG emission

Result and Decision stage

If sugar is given up, ethanol is said to be a trade-off product. Ethanol is the best alternative product available. A trade-off analysis was performed to determine the best alternative and why it was chosen. It should be noted that ethanol is the best alternative because it benefits the economy by providing direct and indirect jobs while also reducing GHG emissions. The optimal trade-off is a sugar-ethanol combination that equals the opportunity cost.

Sugar cane is used to make sugar in Pakistan. During the last decade, Pakistan exported surplus sugar due to generous subsidies. If an integrated model can be installed in sugar mills, which can process sugar cane to produce sugar and ethanol simultaneously depending on demand, it will be the best option. Furthermore, extra sugar can be used to produce ethanol to meet local fuel demand. It has no effect on the sugar industry and does not compete with any food. The findings are that the potential for trade-off between sugar and ethanol may be limited, as ethanol is only produced from molasses. Pakistan has not produced ethanol from any other feedstock so far. The only use of sugar cane in Pakistan is to produce sugar from it and by-product use it for other products mainly ethanol and co-generation.

Sugar beet is used to make sugar in the United Kingdom. Sugar beets only meet half of the UK's sugar requirements. It should be noted that more raw sugar or white sugar is required in any case to meet local demand. Following Brexit, refiners will have the opportunity to import cheap sugar. Currently, 95% of ethanol is produced from feed grade wheat. Other available crops, such as corn, can also be used to produce ethanol, as corn-based ethanol is a valuable product for the feed industry. Sugar beets can be used to produce ethanol, which can benefit both the economy and the environment. Because the Brexit provides an opportunity for cheap raw sugar imports, which can aid in the production of cheap sugar. Moreover, the main finding based one trade-off in the United Kingdom is the ethanol which is produced from wheat or sugar beet. Wheat has no trade-off between sugar and ethanol since it is not the raw material to make sugar. Currently in UK only 5% of sugar beet production is used in the ethanol production.

6.3. SWOT Analysis of Ethanol industry in Pakistan and UK

The SWOT analysis is primarily driven by the sector's strengths and weaknesses, which are internal factors that are dependent on the objective or initiative under consideration. For example, because ethanol is almost entirely derived from a by-product of the sugarcane crushing process: molasses, Pakistan's limited sugarcane crop remains the primary bottleneck to growing ethanol exports. Despite the bottleneck, still 19 firms generated $386.4 million in exports in 2019 (Pakistan Sugar Mills Association, 2020). To generate the SWOT analysis for the UK case, similar cases were examined. Moreover, the criteria to conduct the SWOT analysis is based on raw material, import reduction, capital investment and environment. These variables are applicable to both Pakistan and UK. Moreover, a SWOT Analysis of Pakistan's Ethanol Industry was derived from interviews as well as secondary data gathered through previous statistics, with the goal of clarifying the strengths and weaknesses, as well as opportunities and potential threats, in both Pakistan and the UK. The detail of the analysis is as follow.

6.3.1. SWOT Analysis of Pakistan

The ethanol industry in Pakistan has been thriving in recent years. It is also one of the world's leading ethanol producers. Ethanol was primarily exported prior to the Covid-19, but it also generated local demand afterward. Due to the lack of mandate for ethanol blending in Pakistan, all ethanol is exported to European countries. It uses a by-product of the sugar industry and contributes to foreign reserves through export. Figure 6.1 depicts the Pakistan ethanol industry's strengths, weaknesses, opportunities, and threats.

Strength: (strength is the favourable internal activities, processes, behaviours. and factors that contribute to the success of ethanol production.)

Pakistan is one of the world's ethanol producers. It is the primary buyer of molasses and has increased the product's value; previously, molasses was either wasted or sold at a low price. Ethanol production generates millions of dollars in export revenue. If the government implements an ethanol mandate, it will reduce fossil fuel imports, create jobs, and reduce GHG emissions. One of its main advantages is that it is a renewable fuel.

Weakness: These weaknesses highlight the importance of making provisions to avoid impediments to achieving goals and objectives. In the case of Pakistan, it is based solely on one raw material. Molasses is sometimes sold out (molasses is sold out quickly and locally, many ethanol companies buy it, pre-booking and pre-sales) and ethanol distilleries are closed for half the year due to a lack of raw material. Because most of the owners are from political backgrounds or sugar producing groups, the stakeholders are attempting to create monopolies to divert new investments. The Pakistan Ethanol Manufacturing Association (PEMA) has been unable to establish a lobby for the local use of ethanol in Pakistan in terms of fuel blending.

Opportunities: Molasses exports must be curtailed so that all molasses can be used for local ethanol production. There is a need to implement a blending policy to address economic, rural employment, and environmental issues. To attract investment in ethanol production, ethanol business plans must be pitched. A similar model to that of Brazil and India can be adopted, in which small scale distilleries and on-farm based machinery assist farmers in producing ethanol, which becomes value added.

Threats: One of the main threats to Pakistan's ethanol industry is political influence, as many ethanol distilleries are owned by politicians, who represent various political parties and exert influence over the entire ethanol industry. Pakistan has the capacity to produce more ethanol to meet local demand and export, but due to a lack of molasses, this is becoming difficult. The government must support the ethanol industry to implement environmentally friendly policies. None of the distilleries are multi-feedstock based, as some in India are, producing ethanol from grains and molasses.

Impact: Because ethanol is a renewable fuel, the government has been unable to implement an ethanol mandate, which could have reduced fossil fuel imports, created jobs, and reduced GHG emissions. Another effect is that Pakistan's export bottleneck is caused by limited sugar cane crop cultivation. To counteract this, it has been determined that molasses export should be restricted so that all molasses can be used for local ethanol production. More opportunities can be created if this segment is viewed as an export-oriented segment that is to be subsidised by government policies.

Figure 6.1 SWOT Analysis of Pakistan sugar industry, Source: Author derived from the analysis

6.3.2. SWOT Analysis of UK

UK is also producer of ethanol and very few companies produce ethanol but at a large scale. Ethanol is produced from sugar beet and wheat feed grade mainly. Only 5% sugar beet and 95% wheat are used. Ethanol industry provides employment to rural industry in UK. In last few years some of the ethanol distillers were not producing due to lack of government support on raw material and on the mandate issues. Finally, UK, has tackled the issue of blending and now much of ethanol locally produced can be used in the transport industry UKEthanol2 believes that ethanol does not compete with sugar industry in terms of feedstock. Under the UK's Renewable Transport Fuel Obligation, companies in the UK produce enough biofuel to meet one-third of the country's bioethanol demand (RTFO). The United Kingdom exports to Europe, and there is significant potential to increase output, subject to feedstock availability and no crop cap. Three UK ethanol companies have the capacity to produce up to 900 million litres of ethanol. Figure 6.2 depicts the UK ethanol industry's strengths, weaknesses, opportunities, and threats.

Strength: The United Kingdom produces most of its ethanol from feed grade wheat/feed grade wheat is only used as animal feed. By producing ethanol from wheat, which is the traditional market for the UK, wheat is used for animal feed and milling, the majority of which is used to make bread and biscuits and for brewing and distilling (Hollins et al., 2006; Smith et al., 2006). Milling wheat and feed, wheat have distinct properties: the main distinctions being grain protein concentration and potential grain yield per hectare. Feed wheat has been preferred by the potable alcohol industry and this will be the same for the biofuel industry because of its lower protein concentration and lower market price than that of milling wheat. The price of feedstock is highly volatile depending on market conditions, expectations concerning future harvests and world stocks. Wheat can provide valuable products like DDGS, which will meet the needs of the feed industry. It provides sustainable fuel for automobiles as well as protein-rich animal feed. The ethanol industry benefits the UK economy both economically and environmentally.

Weakness: Due to a lack of government support, UK facilities stopped producing ethanol and eventually shut down production. Following the announcement that 10% ethanol production can be blended, the company has decided to restart operations in 2020. (Office for National Statistics, 2020). It cannot, however, compete with cheaper ethanol from the United States and Brazil. To combat cheaper imports, a strict import policy is required. It will be difficult to produce at this scale if crop cap is not removed.

Opportunities: It will provide a sustainable energy alternative with a positive impact on the local agriculture market. It has the capacity to produce more and meet the government of the United Kingdom's 10% mandate. It has the potential to help local farmers while also creating local jobs. Contribute to the reduction of GHG emissions. The implementation of an E10 policy can help to reduce GHG emissions by 750,000 MTCO2e per year. It contributes to the UK government's goal of achieving a zero-emission future.

Threat: If wheat is not grown in sufficient quantities in the UK for whatever reason, it will be difficult for ethanol producers to produce ethanol from wheat. Lack of demand and inability to implement E10 may cause production to halt, as it did previously. High raw material costs, crop limiting, and cheaper imports from the United States and Brazil may pose a threat to the ethanol industry (wheat is one of the important sources of ethanol production, but it is not in demand in the Kingdom, and therefore it is not cultivated can be termed as a weak point in SWOT analysis, as it depends only on sugar beet for ethanol production).

Impact: The UK relies solely on sugar beets to produce ethanol. Notably, ethanol is a renewable fuel for automobiles, a protein-rich animal feed, and is also used to make bread and biscuits, as well as for brewing and distilling. However, due to a lack of government support, UK facilities stopped producing ethanol, and instead, local demand is met by imports. As previously stated, it poses risks due to market volatility and reliance on the United States and Brazil.

Figure 6.2 SWOT Analysis of UK Ethanol industry, Author: derived from the analysis

6.3.3. Summary of results from SWOT analysis

SWOT analysis revealed the ethanol industry's strengths and opportunities, as well as its weaknesses and threats, in Pakistan and the United Kingdom. Pakistan is also one of the world's leading producers of ethanol. Ethanol is made from molasses, a by-product of the sugar industry. It brings in millions of dollars for the economy. It reduces the use of fossil fuels and helps to reduce GHG emissions. If more molasses is available, it has the capacity to produce more. It creates job opportunities for the rural community. Furthermore, due to molasses limitations, it can only produce a limited amount of ethanol. It is also a highly politicised industry. One of the major shortcomings was that people were unaware of ethanol, and there was a lack of investment and interest in this sector. Lack of policies to support ethanol locally, lack of multi feedstock distilleries and political influence poses the threat to the industry in Pakistan.

Swot analysis, on the other hand, revealed that the UK is producing ethanol from feed grade wheat and can run from any grain. It also manufactures highly valuable products such as DDGS. Ethanol benefits the economy and has the potential to meet GHG emission targets. The production of ethanol has a positive impact on agricultural markets. It can meet the government's 10% mandate. It benefits the local community and offers a great opportunity for the government to achieve a zero-emission future. However, in the past, a lack of government support has resulted in the closure of distilleries in the United Kingdom. It is unable to compete with cheaper imported ethanol. One of its most serious flaws is that it cannot keep up with production if there is a crop cap. If there is less wheat or grain available for ethanol production in the UK, the ethanol industry faces a significant threat. The high cost of raw materials, combined with cheaper imported ethanol, can pose a significant threat.

6.4. Techno-Economic Analysis for the UK and Pakistan ethanol production

Techno-Economic Assessment (TEA) is a framework for determining the technical and economic capabilities of a product or service. Process modelling, engineering designs, and economic evaluations are all used in TEA. The major benefit is that summarize results in a concise and coherent form. A Literature reveals that the techno-economic assessment (TEA) of the anaerobic digestion (AD) and the product resulting from the process is an important step in establishing a large-scale AD process, primarily at the industrial level (Oreggioni et al., 2017; Rajendrana and Ganti, 2019). Further, TEA integrates process modelling, engineering design, and economic analysis to assess the economic viability of both the AD configuration and the resulting bioenergy and biobased products. In terms of Pakistan and the United Kingdom, techno-economic analysis (TEA) could aid in determining the potential economic viability of sugar production and ethanol production in both countries. Furthermore, it will facilitate comparison based on whether the country's economy is dependent on agriculture or not, and to what extent it influences ethanol production. Figure 6.3 depicts the interdependence of the economy and agricultural products, particularly in this case. The graph shows how changes in molasses exports or sugar demand can have an impact on ethanol production. Thus, increased profitability of ethanol supply can make a difference. The equation used in this investigation is shown below and relevant data is presented in Annex 24 and Annex 25.

TEA ($) = [(C for Period 1 / (1 +r)l)] + [(C for Period 2/ (1 +r)2)] + … [(C for given time period t/ (1.r)t] – [C0]. World Bank, 2018.

Where,

"C" represents the cash flow that the asset is projected to generate in each time period.

"r" represents the discount rate that will be used to find the present value of the future cash flows. As standard, 2% discounted rate is assumed.

"C0" represents the initial investment.

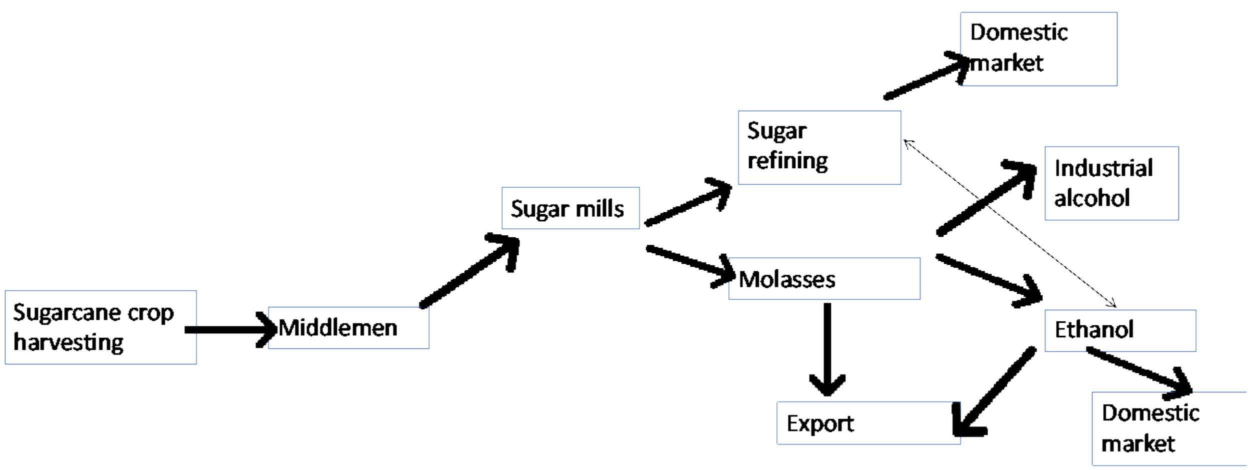


Figure 6.3 Schematic of linkage between the process of ethanol and sugar Source: Pakistan Sugar Mills Association

Techno Economic Evaluation for Ethanol Production by Sugarcane Molasses in Pakistan

Comparison between Pakistan | the UK on technical-economic analysis

Because Pakistan's economy is based on agriculture, farming production takes up more land in the country. While the UK uses 100.000 hectares for sugar beet production, Pakistan uses 12 times as much for sugar cane farming. Despite the fact that there is a significant gap in the production of sugar-based feedstock, the average price is moving in the opposite direction. The huge differences in average feedstock prices can be explained by the distance between source and factory, which is 34 km in the UK and 150 km in Pakistan. This huge distance is affecting logistic cost and increase feedstock prices naturally. In addition, another reason is technology. We can see impact of technology at comparison on Feedstock Requirement for ethanol production. The UK requires 2.500.000 MT /year to produce 710,000 MT ethanol. However, for Pakistan those number is accounting as 2.650.000 MT feedstock to produce 530.000 MT ethanol with 14 factories against 3 factories in the UK. Moreover, the UK ethanol production mostly focuses on Fuel Grade but in Pakistan, industrial grade ethanol production is heavier than other grades.

An investment on a 30 Mt/Day capacity ethanol plant is decided to compare the UK and Pakistan. This capacity was decided as minimum capacities around Pakistan was 100 MT and in UK was also around same, but structure in Brazil and India were different. Many small-scale distilleries are going on and this successful model was adopted in the capacity. The below information is taken in the account at calculations.

The ethanol yield is 4-4.5 MT of molasses per tonne of ethanol (from the interview of Pakistan ethanol producers). The density of ethanol is 0.789Kg/M3 (Bandarkar, 2012). Each tonne of ethanol contains 1267 litres of ethanol, which is usually rounded to 1250 L. And the capacity chosen for this study is 30 MT per day.

According to Arshad et al. 2019, Pakistan's distilleries have a much larger capacity (Arshad et al., 2019). True, as capacity increases, processing costs decrease and returns increase. However, for this research project, 30 MT per day production of fuel grade ethanol was deemed easily doable for medium-sized businesses, farmers, and those able to begin with less capital and profitably. It will enable medium-sized investors to invest in the ethanol industry, which was previously thought to be only for sugar mills or larger corporations.

Machinery

Machinery for this 30 MT per day ethanol production plant was obtained from several Chinese and Iranian companies. Unfortunately, it was discovered during the research that there was not a single company in Pakistan capable of producing the entire distillery. As a result, other countries were considered based on quality, price, and ability to produce ethanol of the desired standard and grade. Author (2019) contacted the following companies and received a quote for Ethanol machinery with a capacity of 30 MT per day to produce 99.9% fuel grade ethanol from molasses, grains, and sugar beets. Some of the quotations are mentioned in the annex-26. The companies are.

1. RAD Engineering (India)
2. Rushan Risheng Machinery Company (China)
3. Chemical Co. (Iran)
4. Barman machinery company (Iran)
5. Hakimi Engg. (Iran)
6. Genyond Machinery Industrial Group (China)
7. Steel Aria Machinery Maker (Iran)

The size of plant/equipment is assumed to be 30MT production per day based on molasses. It is assumed in this study that the plant working days are for 300 days. The average machinery (storage tanks, fermentation tanks, pre fermentation tanks, distillation columns, recovery section, boiler, cooling tower and utilities etc.) will cost $800,000 USD for complete machinery including transportation, erection, insulation, installation, piping, electrical system etc. with wastewater treatment effluent plant. The cost of the machinery alone is $760,000 USD and installation cost are $40,000 USD. These figures are the average subtotal of all the quotations received and are mentioned in the annex 26. If CO_2 recovery Unit to be added, further $400,000 USD is needed and that can add the income as well but for a medium size industry this cost is high, and it is not recommended to put the system in the beginning. To produce 30 MT per day, it needs about 3 HECTARES (Each hectare is 2.47 acres) each acre for industrial use average price is 2.5 million Rupees in Pakistan, which is equivalent to $15,625 USD per acre and will cost about $115,780 USD for 3 hectares. The equipment's occupy 4000m2 area. After the utilities (the boilers, power distribution, recycled water), afforest, office, fire protection, raw material warehouse, and finished product warehouse, etc. are added, more than 30000 m2 (3 hectares) are advised by the industrial people and engineers for the project. For the construction of all the said facilities average cost is PKR 25 million:

which is equivalent to USD $156, 250. In UK, the size of plant/equipment is assumed to be 30 MT production per day based on Grains mainly Corn and wheat with a Dry Milling process. It is assumed in this study that the plant working days are for 300 days. The average machinery will cost $1,200,000 USD for complete Machinery including DDGS system, transportation, erection, insulation, installation, piping, electrical system etc. with wastewater treatment effluent plant. The cost of the machinery alone is $1,100,000 USD and installation cost is $100,000 USD. To produce 30 MT per day, it needs about 3 Hectares for industrial use.

While investment generates enough cash flow through 10 years for Pakistan, we cannot tell same thing for the UK situation. The revenue goes negative after 8th year. In long term, the investment in UK fails to generate enough cash flow to sustain the business. Which means investors should consider increasing the capacity to turn decreasing cash flow to increasing one or should develop new methods on especially purchasing management to decrease input costs. The main reason of having negative cash flow is increases in payrolls. Different human resources strategy can be applied to avoid from negative cash flow.

Detailed analysis of the financial results

All the above figures are summarized in the table below, and they indicate that the project is financially feasible. Due to investment expenses, both plants generate limited cash flow in the first year of operation; however, the project generates sustainable cash flow in all subsequent years, albeit at a lower rate. On the cumulative cash flow chart, we can see that it is rapidly increasing.

Table 6.4 financial comparison

***For 3*0 Mt / Daily Capacity Ethanol Plant**	**Pakistan**	**UK**
Investment Cost	USD $1,259,635	USD $2,7569,250
IRR (Internal Rate of Return on Investment) for 6 years	73.91%	45.58%
NPV /DCF (Net Present Value, as known as Discounted Cash Flow) for 6 years	USD $3,699,842	USD $ 3,697,084
Payback Period	0 year 10 months	1 years 3 months
EBIT	51%	28%
EBITDA	52%	31%

Evaluation results based on the financial comparison are as follows.

Investment Cost: The same plant design and capacity were used for evaluation and comparison. The reasons why investment costs are two times lower in Pakistan than in the UK are land prices, labor costs, and construction costs, all of which are significantly lower in Pakistan than in the UK. This distinction naturally shortens the investment's payback period.

IRR (Internal Rate of Return: Pakistan's IRR / ROI for 6 years is nearly 1.5 times that of the UK, but both ratios demonstrate that investment is feasible. In addition, when we look at the NPV (over a 6-year period), we can see that investment in both Pakistan and the UK generates comparable value. However, when we compare the investment cost and the net present value, the project appears more feasible in Pakistan. Payback period: 0 years 10 months in Pakistan and 1 year 3 months in the rest of the world (UK). Because of the low investment cost, Pakistan's return period is very short. We can simply state that the investment risk is low. Short-term returns provide excellent exit opportunities for investors.

Summary of results of TEA

The governments of both countries indirectly support ethanol production. Their RED aims to develop renewable energy sources and diversify their sources in this field to maintain energy security while reducing reliance on external sources. Both countries have advantages and disadvantages when it comes to investment. For example, the cost of operation and fixed costs are much lower in the UK than in the US, but the US has easy access to other markets and social and economic factors favor it. The key factor for successful investment appears to be the possibility of reaching the external market and the development of the oil sector across.

The demand in the market both domestic and global are increasing for renewable energy sources while demand on sugar is decreasing to due trend of healthy life. There are some decreases and increases on sugar demand over the years, but production of sugar is decreasing sharply, producers' preferences are switching, and ethanol can be new appetite for their preferences. Ethanol and biofuels appear to be a new determinant trend in the sugar industry, with investments in those plants providing quick payback periods for both countries. However, due to the low cost of labor and raw materials, it appears that investing in Pakistan is more feasible. It is possible to realize the investment with a higher IRR and a shorter payback period. It is critical to understand that shorter payback periods are more likely to attract investors, particularly FDI. Despite a lack of infrastructure development and terrain challenges, Pakistan appears to be a good option for economic and sustainability investments.

Conclusion for Pakistan

The investment is low, and the profits are extremely high. Due to high sugar consumption and a large sugar industry, molasses is widely available in Pakistan. Molasses is related to sugar because molasses is used to produce ethanol when sugar is produced.

The ethanol production unit in Pakistan could bring a huge boost to the biofuel market and the export demand is already there. The raw material (molasses) price is between i.e., Rs 17 - Rs.22/Kg and the labour is also cheap as compared to other parts of the world. Overall, the project is viable as the returns are high with the availability of raw material in Pakistan with high demand in Pakistan & abroad.

The ethanol production increases with the increase in the molasses quality. Further, it is quite evident from the analysis that there is a huge difference in the production of ethanol theoretically and practically in Pakistan (PSMA, 2020). This difference can be reduced by using high-quality molasses and cutting-edge equipment for heating, raw material processing, fermentation tanks, distillation, and drying. However, increasing molasses quality means that there is more sugar concentration left in the molasses, resulting in a reduction in sugar production. Because sugar is already in high demand in Pakistan, using high-quality local molasses may not be the best option. With the available quality of molasses and machinery in Pakistan, the production of ethanol is still highly profitable in terms of profits and payback.

Another benefit of ethanol production to the Pakistani economy is the ability to save foreign exchange. With a little innovation and investment, Pakistan can produce ethanol locally from molasses and replace at least 5% of its gasoline consumption. According to research, Pakistan produces approximately 2.2-3 million MT of sugar molasses and can produce 650,000 MT of ethanol from all available molasses (considering average 4-4.5 Mt per each MT of ethanol). The following table 6.5 compares the prices of gasoline and ethanol in Pakistan: If Pakistan produces 10% of its total petrol requirement/consumption, we can save 92.4 billion PKR in foreign reserves, as shown in Table 6.6 below.

Table 6.5 Petrol and ethanol price comparison. Source: Author derived from the Ogra website in August 2021.

Petrol Price in Pakistan(station)	Ethanol Price in Pakistan	Petrol Price at port
Rs.119/Litre	Rs.72/Litre ex-Mill	Rs. 97.35/Litre ex refinery

Table 6.6 World oil price vs local oil price bs ethanol price, Source: Author

World Oil price per barrel	Pakistan Oil price per Litre (Avg cost of supply)	Pakistan Ethanol price per Litre ex gate
68.74 USD/bbl	97.35m(.48$) PKR per Litre	72 rupees (.35$) per Litre
Pakistan petrol consumption	**10% Volume of ethanol Blending requirements**	**Foreign exchange saves (Fuel price equivalent)**
7,600,000 MT	760,000 MT	92,482,500,000 PKR (2,885,7871,108 Mt)

Conclusion for UK

The investment is moderate, and if land is leased, the cost is low, and profits are high. The payback period is approximately one year and ten months, which makes the project feasible, especially given the good equipment life of 15-20 years. Sugar beet availability is limited, but wheat availability is abundant due to the use of feed grade wheat. As a result, feed grade wheat accounts for 90-95 percent of ethanol production, with the remainder coming from sugar beets. The demand for ethanol is very high in the United Kingdom, but the industry has been completely reliant on the government's policy and quotas. Taxation is another factor that can cause some serious threats to the industry. If the government raises tax on sugar and ethanol production, then there is the opportunity for the traders to import cheap sugar from USA which can affect the industry. Please note that, taxes are on the sale cost and bear by the consumer that is why was not included.

6.5. Future Scenario Analysis

A future scenario is a probable description of what might happen in the future, rather than a forecast of what might happen in the future. It is based on current events and trends to forecast future events. It is a method of predicting the future and assuming the trend (Kishita et al., 2016). According to the ISO Yearbook (2020), sugar annual growth will be reduced by 1.2 percent in 2020, and global sugar production will exceed 200 million MT by the end of the decade (ISO, 2020). The per capita income in the world and growth in population remains the main drivers of the sugar consumption. In the last few years, health concern became the driver also. It is also to be noticed that in coming years health policies will have impact on the consumption of sugar. Ethanol demand in the world will be dependent on the policy drivers. It is suggested that world ethanol demand will be increased and Brazil ethanol production from the sugar cane to have no impact on the food production and cutting of forest. The framework steps have been mentioned in the figure 6.4. To that end, the framework is built on the relationship between variables derived from the estimation of ANOVA test results, with sugar production having a significant correlation to mill utilisation, area, and yield.

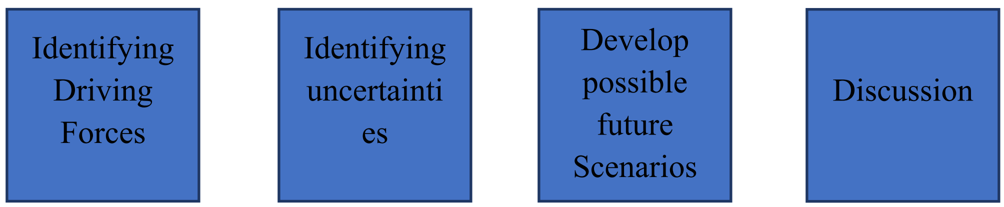


Figure 6.4 Framework of Future scenario analysis

Identifying the driving force

Sugar cane is used to produce sugar in Pakistan. The sugar cane growing area has experienced some decline in recent years. However, this trend is changing from last year, and sugar cane production is expected to increase. More sugar will be produced as sugar cane production increases. Pakistan has been meeting its domestic sugar demand. It has been determined that ethanol is not a factor influencing sugar production in Pakistan. As a result, ethanol production from sugar cane, more molasses, and extra sugar will be a significant shift in society. Health concerns, a sin tax, and the need to reduce GHG emissions will all have an impact on political policies in the coming years.

In UK, the sugar beet is producing sugar. UK is only able to produce half of it sugar from sugar beet and rest is normally imported in shape of raw sugar and white sugar. Ethanol production in the UK is well established but last few years were turbulent due to lack of proper policies and support from the government. Ethanol is produced from feed grade wheat (95%) and sugar beet (5%). It was noted from the analysis that if current level of sugar beet is used it has low impact and if this increases then the impact will increase and if leave all together sugar beet then there will be no impact on the sugar production. After Brexit, environmental concerns, health concerns and ethanol mandate of E10 will have influence on the government.

Identifying Uncertainties

The availability of raw materials and government policies in Pakistan, as well as food caps, government policies, and continuous demand in the UK, will be the two most significant uncertainties for the ethanol business. In Pakistan and the United Kingdom, there is a need to look for alternative feedstock, such as corn.

Possible future scenarios in case of Pakistan and UK

Table 6.7 explains the data for Pakistan and the United Kingdom first, and then briefly elaborates on the scenarios and outcomes. In the following step, all possible scenarios will be discussed and analyzed using table 6.7 and data in the form of figures from the Pakistan Sugar Mills Association and the UK Department for Environment, Food, and Rural Affairs. The scenarios will be based on this table. Notably, the scenarios were created after reviewing the results of SWOT, PESTLE, and thematic analyses and researching when there was an increase or decrease in sugar demand.

Table 6.7 Future scenarios for sugar and ethanol industry in Pakistan and UK Sep 2020, Source: PSMA 2020; PSO, 2019; Defra, 2020)

PAKISTAN DATA 2019-2020		**UNITED KINGDOM DATA 2019-2020**	
Pakistan current sugar demand 2019-2020	5,279,000 MT	UK current sugar demand 2019-2020	1,700,000 MT
Pakistan Current sugar production 2019-2020	4,819,793 MT	UK Current sugar production 2019-2020	1,081,000 MT
Pakistan Sugar previous stock available for 2019-20	825,387 MT	UK Current Sugar beet Production 2019-2020	7,763,000 MT
Pakistan total available Sugar 2019-2020	5,714,221 MT	UK current sugar beet growing area	100,000 HA
Pakistan Current sugarcane Production 2019-2020	67,105,218 MT	UK rest of the sugar production (Raw & White)	944,000 MT
Pakistan Current sugar cane growing area 2019-2020	1,038,879 HA	UK sugar export 2019-2020	248,000 MT
Pakistan average Sugar retail price 2019-2020	79.70 PKR per kg	UK sugar price 2019-2020 Average	73 Pence per kg
Pakistan Sugar export 2019-2020	181,447 MT	UK Ethanol production est. 2019-2020	262,000,000 Litres
International sugar average prices 2019-2020	57.92 PKR per kg	UK ethanol consumption 2019-2020	752,000,000 Litres
Pakistan current Jaggery production est. 2019-2020	300,000 MT	UK total wheat production (feed grade)	7.367.000 MT
Pakistan Current sugarcane molasses 2019-2020	2,236,628 MT	UK total wheat used for ethanol 2019-2020	96,000 MT

Pakistan Ethanol production est. 2019-2020	600,000 MT	UK total sugar beet used for ethanol 2019-20	627,000 MT
Pakistan total molasses production	2,236,628 MT	UK total corn production	228,000 MT
Pakistan molasses export	36,532 MT	UK corn land use for Anaerobic digestion	67,000 HA
Pakistan Molasses price 2019-2020	23,171 PKR per tons	UK current sugar demand 2019-2020	1,700,000 MT
Pakistan ethanol export	474,228,873 Litres	UK Current sugar production 2019-2020	1,081,000 MT
Pakistan ethanol price 2019-2020	96 rupees per Litre	UK Current Sugar beet Production 2019-2020	7,763,000 MT
Pakistan total corn production	7,883,000 MT	UK current sugar beet growing area	100,000 HA
Pakistan corn growing area	1,418,000 HA	UK rest of the sugar production (Raw & White)	944,000 MT
SCENARIOS (The scenarios revolve around an increase or decrease in the demand for sugar and its impact on ethanol production).			
PAKISTAN		**UNITED KINGDOM**	
IF sugar demand in Pakistan increased by 10%	5,806,900 MT	IF sugar demand increases by 10%	1,870,000 MT
IF sugar demand in Pakistan increased by 20%	6,334,800 MT	IF sugar demand increases by 20%	2,040,000 MT
IF sugar demand decreases by 10% in next few years	4,751,100 MT	IF sugar demand decreases by 10%	1,530,000 MT

IF Sugar cane production increased by 10%	73,815,740 MT	IF sugar beet production increased by 10%	8,539,300 MT
IF sugar cane production increased by 20%	80,526,262 MT	IF sugar beet production increased by 20%	9,315,600 MT
IF sugar cane production decreased by 10%	60,394,696 MT	IF sugar beet production decreases by 10%	6,986,700 MT
IF sugar cane production decreased by 20%	53,684,174 MT	IF sugar beet production decreases by 20%	6,210,400 MT
IF ethanol demand increases by 10%	660,000 MT	IF ethanol consumption increases by 10%	827,200,000 Litres
IF ethanol demand increases by 20%	720,000 MT	IF ethanol consumption increases by 20%	902,400,000 Litres
IF mandate of E10 is to be introduced (Current petrol consumption is 7,600,000 MT	760,000 MT required	IF mandate of E10 is to be introduced (UK current petrol consumption is 13.1 billion Litres as of 2020)	1,310,000,000 Litres required
IF ethanol production decreases by 10%	540,000 MT	IF the price of sugar increases in UK by 10%	80 pence per kg
IF the average price of sugar increases in by 10%	87.67 PKR per kg	IF the price of sugar decreases in UK by	66 pence per kg

		10%	
IF the price of sugar decreases in Pakistan by 10%	71.73 PKR per kg	Any new available raw material for ethanol production in UK	Corn
IF ethanol prices increase by 10%	105.6 PKR per Litre	IF sugar demand increases by 10%	1,870,000 MT
IF ethanol prices decrease by 10%	86.4 PKR per Litre	IF sugar demand increases by 20%	2,040,000 MT
Any new available raw material for ethanol production in Pakistan	Corn	IF sugar demand decreases by 10%	1,530,000 MT

IF sugar demand in Pakistan increased by 10%	1.1%	IF sugar demand increases by 10%	1.1%
IF sugar demand in Pakistan increased by 20%	1.2%	IF sugar demand increases by 20%	1.2%
IF sugar demand decreases by 10% in next few years	.9%	IF sugar demand decreases by 10%	.9%
IF Sugar cane production increased by 10%	1%	IF sugar beet production increased by	1.1%

		10%	
IF sugar cane production increased by 20%	1.2%	IF sugar beet production increased by 20%	1.2%
IF sugar cane production decreased by 10%	.9%	IF sugar beet production decreases by 10%	.9%
IF sugar cane production decreased by 20%	.8%	IF sugar beet production decreases by 20%	.8%
IF ethanol demand increases by 10%	1.1%	IF ethanol consumption increases by 10%	1.1%
IF ethanol demand increases by 20%	1.2%	IF ethanol consumption increases by 20%	1.2%
IF mandate of E10 is to be introduced (Current petrol consumption is 7,600,000 MT		IF mandate of E10 is to be introduced (UK current petrol consumption is 13.1 billion Litres as of 2020)	

IF ethanol production decreases by 10%	.9%	IF the price of sugar increases in UK by 10%	1%
IF the average price of sugar increases in by 10%	1.1%	IF the price of sugar decreases in UK by 10%	.9%
IF the price of sugar decreases in Pakistan by 10%	.9%	Any new available raw material for ethanol production in UK	Corn
IF ethanol prices increase by 10%	1.1		
IF ethanol prices decrease by 10%	.9		
Any new available raw material for ethanol production in Pakistan	corn		

Discussion and conclusion

Different interlinkages and pattern in relation to demand, production of sugar and ethanol has been observed (Table 6.7). As identified, when ethanol demand increased significantly then sugarcane production decreased. When ethanol demand increased in tandem with sugar demand, sugarcane yields declined, However, as observed demand for both sugar and ethanol increased during the study period. Therefore, scenario-based analysis seems appropriate as discussed below. To this end, scenarios are based on assumption where either demand or production of sugar or ethanol increased on vice versa. In addition, scenarios also assumed the changes in prices of sugar and ethanol and discussed its possible impacts. All the scenarios are consistent for both Pakistan and the United Kingdom.

Future Scenario for Sugar Industry in Pakistan

Scenario1 & 2

In both cases, this scenario assumes an increase in demand. In the first case, demand is assumed to be 10%, and in the second case, demand is assumed to be 20%. When sugar demand in Pakistan increases by 10%, it will increase the overall demand to reach 5.8 million MT from 5.3 million MT. It can be noticed from the below table 6.8, that the sugar demand from last few years is above 5 million and it is increasing with the increase of population. Table 6.9 indicates that Pakistan has reached the maximum sugar cane production in year 2016-2017 and 2017-2018 and then a significantly decline in 2018-2019 and 2019-2020 due to poor government policies, lack of price mechanism and late payments from the sugar mill owners. Pakistan available sugar in 2019-2020 was 6.3 million MT sugar thus, even the demand increases by 10%, Pakistan will be able to supply from the current sugar cane production. If the sugar demand increases by 20% it will increase the overall demand to reach 6.3 million MT. Still Pakistan will be able to balance the demand and supply. The sugar cane production increased to 75.4 million MT in 2020-2021, which indicates that Pakistan will be able to tackle 10% or even 20% increase in demand easily. In the manufacture of ethanol, Pakistan depends on molasses, and therefore the greater its availability, the higher the rate of ethanol production.

Table 6.8 Sugar consumption data Pakistan, Source: (PSMA, 2020)

Sugar Year	Population Millions	Sugar Consumption	
		Year's	Kg Per Capita
2006-07	162.91	3.958	24.29
2007-08	166.41	4.297	25.82
2008-09	169.94	3.628	21.34
2009-10	173.51	4.186	24.12
2010-11	177.10	4.096	23.12
2011-12	180.71	4.385	24.27
2012-13	184.35	4.420	24.60
2013-14	188.02	4.512	24.00
2014-15	191.71	4.600	24.00
2015-16	195.40	4.904	25.10
2016-17	199.1	5.100	25.65
2017-18	207.77	5.200	25.10
2018-19	212.82	5.196	24.42
2019-20	211.17	5.279	25.00

Table 6.9 Pakistan sugar cane growing area, production, consumption, and supply, Source: (PSMA, 2020)

Sugar Year(Oct-Sept.)	2016-17	2017-18	2018-19	2019-20
Sugarcane area (hect)	1,216,894	1,340,926	1,101,073	1,038,879
Sugarcane produced(Tonnes)	75,450,620	83,289,340	67,129,645	67,105,218
Yield (Tonnes/Hect)	62.00	62.11	60.97	64.59
Cane Utilized by Mills	70,989,948	65,639,963	49,768,113	48,717,544
Percentage of Utilization	94.00	78.80	74.13	72.60
Cane Support Price Punjab, KP, Sindh	180/182/180	180/182/180	180/182/180	190/192/190
Average recovery (%)	9.87	10.02	10.47	10.21
Sugar Production (cane)	7,005,480	6,580,111	5,210,744	4,819,793
Sugar Production (beet)	42,996	40,922	56,828	61,432
Sugar Production (raw)	-	-	-	-
Total Sugar Production	7,048,476	6,621,033	5,267,572	4,881,225
Beginning Stocks 1st Oct.	950,000	2,473,476	2,424,707	825,387
Imports/TCP	-	-	7852	7609
Total Available	7,998,476	9,094,509	7,700,131	6,285,834
Export	425,000	1,469,802	691,994	181,447
End Stock 30th Sep. (Mills)	2,473,476	2,424,707	1,812,137	825,387
Consumption / Marketing	5,100,000	5,200,000	5,196,000	52,279,000
Average Consump. / month	425,000	4,33,333	433,000	442,000
Season's Av. Retail price / kg	61.43	53.57	64.27	79.70
Intl. Av. Sugar Trade Price US $/T	477.43	357.50	334.39	362.34
Molasses Prod. (C+B+R) *	3,095,986	2,971,992	2,263,109	2,236,928

Scenario 3

This scenario is the inverse of the previous ones in that it is assumed that if sugar demand falls by 10% (i.e., to 4.7 million MT) due to health concerns. As a result, consumers may switch to other sweeteners and move toward jaggery. Thus, it will be an opportunity to Pakistan sugar mills to utilize extra sugar cane for ethanol, extra sugar for ethanol, export of sugar if Pakistani prices are lower than international prices. It is highly unlikely that there will be 10% decrease in demand. It can be noticed from table 6.8 and 6.9 that consumption has been steady with 1% fluctuation. The consumption is increasing with the population growth.

Scenario 4 and 5

In both cases, this scenario assumes an increase in production. In the first case, production is assumed to be 10% (73.8 million MT), and in the second case, production is assumed to be 20% (80.5 million MT). It may result in Pakistan meeting all its domestic demand plus exaggerated 10 to 20% extra consumption and being able to export currently. In Pakistan, there has never been a single integrated mill (which uses sugar cane to produce both sugar and ethanol). If extra sugar cane can be diverted to ethanol, it can be highly valuable and provide Pakistan with the opportunity to meet local oil needs while also exporting and earning in foreign exchange. Pakistan maximum sugar cane production in last few years was 83.3 million, which indicates that these figures are reachable without increasing the extra area from the previously available area. Thus, sugar cane demand increases by 10% or 205 will have positive impact such as: (Increasing sugar production, and consequently, profit for the sugar industry) on the sugar industry.

Scenario 6 and 7

This scenario is the inverse of scenarios 5 and 6, in which it is assumed that if sugar demand falls by 10% (60 million MT) and 20% to (54 million MT). As a result, it will limit local sugar production, and with an average 75 percent utilisation of sugar cane for sugar production, Pakistan will be able to produce only 4.5 million tonnes of sugar if production of sugar cane decreases by 10%, and 4 million tonnes of sugar if production of sugar cane decreases by 20%. As a matter of fact, if sugar cane production falls by 10% or 20% from 2019-2020 production, it will be unable to meet local demand and will be forced to import raw or white sugar. Table 6.9 shows that Pakistan's consumption over the last few years has been just over 5 million MT, indicating that 4.5 million MT and 4 million MT will not suffice. It will also have impact on the ethanol industry, since ethanol industry is based on molasses which is a by-product of sugar industry. If less sugar is produced means, there will be less ethanol.

Scenario 8 and 9

If sugar price assumed to be increases by 10% and valued as PKR 87.67 per kg. Possibly, it may have no impact on demand as sugar is a necessity production and inelastic to the price. Quantity will be insensitive to the change in price. But if the price of sugar comes down by 10% to 71.63 Pakistani rupees per kg, it will still have no impact on the demand, but people will buy more sugar, but consumption will remain same. Table 6.9 indicates the steady sugar consumption and table 6.13 indicates the sugar per capita consumption and it verifies that sugar per capita is either steady or increasing.(There will be no effect on ethanol, as sugar consumption will remain constant, as will the individual's consumption of sugar, in addition to the manufacture of ethanol from by product Since the individual consumption of sugar is fixed, the rate of consumption of sugar will remain constant and therefore there will be no effect on ethanol, in addition to manufacturing ethanol from a second by product.

Table 6.13 Sugar per capita, Source: (PSMA, 2020)

Sugar Year	Sugar per capita
2006-07	24.29
2007-08	25.82
2008-09	21.34
2009-10	24.12
2010-11	23.12
2011-12	24.27
2012-13	24.00
2013-14	24.00
2014-15	24.00
2015-16	25.10
2016-17	25.65
2017-18	25.10
2018-19	24.42
2019-20	25.00

Future Scenario for Sugar Industry in United Kingdom (UK)

UK Scenario 1 and 2

If sugar demand rises by 10% (i.e.,1.87 million MT) or 20% (2 million MT), it will have no effect since a UK can only supply half of its sugar from local sugar beets and the rest is imported from the rest of the world and the EU in the form of raw or white sugar. Higher demand will trigger higher imports and cheaper sugar as import of sugar is cheaper, and country can use all the available sugar beet. Instead, wheat can be used to make ethanol, which is highly valuable, and it will be a profitable for UK. If no additional taxes are levied on UK refiners. The import will provide an opportunity for previous refiners such as American Sugar Refinery and others, as well as newcomers, to enter the market and meet local demand. As shown in table 6.16, the sugar beet area is between 100,000 and 110,000 Hectares, which is consistent and producing about 1 million MT out of a demand of 1.7 million MT. It is to be concluded that if sugar demand in the UK increases by any percentage, the number of hectares, yield, and sugar content must be increased to meet all local needs. It is highly unlikely, given the availability of other profitable crops.

Table 6.16 UK sugar beet area, Local sugar production and total consumption, Source: (British Sugar, 2020)

Thousand tonnes (unless specified otherwise)

	2018	2019	2020
Sugar Beet			
Area (thousand hectares)	110	100	104
Yield (tonnes per hectare)	69	78	58
Volume of harvested production	7,600	7,763	5,980
Value of production (£ million)	214	210	172
Sugar content	18%	17%	16%
Price (average market price (£ per adjusted tonne))	28	27	29
All Sugar (refined basis)			
Production	1,080	1,081	1,082
EU imports	526	514	271
Non-EU imports	422	430	428
EU exports	236	180	91
Non-EU exports	125	68	70
Total new supply	1,666	1,778	1,619
Production as % of total new supply for UK use	65%	61%	67%

Notes:

1. Average price include transport allowance and bonus
2. Sugar coming out of the factory in the early part of the year is regarded as being part of production in the previous calendar year.

UK Scenario 3

If sugar demand falls by 10% (i.e., 1.53 million MT), it will be easier for the UK to increase sugar beet area slightly with improved yield to meet all current sugar demand. It is highly unlikely that sugar demand will fall by 10%. It is noted from last few years that consumption is steady despite sugar taxes. Sugar beet area has reached to 121,000 hectares in 2013 and it was a decline to 80,000 hectares, and now reached towards 100,000 hectares in 2019-2020 (Table 6.17). It can be concluded that UK will be able to fulfil local sugar if area increases, demand of sugar decreases, high yield and high yield of sugar content.

Table 6.17 UK Sugar beet and sugar production Source: DEFRA 2020

Thousand tonnes (unless otherwise specified)								Calendar years
	2013	2014	2015	2016	2017	2018	2019	2020 (provisional)
Sugar Beet								
Area (thousand hectares)	121	117	84	80	107	110	100	104
Yield (adjusted tonnes per hectare)	70	80	74	71	83	69	78	58
Volume of harvested production	8,432	9,310	6,218	5,687	8,919	7,600	7,763	5,980
Value of production (£ million)	270	315	173	150	229	214	210	172
Sugar content %	17.49	17.24	17.29	17.30	17.81	17.86	16.84	16.25
Prices (average market price (£ per adjusted tonne) (a)	32.0	33.9	27.8	26.3	25.7	28.2	27.1	28.8
All Sugar (refined basis)								
Production (b)	1,324	1,446	978	897	1,364	1,080	1,081	1,082
Imports from The EU	423	476	586	402	530	526	514	271
The rest of the world	691	699	546	601	458	422	430	428
Exports to: The EU	135	232	258	224	157	236	180	91
The rest of the world	98	94	75	46	46	125	68	70
Total new supply	2,204	2,296	1,776	1,632	2,147	1,666	1,778	1,619
Production as % of total new supply for use in UK	60%	63%	55%	55%	64%	65%	61%	67%

UK Scenario 4 and 5

If sugar beet production increases by 10% (i.e., 8.5 million MT) or 20% (9.3 million MT), it will produce more sugar, and more sugar will lead to meeting the local sugar demand. It should also be noted that there are companies in the UK that rely on imported sugar and use raw sugar to make white sugar. If all the UK's local sugar is produced from sugar beets, these companies will be forced out. Based on data from the previous five years, it is also highly unlikely that sugar beet production will increase by 20% in the next five years. Table 6.17 also shows that when sugar beet production reached 9.3 million MT, it could only produce 63% of the locally produced UK sugar.

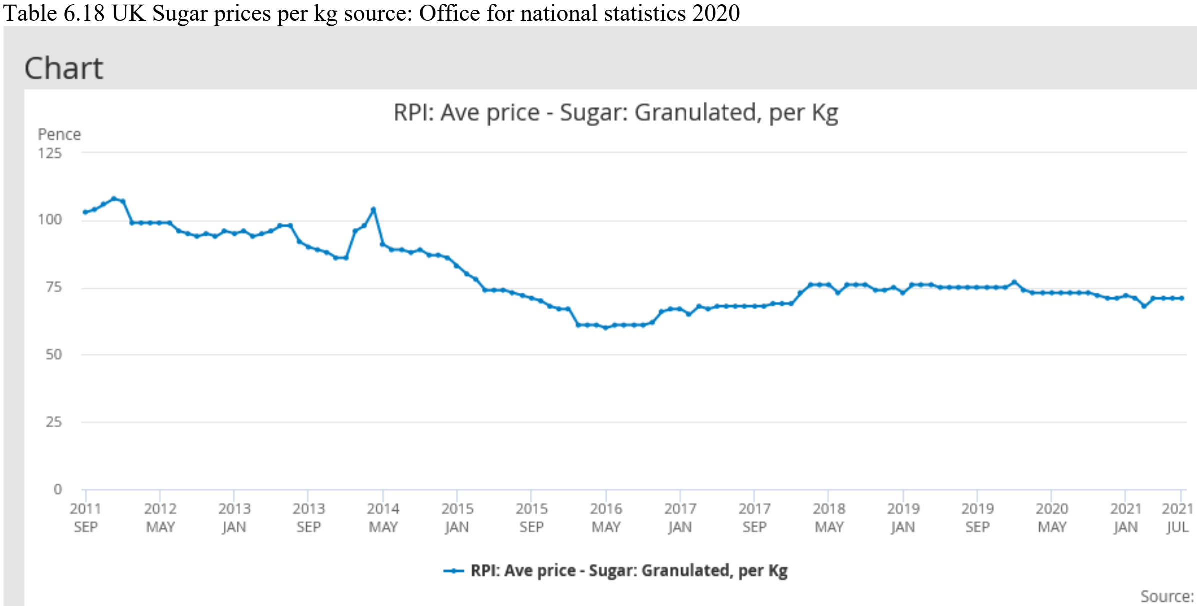
UK Scenario 6 and 7

Sugar will be produced less if sugar beet production falls by 10% (7 million MT) or 20% (6.2 million MT). Table 6.17 shows that when sugar beet production fell from 2014 to 2016, the UK was only able to produce 55% of the locally produced sugar. Furthermore, less sugar beet means more sugar imported from Europe and the rest of the world.

UK Scenario 8 and 9

Sugar is a necessity item with inelastic demand, so if the price of sugar in the UK rises by 10% (80 pence per kg) or falls by 10% (66 pence per kg), it will have no effect on the sugar industry. In this context, if the price rises, people will buy less (demand will remain constant), and if the price falls, people will buy more (demand will remain same). Prices rose to 100 pence but fell to 70 pence in recent years (Table 6.18), but consumption remained stable (Table 6.17).

Table 6.18 UK Sugar prices per kg source: Office for national statistics 2020



Source: Office for National Statistics, 2020

Future Scenario for Ethanol in Pakistan

Scenario 1

These scenarios consider the ethanol instead of sugar demand and production. It is assumed that if ethanol production increases by 10% (i.e.,660,000 MT) or increase by 20% (720,000 MT). Then it would need about 2.77 million MT of molasses if 10% increase and 3 million MT of molasses if 20% would increase. Table 6.10 states the Pakistan molasses production from 2006 and it can be noted that Pakistan has been producing average 2-2.5 million MT of molasses in last 10 years. It reached to 3 million MT in 2016-2017 and 2017-2018, when there was a bumper crop of sugar cane production. Since then, it has decreased due to decrease of area for sugar cane and reduced sugar cane production (Table 6.9). After assessment of the data, it can be noted that Pakistan will be able to fulfil the demand of ethanol if it increased by 10% and 20% without major push for more molasses or alternative feedstock. It is also to be notes that this level of molasses production needs increased sugar cane production and sugar production.

Table 6.10 Pakistan molasses production Source: (PSMA, 2020)

Qty: Tonnes

Year	Punjab	Sindh	K.P	Pakistan
2006-07	1,222,482	578,833	109,787	1,911,102
2007-08	1,607,042	889,566	167,172	2,663,708
2008-09	928,514	493,079	114,739	1,536,332
2009-10	927,056	529,370	101,131	1,557,457
2010-11	1,249,324	643,651	141,580	2,034,555
2011-12	1,445,830	624,956	153,583	2,224,369
2012-13	1,422,807	663,305	166,639	2,252,751
2013-14	1,495,781	854,225	174,196	2,524,202
2014-15	1,281,768	781,665	183,702	2,247,137
2015-16	1,279,715	787,910	178,914	2,246,540
2016-17	1,877,383	982,451	218,128	3,077,962
2017-18	1,777,508	973,986	203,128	2,953,798
2018-19	1,355,016	716,879	167,670	2,239,565
2019-20	1,416,668	663,254	132,366	2,236,628

Molasses figures estimated

Scenario 2

If Pakistan government introduces a mandate of E10, which is about 760,000 MT of ethanol required to make the E10 of 7.6 million MT. As discussed in the previous scenarios 8 and 9, if the molasses level reaches to 3 million on average, it will be possible for Pakistan to produce over 750,000 MT and if sugar production increases, it will give an opportunity to ethanol industry to produce more ethanol. In table 6.11, it can be noticed that molasses export is also decreasing from last few years it is due to introduction of export duty for molasses and increase in local and international demand of ethanol. If the exported molasses also to be used in the ethanol production, it will further increase the ethanol production by 8,700 MT of ethanol.

Table 6.11 Pakistan molasses export data, Source: (PSMA, 2020)

*Year	Quantity	Value	Avg. Price
2006-07	373,177	1,704,034	4,566
2007-08	780,807	3,490,864	4,471
2008-09	936,338	7,486,584	7,996
2009-10	961,300	7,784,000	8,097
2010-11	86,437	892,087	10,321
2011-12	55,608	577,981	10,394
2012-13	225,221	2,747,341	12,198
2013-14	197,342	2,510,421	12,721
2014-15	83,229	1,010,347	12,139
2015-16	73,067	874,398	11,967
2016-17	101,410	1,217,122	12,001
2017-18	168,962	2,114,533	12,515
2018-19	117,909	1,698,719	14,407
2019-20	36,532	846,471	23,171

Scenario 3

In this scenario it is assumed that the demand of ethanol is decreased by 10% (demand decreases by 10% (i, e.540,000 MT) the surplus will go to exports, and this will bring money due to the high price of ethanol in international market. Notably, Pakistan has been exporting ethanol from last decade and revenue amount has been quite high (Table 6.12). In sum, even if the local demand decreases by 10 or 20%, still Pakistan ethanol industry will be viable and will be able to export ethanol.

Table 6.12 Pakistan ethanol export data, Source: (PSMA, 2020)

*Year	Quantity
2006-07	34,116,438
2007-08	28,609,832
2008-09	27,045,396
2009-10	101,260,099
2010-11	168,509,200
2011-12	215,814,894
2012-13	142,065,426
2013-14	492,476,805
2014-15	421,881,994
2015-16	396,940,741
2016-17	358,483,301
2017-18	699,791,482
2018-19	781,089,024
2019-20	474,228,873

Scenario 4 and 5

These scenarios consider the analysis of the variables that affect production at various points in time. For instance, if ethanol prices are raised by 10% to PKR 105.6 per litre from the current PKR 96 per litre (Table 6.14), local consumption may fall. However, the price of ethanol is linked to the price of gasoline. If the price of gasoline exceeds the price of ethanol, ethanol will always be profitable. If the price of ethanol from fossil fuels rises, the government will have to provide a subsidy to protect the environment from GHG emissions. If ethanol prices fall by 10% to PKR 86.4 per litre, demand for ethanol will rise in both the domestic and export markets. More ethanol, more fuel blending results in lower GHG emissions, more rural agricultural jobs, and cost savings from fossil fuel imports.

Table 6.14 Pakistan ethanol prices source: PSMA 2020

2012-2013	61.49 PKR per Litre
2013-2014	65.21 PKR per Litre
2014-2015	61 PKR per Litre
2015-2016	58 PKR per Litre
2016-2017	85 PKR per Litre
2017-2018	61 PKR per Litre
2018-2019	73 PKR per Litre
2019-2020	96 PKR per Litre

Based on historical data from the last ten years, the Pakistan ethanol industry will thrive in the future. It was an export-oriented industry until local demand increased due to the Covid, the need for E10, and local use (It was an export-oriented industry until local demand increased due to the Covid, the need for E10, and local use.) The introduction of new raw materials for ethanol production in Pakistan will significantly increase ethanol production while also benefiting the Pakistani economy. It was suggested that available corn be used in the ethanol industry. Table 6.15 shows that Pakistan corn production is increasing year after year, reaching nearly 8 million in 2019-2020 and expected to reach 8.5 million in 2020-2021. Most of the corn is used in the feed industry, followed by wet milling. If corn is used to produce ethanol, it will produce DDGS as a valuable product and will be able to do two things at once: meet ethanol demand and feed industry demand. As a result, corn will be an excellent choice for ethanol production.

Table 6.15 Pakistan corn area, production, and yield, Source: (Ministry of Finance, 2020)

Year	Area		Production		Yield	
	(000 Hectares)	% Change	(000 Tonnes)	% Change	(Kgs /Hec.)	% Change
2016-17	1,348	-	6,134	-	4,550	-
2017-18	1,251	-7.2	5,902	-3.8	4,718	3.7
2018-19	1,374	9.8	6,826	15.7	4,968	5.3
2019-20	1,404	2.2	7,883	15.5	5,615	13.0
2020-21 (P)	1,418	1.0	8,465	7.4	5,970	6.3

Future Scenario for Ethanol in United Kingdom (UK)

UK Scenario 1 and 2

If ethanol consumption rises by 10% (i.e., 827 million litres) or 20% (902 million litres), the UK ethanol industry will be put under strain. Since it only produced 645 million litres in 2017 (Table 6.19), it has dropped to 516 million litres in 2018 (Table 6.19) and then to 262 million litres in 2019 (Table 6.19). Due to the shutdown of the ethanol factory and low production due to crop cap of wheat to be used for ethanol. As a result, the UK government was unable to introduce E10 and had no policies in place to protect the local industry by preventing cheap imports from the USA.

Table 6.19 UK Ethanol production in Million Litres, Source: (DEFRA, 2020)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Bioethanol										
Total UK production	281	29	154	524	516	333	468	645	516	262
Total bioethanol consumption: UK road transport	631	652	775	819	812	797	759	752	761	752

UK Scenario 3

If an E10 mandate is implemented, which was expected to be implemented in 2020 to protect local ethanol industries. As of 2020, the UK's current petrol consumption is 13.1 billion litres, and if E10 is implemented, the UK would require 1.31 billion litres of ethanol to meet local demand. Table 6.18 shows that the maximum ethanol production in the UK was 645 million litres, implying that meeting the 10% mandate will be difficult. However, lifting the crop cap and being able to use alternative crops to make ethanol will change this dimension, allowing the UK to produce enough ethanol to meet all its domestic demand.

UK Scenario 4

The ethanol industry in the United Kingdom may have a promising future. Following the implementation of the E10 policy and commitment to reducing GHG emissions and protecting local industries, the UK ethanol industry will have a fair chance to produce at full capacity. It was discovered that the three available ethanol producers in the UK can produce 900 million litres of ethanol. Currently, the United Kingdom produces ethanol from sugar beets and wheat. Currently 8% of the sugar beet area is used for ethanol production, putting pressure on the sugar industry in the UK (Table 6.20). The area has been increased from 6% last year to 8% in 2019-2020. Overall, the area has grown from 4% in 2016-2017 to 8% in 2019-2020. While wheat area used for ethanol production is 1% in 2019-2020, it was the same in 2018-2019. Due to crop cap and government restrictions, the number of areas has decreased from 4% in 2016-2017 to 1% in 2019-2020 (Table 6.21).

Table 6.20 Sugar beet area used for the ethanol, Source: (DEFRA, 2020)

Sugar beet (RTFO Year: 15th April - 14th April)	Volume of bioethanol (million litres)(a)	Implied tonnage of crop ('000 tonnes)(b)	Sugar beet yield (t/ha)(c)	Implied area '000 ha	% of UK total sugar beet area(d)
Year 1: 2008/09	41.4	409	64	6.4	5%
Year 2: 2009/10	63.0	624	74	8.4	7%
Year 3: 2010/11	68.5	678	55	12.3	10%
Year 4: 2011/12	21.8	216	75	2.9	3%
Year 5: 2012/13	59.9	593	61	9.7	8%
Year 6: 2013/14	57.8	570	70	8.2	7%
Year 7: 2014/15	67.9	669	80	8.4	7%
Year 8: 2015/16	60.0	592	74	8.0	9%
Year 9: 2016/17	23.1	228	71	3.2	4%
Year 10: 2017/18	46.3	457	83	5.5	5%
Year 11: 2018	47.5	469	69	6.8	6%
Year 12: 2019 prov.(e)	63.5	627	75	8.4	8%

Table 6.21 Wheat area used for the ethanol source: (DEFRA, 2020)

Wheat (RTFO Year: 15th April to 14th April)	Volume of bioethanol (million litres)(a)	Tonnage of crop implied ('000 tonnes)(b)	wheat yield (t/ha)(c)	Implied area '000 ha	% of UK total wheat area(d)
Year 1: 2008/09	0.0	0	8.3	0.0	0%
Year 2: 2009/10	0.9	3	7.9	0.3	0%
Year 3: 2010/11	119.9	327	7.7	42.4	2%
Year 4: 2011/12	17.9	49	7.7	6.3	0.4%
Year 5: 2012/13	48.2	131	6.7	19.7	1%
Year 6: 2013/14	70.8	193	7.4	26.1	2%
Year 7: 2014/15	166.1	452	8.6	52.7	3%
Year 8: 2015/16	134.9	367	9.0	40.9	2%
Year 9: 2016/17	191.7	521	7.9	66.1	4%
Year 10: 2017/18	170.7	464	8.3	56.1	3%
Year 11: 2018	62.6	170	7.8	22.0	1%
Year 12: 2019 prov.(e)	35.2	96	9.0	10.7	1%

Wheat production is expected to be 40% lower in 2020 than it was in 2019. (Table 6.22). This was due to a decrease in harvested area and yield. Wheat yield per hectare fell to 7 tons per hectare in 2019 from 8.9 tons per hectare in 2018. Wheat demand for the flour milling, starch, and ethanol industries increased by 2% in 2020, while imports increased by 47% to meet local demand due to reduced domestic supply of wheat. It is to be worth noted that ethanol distilleries in UK were closed or have reduced the production due to government lack of support and crop cap for the ethanol production. They were forced to import raw materials from the other countries.

Table 6.22 wheat production, value, and supply data for UK, Source: (DEFRA, 2020)

Thousand tonnes (unless otherwise specified)									Calendar years	
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
									(provisional)	
Production										
Area (thousand hectares)	1,969	1,992	1,615	1,936	1,832	1,823	1,792	1,748	1,816	1,387
Yield (tonnes per hectare)	7.7	6.7	7.4	8.6	9.0	7.9	8.3	7.8	8.9	7.0
Volume of harvested production (a)	15,257	13,261	11,921	16,606	16,444	14,383	14,837	13,555	16,225	9,658
Value of production (£ million) (b)	2,322	2,162	2,075	2,432	1,967	1,667	2,068	2,111	2,434	1,550
of which: Sales	2,218	2,230	1,937	1,900	1,686	1,866	1,850	2,012	1,999	1,916
Subsidies (c)	0	0	0	0	0	0	0	0	0	0
On farm use	72	139	188	159	137	106	170	212	229	70
Change in stocks	32	-207	-50	373	143	-304	48	-113	207	-436
Value of production at market prices (£ million) (d)	2,322	2,162	2,075	2,432	1,967	1,667	2,068	2,111	2,434	1,550
Prices (average prices weighted by volumes of sales (£ per tonne))										
Milling wheat	175	173	185	155	132	121	146	163	162	173
Feed wheat	150	163	169	137	116	115	139	157	147	160
Supply and use										
Production	15,257	13,261	11,921	16,606	16,444	14,383	14,837	13,555	16,225	9,658
Imports from: The EU	493	1,358	2,490	1,369	1,131	918	1,283	1,823	668	1,515
The rest of the world	409	427	475	455	451	564	610	668	552	586
Exports to: The EU	2,125	1,282	413	804	1,519	2,163	635	356	959	363
The rest of the world	162	221	35	339	483	772	11	2	152	143
Total new supply	13,872	13,543	14,438	17,287	16,024	12,930	16,084	15,688	16,334	11,253
Change in farm and other stocks	625	-1,325	-194	2,665	1,118	-2,443	356	209	1,908	-2,714
Total domestic uses	13,247	14,868	14,632	14,622	14,906	15,372	15,728	15,479	14,426	13,987
of which: Flour milling	5,857	6,781	6,506	6,725	6,591	6,876	7,138	6,589	5,814	5,930
Animal feed	6,268	6,807	6,719	6,565	7,075	7,270	7,347	7,667	7,367	6,857
Seed	299	304	293	291	281	283	278	271	281	215
Other uses and waste	823	975	1,114	1,042	959	943	964	952	963	985
Production as % of total new supply for use in UK	110%	98%	83%	96%	103%	111%	92%	86%	99%	86%
% of home grown wheat in milling grist	88%	86%	69%	82%	85%	87%	87%	81%	87%	81%

Another point of interest is whether locally grown maize can be used for ethanol production and whether the UK government can allow up to 2% of wheat to be used for ethanol production. It will assist the UK in producing more ethanol to reduce GHG emissions, create more local jobs, and help the economy. Table 6.23 shows that maize is becoming a stable crop in the UK, with plantings increasing from 221,000 to 228,000 hectares by 2020. This presents an excellent opportunity for ethanol distillers to use local maize to produce ethanol as well as a valuable coproduct DDGS, which will be more valuable than feed.

Table 6.23 Maize growing area, Source: (DEFRA, 2020)

Crop name	2018	2019	2020	Percentage change %

Summary

It should be noted that the majority of future scenarios for the Pakistan sugar mill and ethanol mill are positive, and with the given scenarios, the Pakistan sugar and ethanol industry will thrive. With a few exceptions, the sugar industry in the United Kingdom will struggle with less feedstock, and more sugar will be imported in the coming years. With the implementation of

E10 policy and the availability of raw materials such as maize and wheat, the UK ethanol industry will be on the rise.

6.6. Conclusion and Result

The purpose of this chapter was to analyse the impact of ethanol production on the sugar industry. It was concluded from the thematic analysis from the interview that ethanol leaves no impact on sugar industry in Pakistan and impact is minimum in UK when sugar beet is used to make ethanol. Pakistan produces ethanol form the by product of sugar industry, while UK produces from the sugar beet and feed grade wheat. Although they use only 5% of the sugar beet to make ethanol (Table 6.1). A trade-off analysis was performed to determine which trade-off option would be the best. Although there are many products which can be produced from the sugar cane or beet, but ethanol was the best alternative available because it contributes to the economy and helps to reduce GHG emissions in Pakistan and the United Kingdom (Table 6.3). Furthermore, a SWOT analysis was performed to understand the strengths, weaknesses, opportunities, and threats to the ethanol industry in Pakistan and the United Kingdom, and it was discovered that Pakistan's main strength and opportunity is that it uses molasses, a by-product of the sugar industry. It is beneficial to the economy, creates employment and can aid in the reduction of GHG emissions; however, the main threats and weaknesses were its highly political influence, relies on single raw material and a lack of sector policies. In the case of the United Kingdom, the main strength and opportunity were that the country can produce all its needs from any grain crop, and it provides valuable feed products such as DDGS. UK can fulfil 10% mandate and can reduce GHG emissions. The UK's weaknesses and threats were that it will be difficult to compete with the cheap imported ethanol, introduction of crop cap and high cost of raw material (Figure 6.2 & 6.3). Once it was determined through thematic analysis that ethanol does not impact the sugar industry, Trade off analysis was conducted to understand the best alternative product: which turn out to be ethanol. SWOT was carried again on the ethanol industry against the SWOT analysis which was carried in previous chapter, and which was about sugar industry. It clearly shows that there are many strengths and opportunities related to ethanol production in UK and Pakistan.

Life cycle costing was done to fulfil the literature gap, which was identified in the table 3.4. Techno economic analysis was the best option chosen to do LCC. TEA analysis was performed to determine the financial viability of ethanol production in Pakistan and the United Kingdom. For Pakistan, the investment cost is low, but the profits are extremely high. Due to high sugar consumption and a large sugar industry, molasses is widely available in Pakistan. Molasses is related to sugar because molasses is used to produce ethanol when sugar is produced. The ethanol production unit in Pakistan has the potential to significantly boost the biofuel market, and export demand is already present. The raw material (molasses) costs between PKR 17 and PRK 22 per kg, and labour is inexpensive in comparison to other parts of the world. Overall, the project is viable because the returns are high due to the availability of raw materials in Pakistan, as well as the high demand in Pakistan and abroad. In the United Kingdom, the investment cost is medium, and if land is leased, the cost is low, and profits are high. The payback period is approximately one year and ten months, which makes the project feasible, especially given the good equipment life of 15-20 years. Sugar beet availability is limited, but wheat availability is abundant due to the use of feed grade wheat. As a result, feed grade wheat accounts for 90-95 percent of ethanol production, with the remainder coming from sugar beets. The demand for ethanol is very high in the United Kingdom, but the industry has relied entirely on policy and quotas. Table 6.4 shows the caparison of investment returns for the UK market and Pakistan's market.

To understand whether the ethanol industry will be viable in the future and what will happen if ethanol production increases. Future scenarios demonstrate that both countries have enough feedstock to produce more ethanol. If ethanol production in Pakistan increases by 10% or 25% soon, Pakistan will have enough molasses to produce ethanol. Much depends on government policies in the UK, but they have enough wheat and maize to produce more ethanol even if demand rises by 10% or 25%. Based on the viability analysis, if sugar demand falls (as in the UK), it makes sense to divert sugar to ethanol production. This can create a better symbiotic relationship. The coupling can be quite flexible and if sugar demand increases in the future, adjustments in the production can be easily made. In the case of Pakistan, ethanol industry relies on a sugar by-product and is not in direct competition. However, considering the sugar politics (price control, export quota), ethanol production offers an alternative revenue generation route. The potential use of sugar for ethanol production could increase ethanol supply and support low-cost ethanol production. If an industry relies solely on sugarcane and more sugarcane is converted to ethanol, the demand for sugar will rise, causing sugar prices to rise. Table 6.7 demonstrates different option, which was used to do future scenario analysis.

Finally, it has been discovered through interviews that many industrialists prefer to produce ethanol over sugar, especially as its prices rise, which will have an impact on the sugar industry. Normally, the government controls these things by establishing a mandate and a percentage of production to protect local demand. If sugar demand falls or extra sugar cane available, it makes sense to divert sugar to ethanol production, according to the viability analysis. This can result in a more symbiotic relationship. The coupling is quite flexible, and if sugar demand rises in the future, production adjustments are simple. In Pakistan, the ethanol industry is based on a sugar by-product and is not in direct competition. However, given the sugar politics (price control, export quotas), ethanol production provides an alternative revenue generation pathway. The potential use of sugar for ethanol production could increase ethanol supply and support the country's low-carbon transportation sector.

Chapter 7: Mitigation measures to manage the factors affecting sugar industry and manage the potential impact of ethanol production on sugar industry in Pakistan and UK

This chapter will highlight the impacts that were discovered in chapters 5 and 6, as well as the factors affecting the sugar industry in Pakistan and the United Kingdom, as well as a summary of the identified impacts of ethanol production on the sugar industry in Pakistan and the United Kingdom. This chapter will present potential solutions to the problems. The challenges will be linked back to chapters 5 and 6, and a variety of solutions will be proposed.

7.1. Summary of the factors affecting sugar industry in Pakistan and UK

The factors affecting the sugar industry in Pakistan and the United Kingdom are summarized below. It has been presented in the form of a table to aid comprehension of the factors. Table 3.2 and 3.3 of the literature review identified the factors affecting the yield of sugar cane and sugar beet in the Pakistan and UK. SWOT and PESTLE analysis were conducted to fulfil the gap from the existing literature. Table 7.1 was generated from the figure 5.2 & 5.3 and Table 5.9.

Table 7.1 Factors affecting sugar industry in Pakistan and UK, Source: SWOT & PESTLE analysis

Pakistan	UK
Availability of Sugar cane	Lack of raw material for sugar production
Low yield of crop	People converting to other profitable crops
Low sugar yield	Monopoly of production
Old technology with some modifications	Health concerns
Price control	
Farmer union (payment settlement and late payments)	

In summary, in the case of Pakistan, the availability of more sugar cane will be the major factor that will have both positive and negative effects on the sugar industry. It was understood from the SWOT, PESTLE and Thematic analysis that, the current sugar cane variety does not produce a high yield, and transportation becomes a major issue, reducing sugar cane yield. Sugar mill yield is less than 10%, which is a source of concern, along with a lack of cutting-edge technology to extract more sugar from it (Abbassi Securities, 2019; PSMA, 2020). Each season, the price becomes a point of contention between the government, the farmers' union, and the Pakistan Sugar Mills Association. Mills are making late payments to farmers, and as a result, farmers are shifting to alternative crops, which are affecting Pakistan's sugar industry (Thematic analysis, and asserts by (Arif, 2019). In the case of the United Kingdom, there is a scarcity of raw materials to produce sugar. The United Kingdom produces only half of its sugar from sugar beets, (Thematic analysis) with the remainder coming from imported sugar (ABSugar, 2018). Due to low profitability, many farmers switch to other crops, and only a few people grow sugar beet in the UK; data from the last ten years suggest that it was between 100,000-110,000 hectares (AgMRC, 2020). British sugar has a monopoly (SWOT analysis) because it is the only company that produces sugar from locally grown sugar beets, giving other companies less opportunity to compete (Pestle analysis & Thematic analysis) and asserts by (Lynsey, 2019). In Further to that, health concerns are the most recent addition to the factors affecting or potentially affecting the sugar industry, as most people are becoming more health conscious.

7.2 Summary of identified impacts of ethanol production on sugar industry

Table 7.2 summarises the identified possible impacts of ethanol production on the sugar industry in Pakistan and the United Kingdom through analysis and literature review. It aids in understanding of the consequences of each situation. As discussed in the first part of the research, there are variables affecting the ethanol industry that differ between Pakistan and the United Kingdom, with Pakistan relying on sugar cane and the United Kingdom relying on sugar beet. To that end, the degree of influence is determined by the country's rate of dependence on a specific type of substance used to produce ethanol and increasing dependence on one product results in an increase in the effect of that product, as shown in the table, when the dependence on sugar beet increases in the production of ethanol in the UK, the effect of that product increases.

Table 7.2 Potential impacts of ethanol production on sugar industry in Pakistan and UK

Country	Industry	Raw material	Scenario	Possible Impacts
Pakistan	Sugar	Sugar cane	Sugar cane is used for sugar production	None as emphasized in the thematic analysis (Section, 5.5)
Pakistan	Ethanol	Molasses	Molasses is a by-product of sugar industry	None as emphasized in thematic analysis (Section, 6.1)
Pakistan	Ethanol	Sugar cane	By assuming if sugar cane is used for the ethanol production	Medium as emphasized in the future scenario analysis (Section, 6.6) and mentions by the (Asian Development Bank, 2017)
Pakistan	Ethanol	Grains	Wheat, corn etc.	None as emphasized in the future scenario analysis (Section ,6.5)
Pakistan	Sugar & Ethanol	Sugar cane	If excessive sugar cane or sugar to be used to make ethanol	None as emphasized in future scenario analysis (Section,

				6.5)
UK	Sugar	Sugar beet	Sugar beet is used for sugar production	None as emphasized in the thematic analysis (Section, 5.5)
UK	Ethanol	Sugar beet	5% Sugar beet is used for producing ethanol	Medium as emphasized in the thematic analysis (Section, 6.1)
UK	Ethanol	Wheat	95%. Feed grade wheat is used to make ethanol	None as emphasized in the thematic analysis (Section 6.1)
UK	Ethanol	Sugar beet	If more sugar beet is used to make ethanol	High as emphasized in the future scenario analysis (Section 6.5)

Possible Impacts in Pakistan

It was discovered that ethanol production in Pakistan has no effect on the sugar industry in Pakistan because it uses molasses, a by-product of the sugar industry. Because sugar cane is the raw material used to make sugar in Pakistan, if Pakistan uses sugar cane directly for ethanol production, it may have an impact on the sugar industry. It was also revealed that if ethanol demand increases, more sugar cane molasses will be required, which means more sugar production because molasses will be used for ethanol production. Furthermore, if supply restrictions were lifted and the government did not control the sugar industry, more sugar mills might divert sugar to ethanol production due to higher profits. This is an intriguing case: producing more ethanol may benefit the country in terms of foreign exchange savings, reduced pollution, and increased profits for the industry. It is suggested that the government remove the sugar controls. The added benefit could be health benefits from less sugar consumption.

Possible Impacts in the UK

For UK, it was discovered that ethanol production has an impact on the UK sugar industry. Because it produces sugar from sugar beet, and in the UK, 5 percent of sugar beet is used for ethanol production, it has an impact because less sugar beet is available to produce sugar. Already, the UK cannot produce all its own sugar and must rely on sugar beets to meet half of its demand. It was predicted in future scenarios that continuing to use sugar beet for ethanol production or increasing the percentage of sugar beet used for ethanol production would have an impact on sugar production. Furthermore, the imposition of a sugar tax and the possibility of lower sugar demand would enable the UK to produce more ethanol. The sugar industry could benefit from ethanol diversification without losing profitability.

7.3. Overview of the Strategies to mitigate the impacts

Strategies for Pakistan

According to the SWOT and PESTLE analyses, molasses exports must be reduced so that all molasses can be used for local ethanol production. The export of ethanol has a potential to generate significant revenue for Pakistan. A model like that of Brazil and India can be used. These mitigation strategies are based on the SWOT ad PESTLE analysis:

a) Market influence via sugar and ethanol pricing

b) Market influence via technology

c) Governance arrangements

d) Need for integrated system to use excess sugar or sugar cane towards ethanol, depending on the situation

e) Use of E10

f) Requirement for alternative feedstock to eliminate any potential impact on the sugar industry

Strategies for the UK

According to analyses such as SWOT and PESTLE, the UK is the top producer of sugar beets in the EU. The sugar industry can produce a variety of useful byproducts such as molasses, pulp, and leaves. The main advantage is that beet prices are fixed between grower and miller. Furthermore, the elimination of European Union sugar quotas will assist other refineries in importing cheap sugar and producing cheap white sugar. In addition, the following strategies for mitigating are based on SWOT and PESTLE analysis:

a) Influencing the market through sugar and ethanol pricing

b) Allowing sugar refiners to import cheaper raw sugar

c) Implementing the recently introduced E10 policy

d) Stopping the cheaper import of ethanol

e) Either increasing sugar beet production by increasing the area, yield of production, or more fair competition for other sugar makers to import better and cheaper sugar

f) Need for alternative feedstock for ethanol production to eliminate the potential for contamination

7.4.1. Factors of production of Ethanol, Impact on Sugar industry and Measures to Mitigate the impact -The Case of the UK

Table 7.3 depicts the ethanol production factors that have an impact on the UK sugar industry. The table also shows the impact on the sugar industry. Mitigation measures are presented in column 4 and have derived from the SWOT analysis (section 6.3) and was presented in PESTLE style, so that it can be understood in much clear manner. In the United Kingdom, the increased RTFO target encourages ethanol production, while the sugar tax reduces demand for sugar and allows for some sugar diversion. The question is whether the UK sugar industry will reduce sugar for the food industry while increasing ethanol production. and whether this ensures the industry's survival. It should also be noted whether additional ethanol can be produced from sugar beets and whether this can offset the effect of the sugar tax. Sugar taxation has very little effect on price or demand changes. Second, the UK can only produce half of its sugar from sugar beet and using sugar beet to make ethanol can put strain on the sugar industry.

Table 7.3: Impact of Ethanol Production on Sugar Industry of the UK, Source: Author

Environmental Factor	**Factors related to production of ethanol**	**Impact on sugar Industry**	**Measures for mitigation of the impact of production of ethanol on sugar industry**
Political	The UK Government following the proposed amendments to the Renewable Transport Fuel Obligations Order has indicated that the target level under the obligation will rise to 7.25% from April 2018, further increasing to 9.75% in 2020 and to 12.4% by 2032.	This will help meet the Renewable Transport Fuel Obligation Order (RTFO) which calls for increased use of biofuels in transport.	The use of sugar beet to produce ethanol can be reduced by using feed grade wheat and maize instead because all sugar beets can be used to make sugar only. Government should help to implement the E10, which has been introduced to maximize the positive impact of ethanol on the environment.
Economical	The abolition of EU sugar quotas at the end of 2017 led to a 30% increase in cropped area and a 58% rise in production of sugar beet in 2017 compared to the previous year. Furthermore, after the Brexit will create more opportunities.	After Brexit UK sugar industry will be free to work independently, Increased demand for sugar beet will necessitate expansion of the sugar industry in the UK following a post-Brexit UK exit from the EU into the European Union.	Land use should be reviewed at a national level by a panel of experts from various sectors so that land use may be planned based on priorities of the UK. More land should be allocated for growing sugar beet.

	Ethanol producing industries in UK greatly emphasize on producing biofuel through wheat and sugar beet. They also produce by-products for the animal from it (FOA, 2021).	Use of sugar beet for production of ethanol will take away some quantity of sugar that could have been available to produce sugar. This would have a little impact on sugar industry as most of the sugar is imported and not from the region where sugar beet is grown.	Extensive research should be carried out to increase the yield of sugar beet and able to import cheap raw sugar to refine and fulfil local demand to reduce its dependence on sugar beet. Since sugar beet cannot be produced more under land policies.
Technological	Technological advancement in process of ethanol production in the UK drastically surges the production of ethanol in the UK. Need to develop technology to produce ethanol from cellulosic material (Amies-Cull, Briggs and Scarborough, 2019).	This helps the sugar industry as the demand on sugar industry would reduce due to technology improvement and less use of sugar beet for the ethanol.	Improvements in technology should continue to relieve pressure on the sugar industry to meet demand. The increase in ethanol production from sugar beets will cause an increase in demand for sugar due to its scarcity, so the UK will need to develop technology to produce ethanol from cellulosic material.
			The development of applications for schools to teach children about sustainability, food security, and health issues. The education system may introduce and remodel the existing curriculum of educational

			programmes at all levels (primary education, secondary education, college and university level) to educate people about the dangers of obesity and related problems and how to avoid them.
Ecological	The reduction in emission from the utilization of biofuel.	Emission reductions will assist the sugar industry in reducing emissions. Biodiesel production from waste cooking oil and bioethanol production from sugar beet offer the greatest potential for emissions savings relative to fossil fuel equivalents, with a maximum emission savings of 4.1 percent observed with a biofuel market share of 10% achieved in 2020. It was also determined that, under the current biofuel feedstock mix, to achieve the 6 percent emissions savings primarily from biofuels proposed in the LCTP, biofuels would need to hold 23.8 percent of the transport fuels market by 2020.	To reduce GHG emissions, the government should increase ethanol production.

Legal	Increased demand for the petroleum in the world would create pressure on UK to increase production of ethanol to comply with the international biofuel market demand.	This would force UK ethanol industry to increase its production so that more ethanol is produced that can be used as fuel to fulfil the demand.	E10 has been implemented in the UK, and now is the time to support the industries for them to begin as soon as possible. The UK should continue its research and development in the field of energy conservation and find alternative solutions to the use of petroleum and ethanol, such as battery-powered cars and hydrogen/methanol blended systems.

7.4.2 Factors of production of Ethanol, Impact on Sugar industry and Measures to Mitigate the impact -The Case of the Pakistan

Table 7.4 depicts the ethanol production factors that have an impact on the UK sugar industry. The table also shows the impact on the sugar industry. Mitigation measures are presented in column 4 and have derived from the SWOT analysis (section 6.3) and was presented in PESTLE style, so that it can be understood in much clear manner. Ethanol production has no impact on the sugar industry in the UK since it relies on the by product of the sugar industry.

Table 7.4: Impact of Ethanol Production on Sugar Industry of Pakistan, Source: Author			
Environmental Factor	**Factors related to production of ethanol**	**Impact on sugar Industry**	**Mitigation Measures**
Political	In Pakistan, the biofuel industry has been hampered by a lack of government policies that could encourage the private sector to invest heavily in the industry. Monopolization in the sugar and biofuel industries is a significant barrier.	Sustaining sugar production in Pakistan will necessitate a combination of policy incentives and political will. The sugar industry's growth has also been hampered by a lack of supportive government policies and monopolisation.	Price liberalisation is better for everyone. Furthermore, the government should provide sufficient export quotas and subsidies for sugar export.
	Pakistan lacks political support for conflicts over food versus fuel production. Because of a lack of awareness. However, this is changing.	Food versus fuel production conflicts in Pakistan can be contained, but they have no effect on ethanol production as it uses molasses as a raw material.	The Pakistani government should pay attention to the energy sector and shift its focus from short-term to long-term measures by implementing a strategy to implement a biofuel mandate.
Economical	Sustaining sugar/biofuel production in Pakistan necessitates economic and institutional policy options.	The lack of economic and institutional policy options for increasing ethanol production has an impact on local ethanol consumption.	Policy options for ethanol pricing per litre for domestic and export use would encourage cane growers to increase sugar production.

	The rise in ethanol demand is expected to continue due to quotas and targets set by various countries. The demand for transportation fuel in Pakistan will have a positive impact on the demand for sugarcane ethanol, which will reflect strong economic growth.	The rise in ethanol demand in Pakistan will have an impact on the sugar industry's growth.	The Government of Pakistan should enact policies that benefit the ethanol industry. As oil prices rise, the government may declare an RTFO for Pakistan.
Social & Cultural	Pakistan's transportation sector is critical to economic growth as well as social and cultural stability	If ethanol is used in the transportation sector in Pakistan, the sugar industry will grow as well. The Pakistani government promotes sugar/biofuel production in areas with extremely high unemployment, poverty, and social constraints	To protect the social benefits provided by the sugar industry, the government should use a synergistic approach between the sugar and ethanol industries, which can complement each other and create a more resilient industry by leaving the market to its own devices. If there is a greater demand for sugar, more sugar can be produced, and if there is a greater demand for ethanol, more ethanol can be produced.

Technological	Pakistan's sugar/biofuel industry lacks advanced technological infrastructure. In Pakistan, the sugar/biofuel industry lacks advanced technology/mechanisms for converting sugarcane waste to useful materials or using other available raw materials to make ethanol.	The sugar/biofuel industry's production is hampered by a lack of technological infrastructure. Sugarcane yield improvement and sugar loss recovery during processing boost sugar industry output.	To assist industries in growing, the government should prioritise infrastructure development in Pakistan. More funds should be set aside for infrastructure development. The possibility of ethanol fermentation directly from sugarcane juice, as well as other available raw materials such as feed grade wheat and corn, should be investigated.
Ecological	Pre-harvest sugarcane burning is a common practise in Pakistan, resulting in GHG emissions and air pollution. This has a negative effect on the ethanol manufacturing industry.	Ecological factors affecting ethanol production from sugar cane have a negative impact on the growth of Pakistan's sugar industry. If emissions rise significantly in the future, the government may impose a penalty.	Environmental protection is required, as is the development of industries such as ethanol. GOP should prioritise environmental protection by enacting policies governing distilleries' air and water waste.
Legal	The lack of a legal framework for land allocation for ethanol production in Pakistan results in lower ethanol production and quantity.	Lower ethanol production has a negative impact on the sugar industry.	The government of Pakistan should review its policy framework and allocate adequate land to the ethanol industry, as well as the amount of ethanol to be produced. Policy is being implemented to encourage small and medium-sized businesses to produce ethanol and share sugar cane and molasses.

Conclusions

This study draws several conclusions about the relationship between ethanol production and the sugar industry in the United Kingdom and Pakistan. In the case of Pakistan, bioethanol production policies and other drivers are heavily reliant on export potential, government policies for introducing ethanol blending, and other R & D to use grain-based feedstock to produce more ethanol. On the other hand, regulators, automobile engine certification (a certificate specialised in the field of engine diagnostics and maintenance that requires practical experience in engine diagnosis, measurement, disassembly, and assembly), and quotas estimation influence and drive UK bioethanol production. Table 7.5 compares the bioethanol production policies and other drivers in Pakistan and the United Kingdom.

Table 7.5: Comparison of the bioethanol production policies, feedstocks and drivers in Pakistan and the UK

	Aspects	**Pakistan**	**UK**
Policies	Current blending mandate for mixing ethanol with fossil fuels	0% -5%	4.75%
	Targets 2020 for mixing ethanol with fossil fuels	5%	5%
	New Policy for higher mandate for mixing ethanol with fossil fuels	5%	10%
Feedstocks	Feedstocks	Sugar cane Molasses	• Wheat • Sugar beet
	Future feedstock	Grain based (Corn, wheat etc.)	• Cellulosic based, • Waste feedstocks
Drivers	Drivers	High export potential	• Low GHG, • Employment • Cleaner air • Economy support

	Future drivers	• Policies to use more ethanol locally for blending • Low GHG • Saving foreign reserves • Direct and indirect employment • Rural development	• 10% introduction of blending to have cleaner air quality • Low GHG emission • Economy support • Rural development
	Other factors	• No blending policies • No counting on molasses • No research done on new feedstocks • Neglected industry left in the hands of sugar and ethanol mafia	• Cheaper import of ethanol from other countries • Low mandate • High taxes

7.5. Cross-learning opportunities

The cross-learning opportunities are available in Pakistan and the United Kingdom (Table 7.6). It is summarized that Pakistan can learn from the UK in terms of better technology for sugar and ethanol production, better agricultural practices for higher yield, policies to protect the sugar and ethanol industries, and identifying and eliminating environmental issues through the implementation of environmentally controlled policies. On the other hand, the UK can learn from Pakistan by using sugar beet molasses to produce ethanol, using available crops, having a rural-based economy to support the rural economy, and protecting.

Table 7.6 Cross learning opportunities for Pakistan and UK, Source: Author

Pakistan can learn these from the UK	UK can learn these from the Pakistan
Better technology	Use molasses for ethanol production
Better agriculture practices	Rural based sugar and ethanol industry
Policies	Use available raw material for the ethanol production
Environmental impacts	Protect ethanol producers with import and export policies

Chapter 8: Conclusion and recommendations for further work

The findings of this research study are presented in this chapter. First, it returns to the main objectives and research questions to ensure that the study adequately addressed them. It then emphasises the contribution of this work before indicating areas for future work.

8.1. Revisiting research objectives and their achievement

The goal of this study was to investigate the relationship between the sugar and ethanol industries to understand the factors affecting the sugar industry in general in Pakistan and the United Kingdom, as well as the effects of ethanol production on the sugar industry and fundamental changes to eliminate all possible and potential impacts. There were three proposed questions, the first of which was to understand the factors affecting sugar production in Pakistan and the United Kingdom, which was accomplished through various analyses such as PESTLE analysis, thematic analysis, SWOT analysis, and demand and supply analysis. As a result, it establishes the relationship between the sugar and ethanol industries and thoroughly explains the factors affecting the sugar industry in Pakistan and the United Kingdom. The second question was to look at the potential impacts of ethanol production in Pakistan and the United Kingdom, and this research goal was accomplished by conducting thematic analysis, swot analysis, technoeconomic analysis, and future scenario analysis to understand, establish, and see through these impacts. The third question, which was to examine the available mitigation alternatives and reduce/eliminate the impact, was answered by concluding the first two research questions and developing recommendations and procedures to eliminate the impacts in Pakistan and the United Kingdom.

8.2. Summary of main findings and contribution to knowledge

This study makes an important contribution because it compares the economic, environmental, and political contexts of ethanol versus sugar production. The findings of this study will aid in comparing how ethanol production influences or does not influence the sugar industries in the United Kingdom and Pakistan, and how the long-term returns from this trade-off can be optimised. A research gap in ethanol impacts on the sugar industry is a problem that has yet to be addressed in a specific field.

Researchers have been addressing food vs fuel debate: which is a wide topic, and it could not have discussed how ethanol production in UK or Pakistan can or cannot impact sugar production. Due to a lack of or a gap in the existing literature, this study will address any ethanol impacts on the sugar industry in the UK and Pakistan in a comparative analysis style. This study ensures that the chosen topic necessitates additional research. To fill a research gap, this study chose a novel aspect of existing studies on the subject and decided to conduct a comparative analysis of sugar and ethanol production methods in two different countries: Pakistan and the United Kingdom.

This study covers the sustainability assessment of ethanol along with a detailed analysis of its availability in Pakistan through PESTLE analysis, thematic analysis, Techno economic assessment, and demand and supply analysis. The goal was to learn about the factors influencing sugar production in Pakistan and the United Kingdom. Pestle analysis can be broken down into three steps: Data collection, selection of factors to discuss, and analysis for the purpose of data collection: Primary data was gathered through semi-structured interviews, and secondary data was obtained from government officials in Pakistan and the United Kingdom. These will be utilised in the analysis. To analyse the impact based on each dimension, all Six Dimensions of Drivers (PESTLE) will be used. Once the PESTLE analysis has determined the overall impacts on the sugar industry, further Thematic analysis will be performed to obtain a synopsis of the interviews. As a result, it will help to understand how people in the sugar industry think about potential factors affecting sugar production in Pakistan and the United Kingdom. Such as Pakistan has a high potential for sugar cane cultivation, but the government has failed to manage surplus sugar export. There exists a lack of adequate research and development for sugarcane production. R&D must focus on new and advanced technologies, and farmer income may be protected through government policy. The use of sugar beet and wheat for ethanol raises food security concerns. In the United Kingdom, there are no sugar lobbies, and the government provides subsidies to farmers. Until the EU splits up, the sugar and ethanol markets are heavily protected, but this is expected to change. Moreover, appropriate policies are also recommended for the expansion of the ethanol and sugar industries in Pakistan and the United Kingdom. The main finding is summarised below in relation to the questions. Overall, the main finding is mentioned in sections 5.6 and 6.6.

Q1. Analysing factors affecting sugar Production in Pakistan and UK

Main finding: In case of Pakistan, Government policies to protect the farmers, crop price and sugar mill interest, lack of lucrative agriculture policy, not able to have more sugar yield from the machinery and low yield variety is the main factors affecting sugar industry in Pakistan. In the case of UK, lack of sugar beet, farmers converting to other crops due to low profit crop, monopoly of British sugar, and health concerns are affecting the sugar production in UK.

Q2. Analysis of the possible impacts of ethanol production on the sugar industry in Pakistan and UK

Main finding: Ethanol has no impact on sugar industry in Pakistan as Pakistan is using sugar cane molasses, which is a by-product of sugar industry. Pakistan ethanol industry is dependent on the sugar industry, more sugar production means more ethanol will be produced. Ethanol has low impact on sugar industry in UK as ethanol is being produced from the sugar beet and grains. Only little percentage is produced from sugar beet, if it increases, it will have impact on sugar production.

8.3. Recommendations for growth of ethanol & sugar industries in Pakistan and UK

Recommendations for the growth of ethanol and sugar industries in Pakistan

The main focus is to remove all government restrictions on the sugar industry and let the market work. This may allow the mills to decide whether they produce sugar or invest in ethanol – as the payback period is low, industry will benefit quickly by producing more ethanol (Techno Economic analysis, Section: 6.4). The other area is to improve the productivity – the regression analysis highlights the possibility of improving sugar production without increasing land area. This can be useful for the farmers, but this requires support from the government in terms of technology development, seeds, etc.

The recommendations for the growth of ethanol and sugar industries in Pakistan are presented from Political, Economic, Social and Cultural, Technological, Ecological and Legal perspective.

i. Mixing of ethanol and fossil fuels percentage should be increased from the present level of 0% - 5% to higher limit of up to 10% by 2022. Attempt should be made to increase this level to still higher level.
ii. By adopting the integrated advanced management practices, the sugar yield can be enhanced, which is helpful in enhancing the sugar production as well as ethanol production and indirectly, the farmers will get better wages in response of more income from sugar and ethanol production.
iii. Sugar cane farmers should be protected with right price & from middleman exploitation and right weight policy must be implemented to protect sugar cane farmers.
iv. More licenses should be issues for the sugar mills and ethanol. Currently No new sugar mill can be opened in Pakistan due to monopoly by the sugar mill and government backing. Unlike in India and Brazil where there are 1000 of sugar mills ranging from small to large and equal number of small to large distilleries for ethanol. Such system or law should be introduced where no one can stop the small-scale business entity to open a small sugar mill, jaggery mill, on field distillery, distillery and for integrated mills. And Export of ethanol should be encouraged to improve the foreign reserves.
v. Government should start the awareness of climate change, GHG emissions to push people towards biofuel to control the air quality standards. This will help government in tackling smog which is becoming major issue in recent years.
vi. Car companies should be directed to produce flex fuel vehicle and to have engines which can take 20% ethanol with no modifications.
vii. Pakistan sugar industry should take the Brazil model to have integrated mills, where they can produce more sugar or more ethanol depending on the demand and need.

Recommendations for the growth of ethanol and sugar industries in the UK

The recommendations for the growth of ethanol and sugar industries in the UK are presented From Political, Economic, Social and Cultural, Technological, Ecological and Legal perspective.

i. The UK government should consider lowering the value-added taxation of the products of the industries.

ii. Mixing of ethanol and fossil fuels percentage should be increased from the present level of 10% in 2021and to 20-25% by 2030
iii. Farming, an integrated part of the UK's social and cultural environment, should be encouraged with new incentives such as more liberal loan facilities, use of new technologies, new processes, new systems, and new policies.
iv. If raw sugar provides cheaper option, then it should be explored and local sugar beet to be used for ethanol to help transport industry in terms of less GHG emission and able to fulfil the targets.
v. Cheaper import of ethanol from other countries should be barred and local ethanol should be preferred to use first, if the prices are in align with international prices and if the local production cost is high, then low-cost import makes economic sense.
vi. There is a need to break the monopoly of British sugar so that other companies such as American sugar refinery (formerly Tate and Lyle) etc.

8.4. Recommendations for further research

This study opens a door towards few research areas which researchers can explore in future. In Pakistan, the possibility of ethanol fermentation directly from sugarcane juice should be explored. Renewable transport fuel obligation RTFO should be considered in Pakistan by proper research work. Model of integrated sugar mills should be explored and see how ethanol and sugar can be produce and studies is needed to understand if it is financially and economically viable. Furthermore, Life cycle analysis of ethanol production from different crops in Pakistan can be considered for future research. In UK, cellulosic based ethanol can be studied to divert the attention from food crops to waste to ethanol. New feedstocks can be studied and test to see if it can fulfil the local sugar and ethanol demand. Sustainable aviation fuel, marine fuel and E25% are hot topics to be explored, which will help Pakistan and UK in terms of environmental, social, and Economical.

8.5. Conclusion

This study provides answers to all the research questions regarding the impact and analysis of ethanol production on sugar industries in Pakistan and UK. It has achieved the goal of covering aims and objectives through detailed research, authentic data collection and use of proper tools. In Pakistan Ethanol is produced from molasses, a by-product of sugar industry whereas Sugar is made from sugar cane juice. The study concludes that impact of ethanol production by molasses in Pakistan has a positive impact on sugar industry in a way of creating a lucrative and profitable market for cane growers and sugar industry owners and investors. In UK Ethanol is produced from sugar beet (5%) and rest from the feed grade wheat (95%). Ethanol from sugar beet is produced by thick beet juices with some quantity of molasses. Sugar in UK is produced from sugar beet thick juices. If more ethanol is produced in UK from sugar beet, it will have negative impacts on sugar industry in a way that it will lessen the sugar production. Feed grade wheat for ethanol will have no impact on sugar industry as it is a different crop. The impacts are different for both the countries because of number of factors. The factors include production technologies, government policies, legal framework, socio-economic and environmental environment of ethanol and sugar sector. This study would be helpful to the government of both the countries to carefully investigate the policies provided which will help building the economy, investors or businesspeople to consider the impacts related to ethanol distilleries and sugar industries for more revenues, profits, and researchers to further enhance this work by contributing to new areas of research.

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Annex

Annex-1

Companies contacted for the price of ethanol machinery

1. Feicheng Jinta Machinery Company (China)
2. Rushan Risheng Machinery Company (China)
3. chemical co (Iran)
4. Artadig Megan Machinery company (Iran)
5. Hakimi engg (Iran)
6. Genyond Machinery Industrial Group (China)
7. Kiyan Machinery Company (Iran)

Annex-2

Short Questionnaire for Pakistan Sugar mill

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 10-15 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title: Mr.

Name: Age: 35-50 Gender Male Date: 21/09/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	Answers
Q1 How many factories do you own? a) Indicate the location of your plant	

b) Indicate the production capacity of your plant c) Indicate the number of days of operation per year d) Indicate the number of shifts per day	
Q2. Indicate the feedstock (s) / Sources used for Production of Sugar. Indicate how you source your feedstock Indicate the price of feedstock per ton	
Q3. Indicate the annual feedstock requirement for your plant Indicate the yield of Sugar from each MT of feedstock you use. I.e., 1 MT of Sugar Beet or Sugar cane produces how much sugar? Provide separately for each feedstock if possible	
Q4. Indicate if there are any byproducts from Sugar production, if yes, please provide details for each. Indicate how much waste each MT of Sugar cane or Sugar beet produces? And how you Utilize them?	
Q5. Indicate the cost to make 1 ton of Sugar from your plant. If possible, provide break down in terms of Capital costs and Operating costs	

PART-2: Market information

Q6. Indicate where you sell your products Indicate the selling price per MT	
Q7. Indicate your major competitors in the market Please elaborate any threat or opportunities to the market and to your plant.	
Q8. Indicate if Sugar producers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment, if this applies and indicate if there is any condition attached	
Q9. Indicate if there is any Sugar import? How Government and you tackle that?	
Q10. Indicate the future prospects of Sugar in the country.	
Q11. Will the Sugar production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in food and beverages?	

PART-3: Management strategies

Q12. Indicate options/ strategies that can be considered to enhance Sugar production	
Q13. Do you see any export potential for Sugar?	
Q14. Indicate how Sugar Production supports the	

country?	
Q15. Indicate the factors affecting Sugar production.	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Aneex-3

Short Questionnaire for Ethanol industry in Pakistan

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 10-15 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title:

Age: 35-50 Gender Male Date: 26/10/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	Answers
Q1 How many factories do you own? a) Indicate the location of your plant b) Indicate the production capacity of your plant	

c) Indicate the number of days of operation per year d) Indicate the number of shifts per day	
Q2. Indicate the feedstock (s) / Sources used for Production of Ethanol. Indicate which grade of ethanol your plant produces Indicate how you source your feedstock Indicate the price of feedstock per ton	
Q3. Indicate the annual feedstock requirement for your plant Indicate the yield of Ethanol from each MT of feedstock you use. I.e., 1 MT of Beet/Cane/Wheat/Corn/Molasses/Others produces how much sugar? Provide separately for each feedstock if possible	
Q4. Indicate if there are any byproducts from ethanol production: If yes, please provide details for each. Indicate how much waste each MT of Beet/Cane/Wheat/Corn/Molasses/Others produces	
Q5. Indicate the cost to make 1 ton of ethanol from your plant. If possible, provide break down in terms of Capital costs and Operating costs	

PART-2: Market information

Q6. Indicate where you sell your products Indicate the selling price per MT	
Q7. Indicate your major competitors in the market Please elaborate any threat or opportunities to the market and to your plant.	
Q8. Indicate if ethanol producers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment if this applies. Indicate if there is any condition attached	
Q9. Indicate if there is any mandate for ethanol blending Indicate if you are aware of any plans for increasing the mandate by the government in the future	
Q10. Indicate the future prospects of ethanol in the country.	
Q11. Will the ethanol production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in food and beverages?	

PART-3: Management strategies

Q12. Indicate options/ strategies that can be considered to enhance Ethanol production	

Q13. Do you see any export potential for ethanol?	
Q14. Indicate how plants can choose feedstock in the future without conflicting with sugar industry for the production of ethanol.	
Q15. Do you Believe that Ethanol industry has any direct or indirect impact on Sugar industry or Sugar based food industry? How?	
Q16. Indicate the factors affecting Ethanol production.	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Annex-4

Short Questionnaire for Farmers in Pakistan

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 5-8 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title: Mr

Name: Click or tap here to enter text. Age: 35-50 Gender Male Date: 17/10/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	**Answers**
Q1 How many Acres/Hectares do you own? a) Indicate the Number of Acres/Hectares you have cultivated	

b) What are your reasons for growing Sugar cane or Sugar beet. c) Indicate the yield of Sugar cane or Beet per Acre or Hectare.	
Q2. Indicate the Input cost for Cultivating Sugar Cane or Beet Production? Do you face any issues in Cultivation?	

PART-2: Market information

Q3. Indicate where you sell your products Indicate the selling price per MT	
Q4. Indicate Profitability level of Sugar Cane or Sugar Beet Production per each Acre or Hectare?	
Q5. Where is Sugar cane or Beet sold? How do you sell? Is there any contract with sugar mills? Are you aware of use of cane for other purposes, say ethanol, jaggery?	
Q6. Indicate if Farmers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment if this applies Indicate if there is any condition attached	
Q7. Indicate the future prospects of Sugar cane or Sugar Beet Production in the country. Will you continue to grow Sugar cane/Beet, or will you convert to another crop? And if yes why	

PART-3: Management strategies

Q8. Indicate the factors affecting Ethanol production.	
Q9. Do you adopt any approaches to improve yield? Protect your cultivation?	
Q10. Indicate options/ strategies that can be considered to enhance Sugar Cane or Beet production	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Annex-5

<u>Short Questionnaire for Farmers in Pakistan</u>

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 5-8 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title: Mr

Name: Click or tap here to enter text. Age: 35-50 Gender Male Date: 17/10/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	Answers
Q1 How many Acres/Hectares do you own? a) Indicate the Number of Acres/Hectares you have cultivated b) What are your reasons for growing Sugar cane or Sugar beet.	

c) Indicate the yield of Sugar cane or Beet per Acre or Hectare.	
Q2. Indicate the Input cost for Cultivating Sugar Cane or Beet Production? Do you face any issues in Cultivation?	

PART-2: Market information

Q3. Indicate where you sell your products Indicate the selling price per MT	
Q4. Indicate Profitability level of Sugar Cane or Sugar Beet Production per each Acre or Hectare?	
Q5. Where is Sugar cane or Beet sold? How do you sell? Is there any contract with sugar mills? Are you aware of use of cane for other purposes, say ethanol, jaggery?	
Q6. Indicate if Farmers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment if this applies Indicate if there is any condition attached	
Q7. Indicate the future prospects of Sugar cane or Sugar Beet Production in the country. Will you continue to grow Sugar cane/Beet, or will you convert to another crop? And if yes why	

PART-3: Management strategies

Q8. Indicate the factors affecting Ethanol production.	
Q9. Do you adopt any approaches to improve yield? Protect your cultivation?	
Q10. Indicate options/ strategies that can be considered to enhance Sugar Cane or Beet production	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Annex-6

Short Questionnaire for Sugar industry in UK

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 10-15 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project.

However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title: Mr

Name: Age: 35-50 Gender Male Date: 17/09/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	Answers
Q1 How many factories do you own? a) Indicate the location of your plant b) Indicate the production capacity of your plant c) Indicate the number of days of operation per year d) Indicate the number of shifts per day	

Q2. Indicate the feedstock (s) / Sources used for Production of Sugar. Indicate how you source your feedstock Indicate the price of feedstock per ton	
Q3. Indicate the annual feedstock requirement for your plant Indicate the yield of Sugar from each MT of feedstock you use. I.e., 1 MT of Sugar Beet or Sugar cane produces how much sugar? Provide separately for each feedstock if possible	
Q4. Indicate if there are any byproducts from Sugar production If yes, please provide details for each. Indicate how much waste each MT of Sugar cane or Sugar beet produces? And how you Utilize them?	
Q5. Indicate the cost to make 1 ton of Sugar from your plant. If possible, provide break down in terms of Capital costs Operating costs	

PART-2: Market information

Q6. Indicate where you sell your products Indicate the selling price per MT	
Q7. Indicate your major competitors in the market Please elaborate any threat or opportunities to the market and to your plant.	
Q8. Indicate if Sugar producers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment if this applies Indicate if there is any condition attached	
Q9. Indicate if there is any Sugar import? How Government and you tackle that?	
Q10. Indicate the future prospects of Sugar in the country.	
Q11. Will the Sugar production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in food and beverages?	

PART-3: Management strategies

Q12. Indicate options/ strategies that can be considered to enhance Sugar production	
Q13. Do you see any export potential for Sugar?	

Q14. Indicate how Sugar Production supports the country?	
Q15. Indicate the factors affecting Sugar production.	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Annex-7

Short Questionnaire for Sugar industry in UK

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 10-15 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title: Mr

Name: Age: 35-50 Gender Male Date: 17/09/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	Answers
Q1 How many factories do you own? a) Indicate the location of your plant b) Indicate the production capacity of your plant c) Indicate the number of days of operation per year	

d) Indicate the number of shifts per day	
Q2. Indicate the feedstock (s) / Sources used for Production of Sugar. Indicate how you source your feedstock Indicate the price of feedstock per ton	
Q3. Indicate the annual feedstock requirement for your plant Indicate the yield of Sugar from each MT of feedstock you use. I.e., 1 MT of Sugar Beet or Sugar cane produces how much sugar? Provide separately for each feedstock if possible	
Q4. Indicate if there are any byproducts from Sugar production If yes, please provide details for each. Indicate how much waste each MT of Sugar cane or Sugar beet produces? And how you Utilize them?	
Q5. Indicate the cost to make 1 ton of Sugar from your plant. If possible, provide break down in terms of Capital costs Operating costs	

PART-2: Market information

Q6. Indicate where you sell your products Indicate the selling price per MT	
Q7. Indicate your major competitors in the market Please elaborate any threat or opportunities to the market and to your plant.	
Q8. Indicate if Sugar producers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment if this applies Indicate if there is any condition attached	
Q9. Indicate if there is any Sugar import? How Government and you tackle that?	
Q10. Indicate the future prospects of Sugar in the country.	
Q11. Will the Sugar production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in food and beverages?	

PART-3: Management strategies

Q12. Indicate options/ strategies that can be considered to enhance Sugar production	
Q13. Do you see any export potential for Sugar?	

Q14. Indicate how Sugar Production supports the country?	
Q15. Indicate the factors affecting Sugar production.	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Annex-8

<u>Short Questionnaire for Ethanol in UK</u>

You are invited to participate in this interview. This questionnaire will take approximately 10-15 minutes. This Questionnaire will take approximately 10-15 minutes. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Applicant's Interview Notes Form

Interview Details

Title: Mr

Name: Age: 35-50 Gender Male Date: 31/10/2019

Interviewer Name: Ali Hassnain Khan Khichi

Interviewer Position: PhD Researcher Interviewer ID: P1304218

University Name: De Mont fort University, The Gateway, Leicester. LE1 9BH United Kingdom

Faculty: Faculty of Technology, Department of Energy and sustainable

PART-1: Production from your plant

Questions	**Answers**
Q1 How many factories do you own? a) Indicate the location of your plant b) Indicate the production capacity of your plant c) Indicate the number of days of operation per year d) Indicate the number of shifts per day	

Q2. Indicate the feedstock (s) / Sources used for Production of Ethanol. Indicate which grade of ethanol your plant produces Indicate how you source your feedstock Indicate the price of feedstock per ton	
Q3. Indicate the annual feedstock requirement for your plant Indicate the yield of Ethanol from each MT of feedstock you use. I.e., 1 MT of Beet/Cane/Wheat/Corn/Molasses/Others produces how much sugar? Provide separately for each feedstock if possible	
Q4. Indicate if there are any byproducts from ethanol production If yes, please provide details for each. Indicate how much waste each MT of Beet/Cane/Wheat/Corn/Molasses/Others produces	
Q5. Indicate the cost to make 1 ton of ethanol from your plant. If possible, provide break down in terms of Capital costs Operating costs	

PART-2: Market information

Q6. Indicate where you sell your products Indicate the selling price per MT	
Q7. Indicate your major competitors in the market Please elaborate any threat or opportunities to the market and to your plant.	
Q8. Indicate if ethanol producers receive any price subsidies and tax reliefs. Indicate the mechanism of subsidy payment if this applies Indicate if there is any condition attached	
Q9. Indicate if there is any mandate for ethanol blending Indicate if you are aware of any plans for increasing the mandate by the government in the future	
Q10. Indicate the future prospects of ethanol in the country.	
Q11. Will the ethanol production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in food and beverages?	

PART-3: Management strategies

Q12. Indicate options/ strategies that can be considered to enhance Ethanol production	

Q13. Do you see any export potential for ethanol?	
Q14. Indicate how plants can choose feedstock in the future without conflicting with sugar industry for the production of ethanol.	
Q15. Do you Believe that Ethanol industry has any direct or indirect impact on Sugar industry or Sugar based food industry? How?	
Q16. Indicate the factors affecting Ethanol production.	

Please share any additional comments of concerns on this subject.

Thank you for taking the time to complete this questionnaire. We truly value the information you have provided. Your responses will contribute to our research. I will thoroughly provide you the updates of the research project in due course.

Many thanks,

Ali Hassnain Khan Khichi

Annex-9

Questions for Interview for NFU on farmers behalf

You are invited to participate in this interview. Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can leave it empty. It is very important for us to learn your opinions. Your answers will be strictly confidential and data from this research will be reported only in the aggregate as agreed on consent form. If you have questions at any time about the Questions, you may contact Ali Hassnain Khan Khichi by email at the email address specified below. Thank you very much for your time and support.

Name:

Position:

Organization or individual name:

Questions:

1. How many acres/Hectares of sugar beet have been cultivated for the year 2014-2015 and 2015-2016?

   Answer:

2. What is the sugar yield of sugar beet?

   Answer:

3. What is the yield of sugar beet per acre/hectare?

   Answer:

4. Areas where sugar beet are been grown?

   Answer:

5. From last 5 years, what are the figures of sugar beet production in UK?

   Answer:

6. Are all sugar beets being used for sugar production in the UK?

   Answer:

7. How rest of the sugar is being produced in the UK?
8. Alternative to Sugar beet for producing Sugar

   Answer:

9. If no, what are the other uses of sugar beet in UK? Etc. Biofuel production?
10. Can sugar beet be import from other European Union countries? Is it feasible?

    Answer:

11. How are the farmers' incomes per acre of hectare from Sugar beet production? Compare from last 5 years

Answer:

12. Are farmers ready to increase the production of Sugar beet? Or are they considering decreasing sugar beet production? Why?

    Answer:

13. Do you believe that sugar beet production has a future in terms of fulfilling the local demand of sugar production from sugar beet in UK? With many news roaming around that Sugar beet doesn't have enough yield, cannot fulfill local demand of sugar and income for farmers are soaring?

    Answer:

14. How many sugar mills working in UK currently? And with what feedstock and where are they located?

    Answer:

15. Are there any subsidies from Government for growing sugar beet? For example, if there is a net loss on income?

    Answer

Please share any additional comments of concerns on this subject.

Annex-10

Interview questions in Urdu

انٹرویو کے لیے سوالنامہ

علاقے کا نام

فصل

کتنے ایکڑ پر کاشت کرتے ہیں

کیوں کاشت کرتے ہیں

پیداوار کتنی ہے

فی ایکڑ کتنا خرچ آیا

کیا کاشت میں کوئی مسئلہ آیا

کہاں بیچتے ہیں

فی من کیا قیمت

ہر ایکڑ پر کتنا منافع آیا

کیا گنے کا کوئی دوسرا استعمال ہے؟

کیا حکومت کو سبسڈی دیتی ہے

گنے کی کاشت کا کیا مستقبل ہے

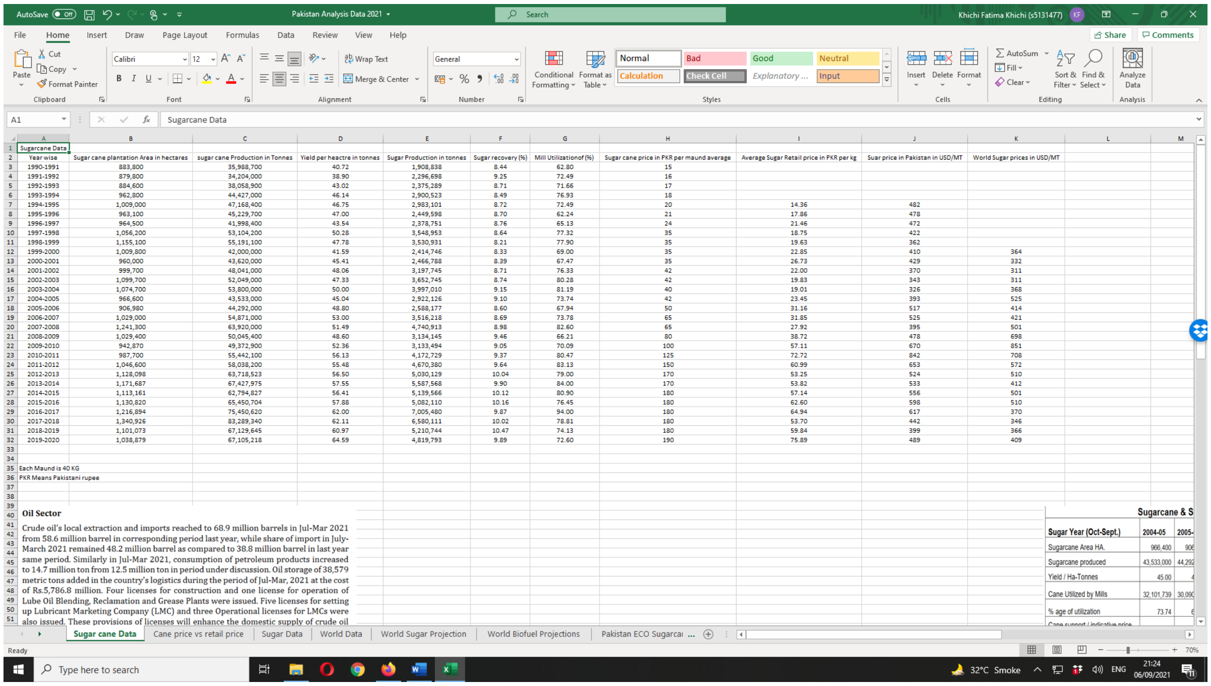
کیا آپ دوبارہ کاشت کریں گے

کیا آپ کا اثاثوں کے بارے میں بتایئے

شکریہ

Annex-11

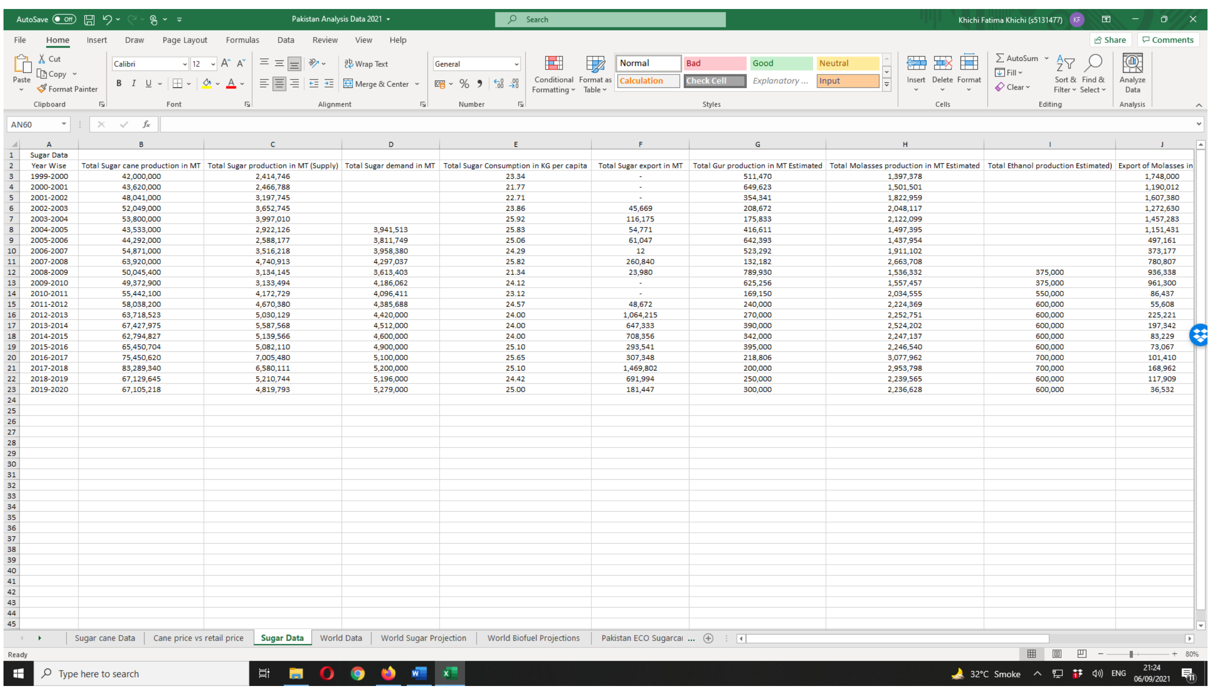
Pakistan Sugar cane data survey



Year wise	Sugar cane plantation Area in hectares	sugar cane Production in Tonnes	Yield per heactre in tonnes	Sugar Production in tonnes	Sugar recovery (%)	Mill Utilizationof (%)	Sugar cane price in PKR per maund average	Average Sugar Retail price in PKR per kg	Suar price in Pakistan in USD/MT	World Sugar prices in USD/MT
1990-1991	883,800	35,988,700	40.72	1,908,838	8.44	62.80	15			
1991-1992	879,800	34,204,000	38.90	2,296,698	9.25	72.49	16			
1992-1993	884,600	38,058,900	43.02	2,375,289	8.71	71.66	17			
1993-1994	962,800	44,427,000	46.14	2,900,523	8.49	76.93	18			
1994-1995	1,009,000	47,168,400	46.75	2,983,101	8.72	72.49	20	14.36	482	
1995-1996	963,100	45,229,700	47.00	2,449,598	8.70	62.24	21	17.86	478	
1996-1997	964,500	41,998,400	43.54	2,378,751	8.76	65.13	24	21.46	472	
1997-1998	1,056,200	53,104,200	50.28	3,548,953	8.64	77.32	35	18.75	422	
1998-1999	1,155,100	55,191,100	47.78	3,530,931	8.21	77.90	35	19.63	362	
1999-2000	1,009,800	42,000,000	41.59	2,414,746	8.33	69.00	35	22.85	410	364
2000-2001	960,000	43,620,000	45.41	2,466,788	8.39	67.47	35	26.73	429	332
2001-2002	999,700	48,041,000	48.06	3,197,745	8.71	76.33	42	22.00	370	311
2002-2003	1,099,700	52,049,000	47.33	3,652,745	8.74	80.28	42	19.83	343	311
2003-2004	1,074,700	53,800,000	50.00	3,997,010	9.15	81.19	40	19.01	326	368
2004-2005	966,600	43,533,000	45.04	2,922,126	9.10	73.74	42	23.45	393	525
2005-2006	906,980	44,292,000	48.80	2,588,177	8.60	67.94	50	31.16	517	414
2006-2007	1,029,000	54,871,000	53.00	3,516,218	8.69	73.78	65	31.85	525	421
2007-2008	1,241,300	63,920,000	51.49	4,740,913	8.98	82.60	65	27.92	395	501
2008-2009	1,029,400	50,045,400	48.60	3,134,145	9.46	66.21	80	38.72	478	698
2009-2010	942,870	49,372,900	52.36	3,133,494	9.05	70.09	100	57.11	670	851
2010-2011	987,700	55,442,100	56.13	4,172,729	9.37	80.47	125	72.72	842	708
2011-2012	1,046,600	58,038,200	55.48	4,670,380	9.64	83.13	150	60.99	653	572
2012-2013	1,128,098	63,718,523	56.50	5,030,129	10.04	79.00	170	53.25	524	510
2013-2014	1,171,687	67,427,975	57.55	5,587,568	9.90	84.00	170	53.82	533	412
2014-2015	1,113,161	62,794,827	56.41	5,139,566	10.12	80.90	180	57.14	556	501
2015-2016	1,130,820	65,450,704	57.88	5,082,110	10.16	76.45	180	62.60	598	510
2016-2017	1,216,894	75,450,620	62.00	7,005,480	9.87	94.00	180	64.94	617	370
2017-2018	1,340,926	83,289,340	62.11	6,580,111	10.02	78.81	180	53.70	442	346
2018-2019	1,101,073	67,129,645	60.97	5,210,744	10.47	74.13	180	59.84	399	366
2019-2020	1,038,879	67,105,218	64.59	4,819,793	9.89	72.60	190	75.89	489	409

Annex-12

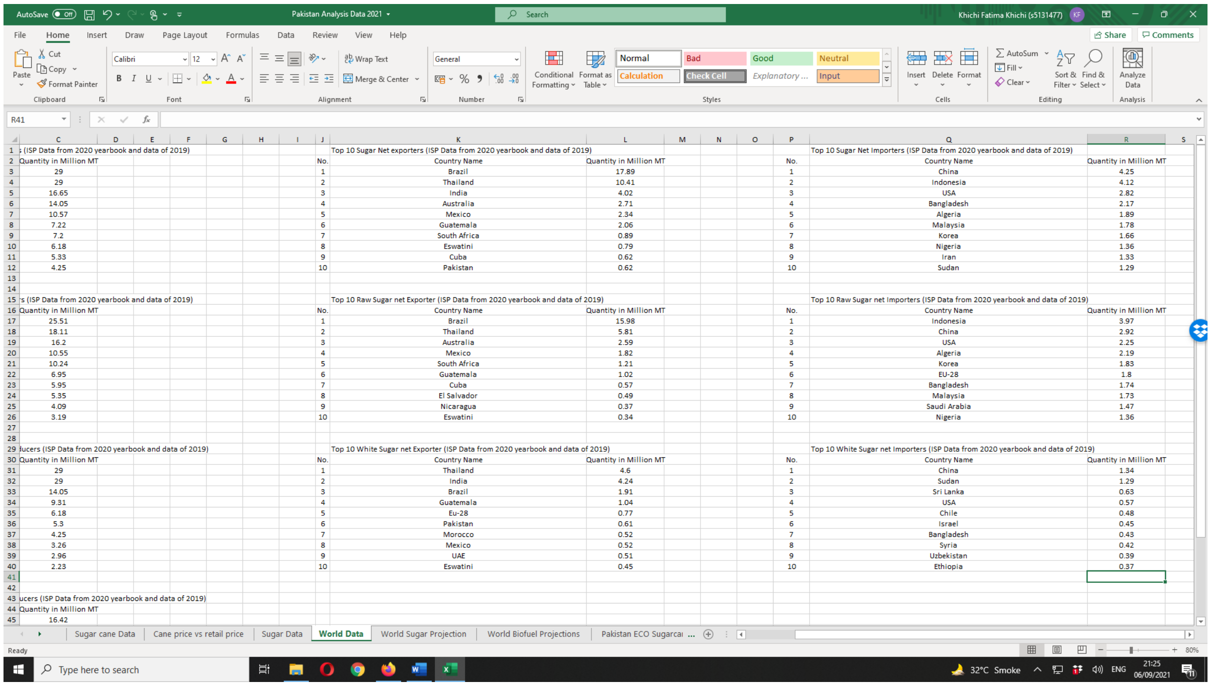
Pakistan sugar data along with sugar cane production, ethanol, molasses etc



Year Wise	Total Sugar cane production in MT	Total Sugar production in MT (Supply)	Total Sugar demand in MT	Total Sugar Consumption in KG per capita	Total Sugar export in MT	Total Gur production in MT Estimated	Total Molasses production in MT Estimated	Total Ethanol production Estimated)	Export of Molasses in
1999-2000	42,000,000	2,414,746		23.34	-	511,470	1,397,378		1,748,000
2000-2001	43,620,000	2,466,788		21.77	-	649,623	1,501,501		1,190,012
2001-2002	48,041,000	3,197,745		22.71	-	354,341	1,822,959		1,607,380
2002-2003	52,049,000	3,652,745		23.86	45,669	208,672	2,048,117		1,272,630
2003-2004	53,800,000	3,997,010		25.92	116,175	175,833	2,122,099		1,457,283
2004-2005	43,533,000	2,922,126	3,941,513	25.83	54,771	416,611	1,497,395		1,151,431
2005-2006	44,292,000	2,588,177	3,811,749	25.06	61,047	642,393	1,437,954		497,161
2006-2007	54,871,000	3,516,218	3,958,380	24.29	12	523,292	1,911,102		373,177
2007-2008	63,920,000	4,740,913	4,297,037	25.82	260,840	132,182	2,663,708		780,807
2008-2009	50,045,400	3,134,145	3,613,403	21.34	23,980	789,930	1,536,332	375,000	936,338
2009-2010	49,372,900	3,133,494	4,186,062	24.12	-	625,256	1,557,457	375,000	961,300
2010-2011	55,442,100	4,172,729	4,096,411	23.12	-	169,150	2,034,555	550,000	86,437
2011-2012	58,038,200	4,670,380	4,385,688	24.57	48,672	240,000	2,224,369	600,000	55,608
2012-2013	63,718,523	5,030,129	4,420,000	24.00	1,064,215	270,000	2,252,751	600,000	225,221
2013-2014	67,427,975	5,587,568	4,512,000	24.00	647,333	390,000	2,524,202	600,000	197,342
2014-2015	62,794,827	5,139,566	4,600,000	24.00	708,356	342,000	2,247,137	600,000	83,229
2015-2016	65,450,704	5,082,110	4,900,000	25.10	293,541	395,000	2,246,540	600,000	73,067
2016-2017	75,450,620	7,005,480	5,100,000	25.65	307,348	218,806	3,077,962	700,000	101,410
2017-2018	83,289,340	6,580,111	5,200,000	25.10	1,469,802	200,000	2,953,798	700,000	168,962
2018-2019	67,129,645	5,210,744	5,196,000	24.42	691,994	250,000	2,239,565	600,000	117,909
2019-2020	67,105,218	4,819,793	5,279,000	25.00	181,447	300,000	2,236,628	600,000	36,532

Annex-13

World data



s (ISP Data from 2020 yearbook and data of 2019)	
Quantity in Million MT	
29	
29	
16.65	
14.05	
10.57	
7.22	
7.2	
6.18	
5.33	
4.25	

Top 10 Sugar Net exporters (ISP Data from 2020 yearbook and data of 2019)

No.	Country Name	Quantity in Million MT
1	Brazil	17.89
2	Thailand	10.41
3	India	4.02
4	Australia	2.71
5	Mexico	2.34
6	Guatemala	2.06
7	South Africa	0.89
8	Eswatini	0.79
9	Cuba	0.62
10	Pakistan	0.62

Top 10 Sugar Net Importers (ISP Data from 2020 yearbook and data of 2019)

No.	Country Name	Quantity in Million MT
1	China	4.25
2	Indonesia	4.12
3	USA	2.82
4	Bangladesh	2.17
5	Algeria	1.89
6	Malaysia	1.78
7	Korea	1.66
8	Nigeria	1.36
9	Iran	1.33
10	Sudan	1.29

s (ISP Data from 2020 yearbook and data of 2019)	
Quantity in Million MT	
25.51	
18.11	
16.2	
10.55	
10.24	
6.95	
5.95	
5.35	
4.09	
3.19	

Top 10 Raw Sugar net Exporter (ISP Data from 2020 yearbook and data of 2019)

No.	Country Name	Quantity in Million MT
1	Brazil	15.98
2	Thailand	5.81
3	Australia	2.59
4	Mexico	1.82
5	South Africa	1.21
6	Guatemala	1.02
7	Cuba	0.57
8	El Salvador	0.49
9	Nicaragua	0.37
10	Eswatini	0.34

Top 10 Raw Sugar net Importers (ISP Data from 2020 yearbook and data of 2019)

No.	Country Name	Quantity in Million MT
1	Indonesia	3.97
2	China	2.92
3	USA	2.25
4	Algeria	2.19
5	Korea	1.83
6	EU-28	1.8
7	Bangladesh	1.74
8	Malaysia	1.73
9	Saudi Arabia	1.47
10	Nigeria	1.36

ducers (ISP Data from 2020 yearbook and data of 2019)	
Quantity in Million MT	
29	
29	
14.05	
9.31	
6.18	
5.3	
4.25	
3.26	
2.96	
2.23	

Top 10 White Sugar net Exporter (ISP Data from 2020 yearbook and data of 2019)

No.	Country Name	Quantity in Million MT
1	Thailand	4.6
2	India	4.24
3	Brazil	1.91
4	Guatemala	1.04
5	Eu-28	0.77
6	Pakistan	0.61
7	Morocco	0.52
8	Mexico	0.52
9	UAE	0.51
10	Eswatini	0.45

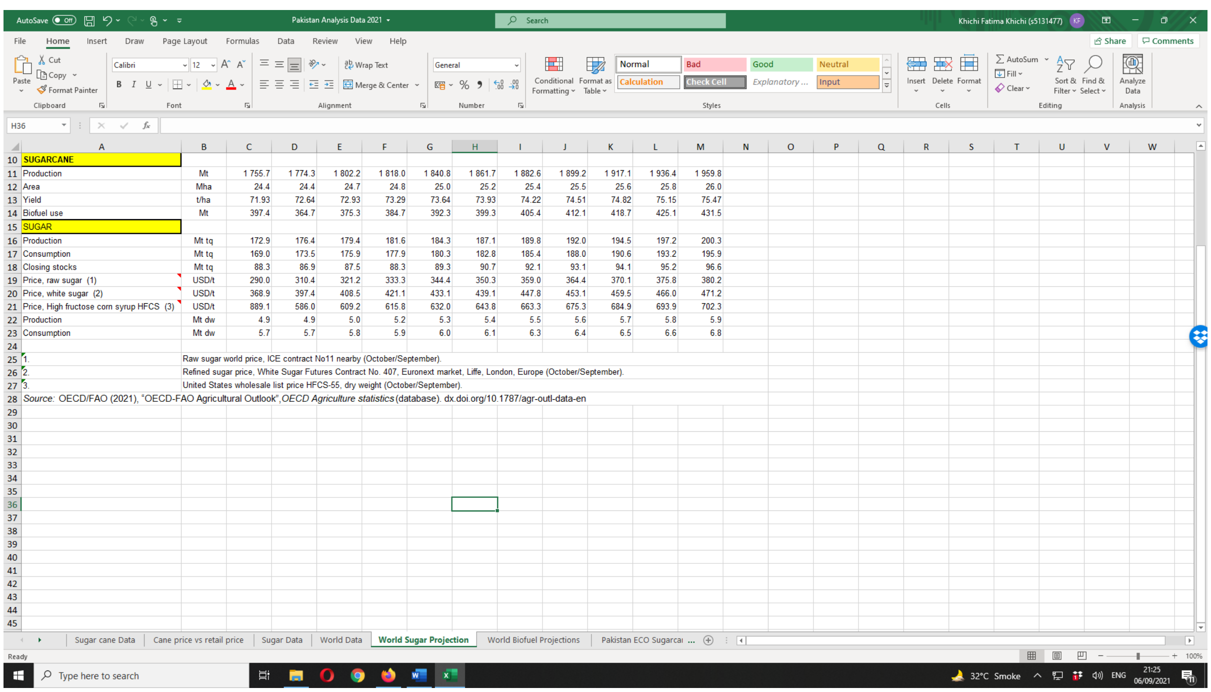
Top 10 White Sugar net Importers (ISP Data from 2020 yearbook and data of 2019)

No.	Country Name	Quantity in Million MT
1	China	1.34
2	Sudan	1.29
3	Sri Lanka	0.63
4	USA	0.57
5	Chile	0.48
6	Israel	0.45
7	Bangladesh	0.43
8	Syria	0.42
9	Uzbekistan	0.39
10	Ethiopia	0.37

ucers (ISP Data from 2020 yearbook and data of 2019)	
Quantity in Million MT	
16.42	

Annex-14

World sugar projection



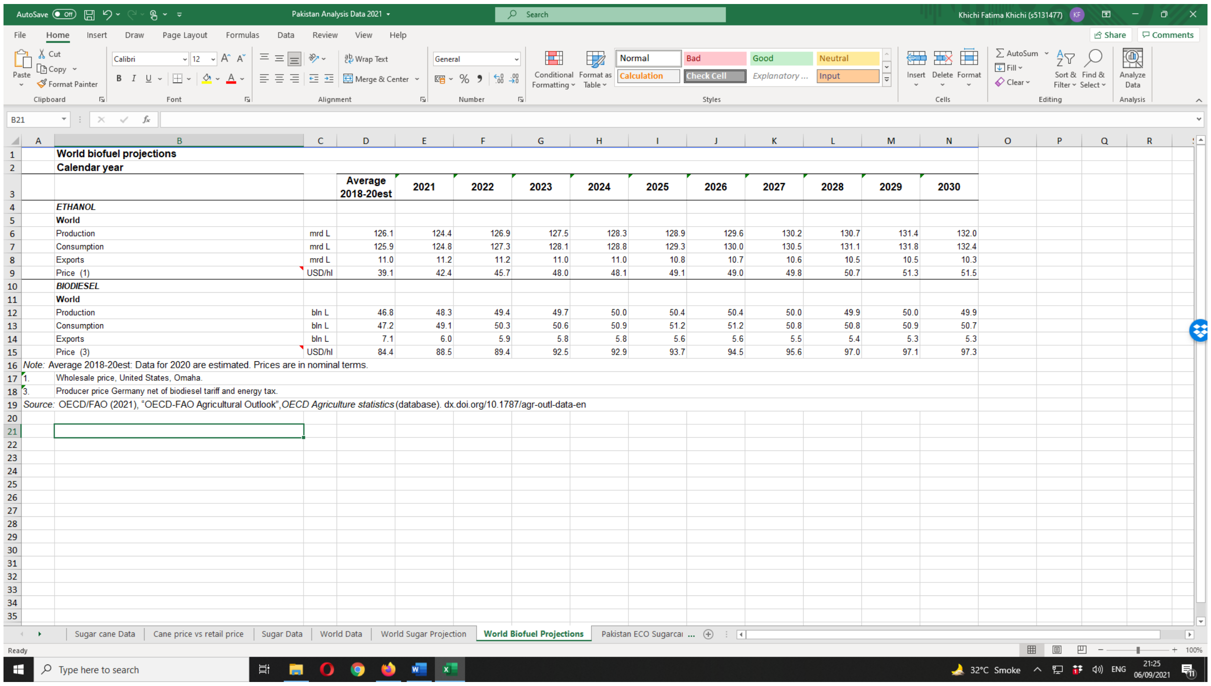
A	B	C	D	E	F	G	H	I	J	K	L	M
SUGARCANE												
Production	Mt	1 755.7	1 774.3	1 802.2	1 818.0	1 840.8	1 861.7	1 882.6	1 899.2	1 917.1	1 936.4	1 959.8
Area	Mha	24.4	24.4	24.7	24.8	25.0	25.2	25.4	25.5	25.6	25.8	26.0
Yield	t/ha	71.93	72.64	72.93	73.29	73.64	73.93	74.22	74.51	74.82	75.15	75.47
Biofuel use	Mt	397.4	364.7	375.3	384.7	392.3	399.3	405.4	412.1	418.7	425.1	431.5
SUGAR												
Production	Mt tq	172.9	176.4	179.4	181.6	184.3	187.1	189.8	192.0	194.5	197.2	200.3
Consumption	Mt tq	169.0	173.5	175.9	177.9	180.3	182.8	185.4	188.0	190.6	193.2	195.9
Closing stocks	Mt tq	88.3	86.9	87.5	88.3	89.3	90.7	92.1	93.1	94.1	95.2	96.6
Price, raw sugar (1)	USD/t	290.0	310.4	321.2	333.3	344.4	350.3	359.0	364.4	370.1	375.8	380.2
Price, white sugar (2)	USD/t	368.9	397.4	408.5	421.1	433.1	439.1	447.8	453.1	459.5	466.0	471.2
Price, High fructose corn syrup HFCS (3)	USD/t	889.1	586.0	609.2	615.8	632.0	643.8	663.3	675.3	684.9	693.9	702.3
Production	Mt dw	4.9	4.9	5.0	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
Consumption	Mt dw	5.7	5.7	5.8	5.9	6.0	6.1	6.3	6.4	6.5	6.6	6.8

1. Raw sugar world price, ICE contract No11 nearby (October/September).
2. Refined sugar price, White Sugar Futures Contract No. 407, Euronext market, Liffe, London, Europe (October/September).
3. United States wholesale list price HFCS-55, dry weight (October/September).

Source: OECD/FAO (2021), "OECD-FAO Agricultural Outlook", *OECD Agriculture statistics* (database). dx.doi.org/10.1787/agr-outl-data-en

Annex-15

World biofuel projection

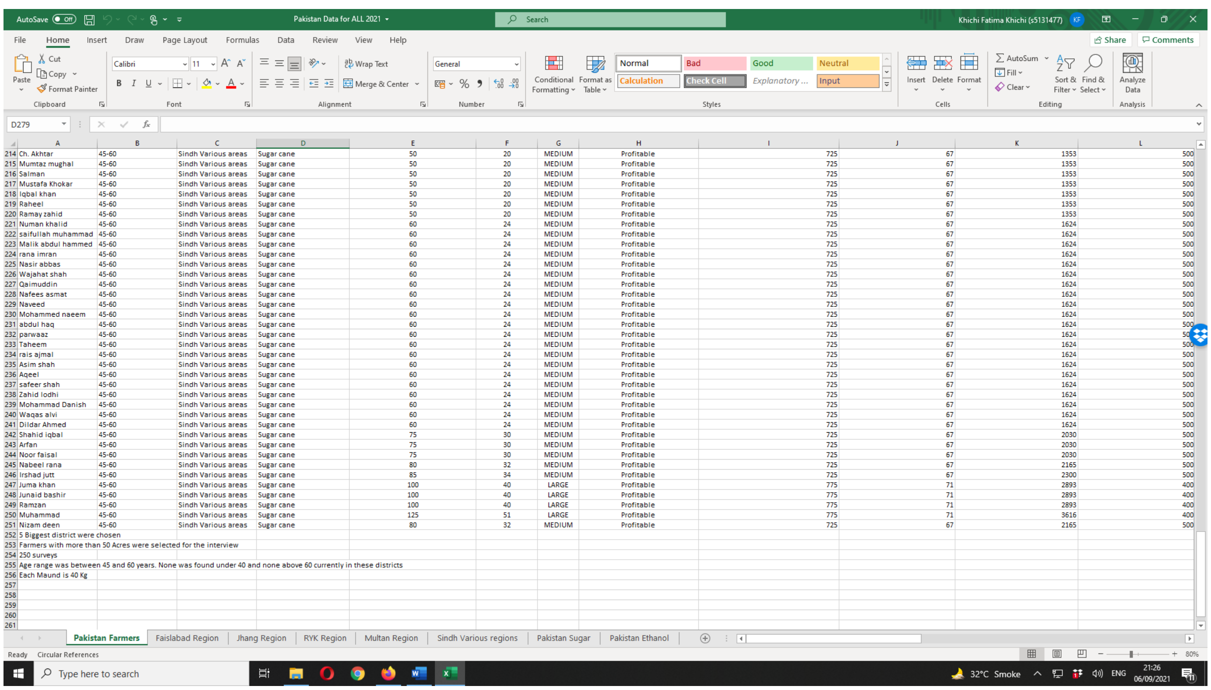


	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**World biofuel projections**												
2	**Calendar year**												
3			**Average 2018-20est**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
4	***ETHANOL***												
5	**World**												
6	Production	mrd L	126.1	124.4	126.9	127.5	128.3	128.9	129.6	130.2	130.7	131.4	132.0
7	Consumption	mrd L	125.9	124.8	127.3	128.1	128.8	129.3	130.0	130.5	131.1	131.8	132.4
8	Exports	mrd L	11.0	11.2	11.2	11.0	11.0	10.8	10.7	10.6	10.5	10.5	10.3
9	Price (1)	USD/hl	39.1	42.4	45.7	48.0	48.1	49.1	49.0	49.8	50.7	51.3	51.5
10	***BIODIESEL***												
11	**World**												
12	Production	bln L	46.8	48.3	49.4	49.7	50.0	50.4	50.4	50.0	49.9	50.0	49.9
13	Consumption	bln L	47.2	49.1	50.3	50.6	50.9	51.2	51.2	50.8	50.8	50.9	50.7
14	Exports	bln L	7.1	6.0	5.9	5.8	5.8	5.6	5.6	5.5	5.4	5.3	5.3
15	Price (3)	USD/hl	84.4	88.5	89.4	92.5	92.9	93.7	94.5	95.6	97.0	97.1	97.3

16 *Note:* Average 2018-20est: Data for 2020 are estimated. Prices are in nominal terms.
17 1. Wholesale price, United States, Omaha.
18 3. Producer price Germany net of biodiesel tariff and energy tax.
19 *Source:* OECD/FAO (2021), "OECD-FAO Agricultural Outlook", *OECD Agriculture statistics* (database). dx.doi.org/10.1787/agr-outl-data-en

Annex-16

Pakistan farmers survey data

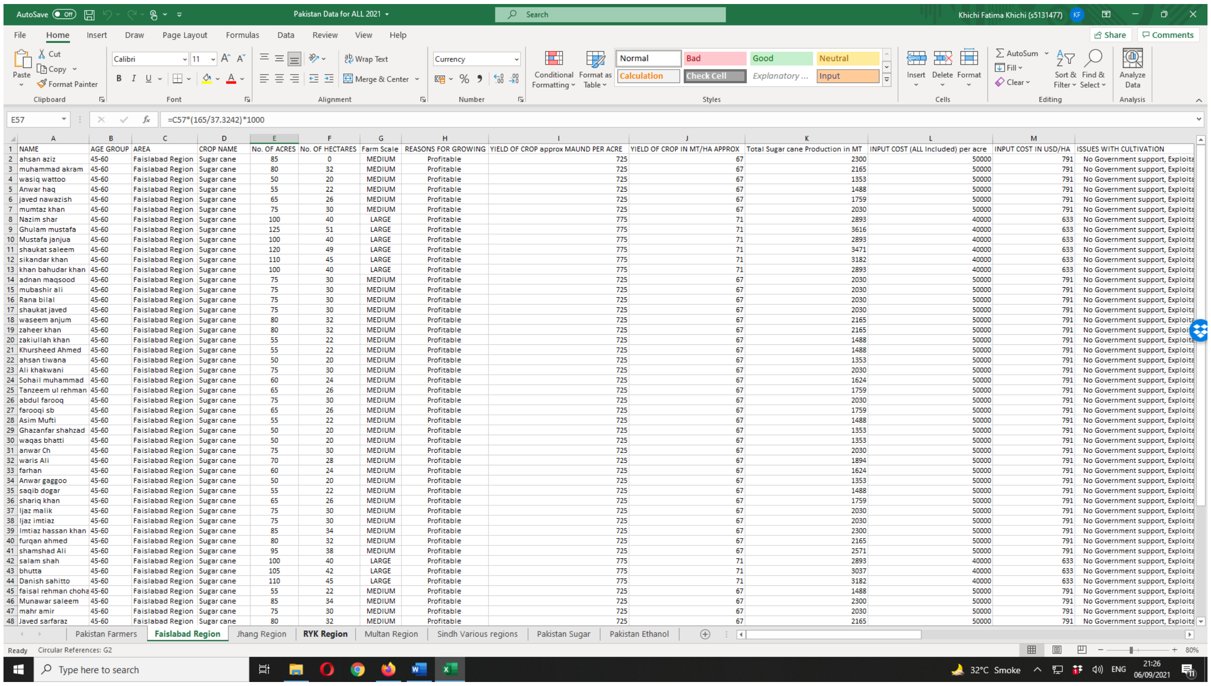


	A	B	C	D	E	F	G	H	I	J	K	L
214	Ch. Akhtar	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
215	Mumtaz mughal	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
216	Salman	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
217	Mustafa Khokar	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
218	Iqbal khan	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
219	Raheel	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
220	Ramay zahid	45-60	Sindh Various areas	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	500
221	Numan khalid	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
222	saifullah muhammad	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
223	Malik abdul hammed	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
224	rana imran	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
225	Nasir abbas	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
226	Wajahat shah	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
227	Qaimuddin	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
228	Nafees asmat	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
229	Naveed	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
230	Mohammed naeem	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
231	abdul haq	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
232	parwaaz	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	[illegible]
233	Taheem	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
234	rais ajmal	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
235	Asim shah	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
236	Aqeel	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
237	safeer shah	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
238	Zahid lodhi	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
239	Mohammad Danish	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
240	Waqas alvi	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
241	Dildar Ahmed	45-60	Sindh Various areas	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	500
242	Shahid iqbal	45-60	Sindh Various areas	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	500
243	Arfan	45-60	Sindh Various areas	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	500
244	Noor faisal	45-60	Sindh Various areas	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	500
245	Nabeel rana	45-60	Sindh Various areas	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	500
246	Irshad jutt	45-60	Sindh Various areas	Sugar cane	85	34	MEDIUM	Profitable	725	67	2300	500
247	Juma khan	45-60	Sindh Various areas	Sugar cane	100	40	LARGE	Profitable	775	71	2893	400
248	Junaid bashir	45-60	Sindh Various areas	Sugar cane	100	40	LARGE	Profitable	775	71	2893	400
249	Ramzan	45-60	Sindh Various areas	Sugar cane	100	40	LARGE	Profitable	775	71	2893	400
250	Muhammad	45-60	Sindh Various areas	Sugar cane	125	51	LARGE	Profitable	775	71	3616	400
251	Nizam deen	45-60	Sindh Various areas	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	500

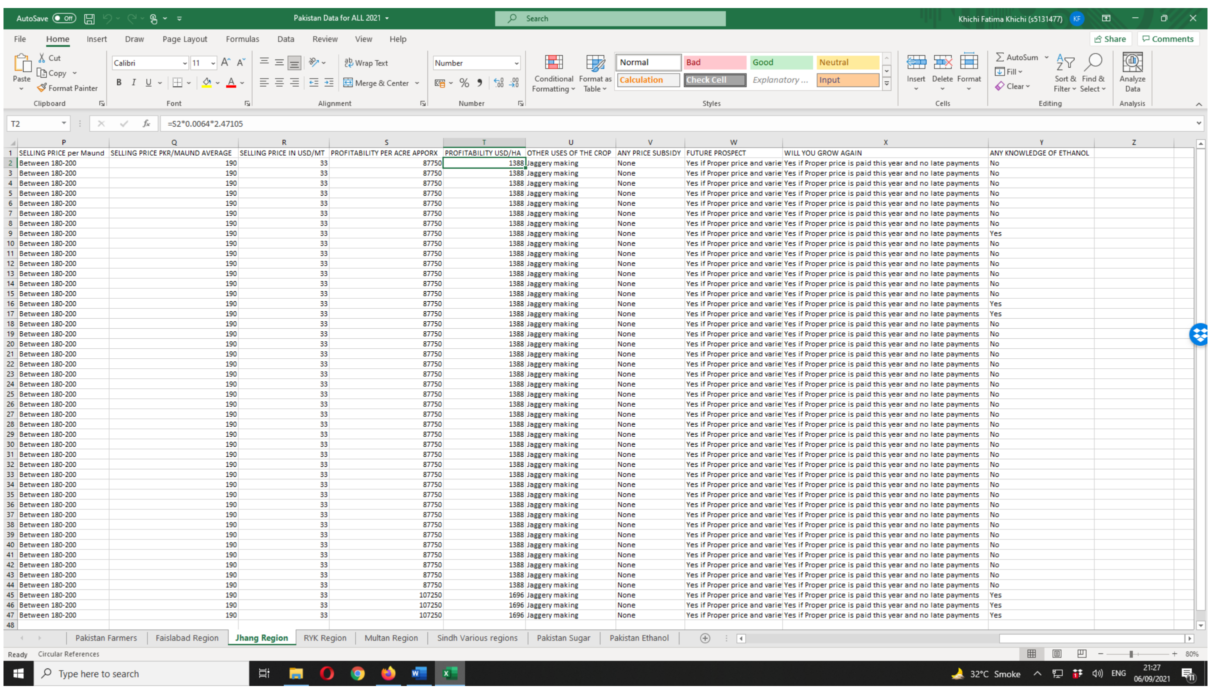
252 5 Biggest district were chosen
253 Farmers with more than 50 Acres were selected for the interview
254 250 surveys
255 Age range was between 45 and 60 years. None was found under 40 and none above 60 currently in these districts
256 Each Maund is 40 Kg

Annex-17

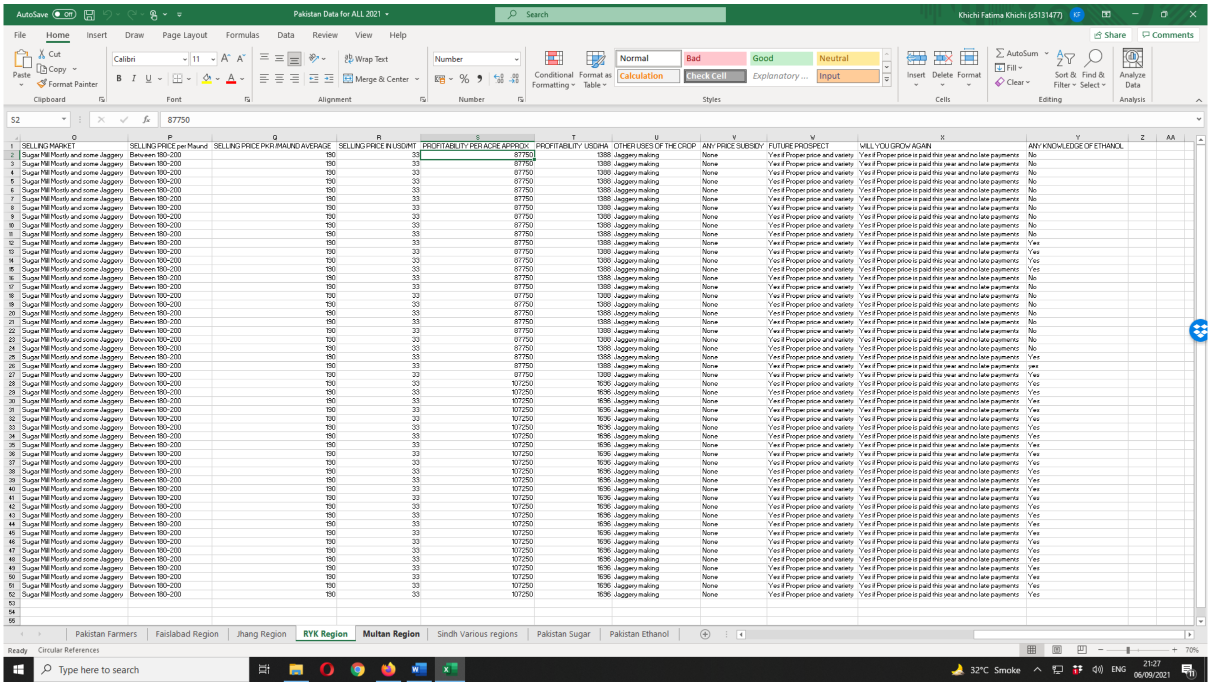
Different regions of Pakistan assorted



	NAME	AGE GROUP	AREA	CROP NAME	No. OF ACRES	No. OF HECTARES	Farm Scale	REASONS FOR GROWING	YIELD OF CROP approx MAUND PER ACRE	YIELD OF CROP IN MT/HA APPROX	Total Sugar cane Production in MT	INPUT COST (ALL Included) per acre	INPUT COST IN USD/HA	ISSUES WITH CULTIVATION
2	ahsan aziz	45-60	Faislabad Region	Sugar cane	85	0	MEDIUM	Profitable	725	67	2300	50000	791	No Government support, Exploita
3	muhammad akram	45-60	Faislabad Region	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	50000	791	No Government support, Exploita
4	wasiq wattoo	45-60	Faislabad Region	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	50000	791	No Government support, Exploita
5	Anwar haq	45-60	Faislabad Region	Sugar cane	55	22	MEDIUM	Profitable	725	67	1488	50000	791	No Government support, Exploita
6	javed nawazish	45-60	Faislabad Region	Sugar cane	65	26	MEDIUM	Profitable	725	67	1759	50000	791	No Government support, Exploita
7	mumtaz khan	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
8	Nazim shar	45-60	Faislabad Region	Sugar cane	100	40	LARGE	Profitable	775	71	2893	40000	633	No Government support, Exploita
9	Ghulam mustafa	45-60	Faislabad Region	Sugar cane	125	51	LARGE	Profitable	775	71	3616	40000	633	No Government support, Exploita
10	Mustafa janjua	45-60	Faislabad Region	Sugar cane	100	40	LARGE	Profitable	775	71	2893	40000	633	No Government support, Exploita
11	shaukat saleem	45-60	Faislabad Region	Sugar cane	120	49	LARGE	Profitable	775	71	3471	40000	633	No Government support, Exploita
12	sikandar khan	45-60	Faislabad Region	Sugar cane	110	45	LARGE	Profitable	775	71	3182	40000	633	No Government support, Exploita
13	khan bahudar khan	45-60	Faislabad Region	Sugar cane	100	40	LARGE	Profitable	775	71	2893	40000	633	No Government support, Exploita
14	adnan maqsood	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
15	mubashir ali	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
16	Rana bilal	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
17	shaukat javed	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
18	waseem anjum	45-60	Faislabad Region	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	50000	791	No Government support, Exploita
19	zaheer khan	45-60	Faislabad Region	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	50000	791	No Government support, Exploi
20	zakiullah khan	45-60	Faislabad Region	Sugar cane	55	22	MEDIUM	Profitable	725	67	1488	50000	791	No Government support, Exploita
21	Khursheed Ahmed	45-60	Faislabad Region	Sugar cane	55	22	MEDIUM	Profitable	725	67	1488	50000	791	No Government support, Exploita
22	ahsan tiwana	45-60	Faislabad Region	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	50000	791	No Government support, Exploita
23	Ali khakwani	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
24	Sohail muhammad	45-60	Faislabad Region	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	50000	791	No Government support, Exploita
25	Tanzeem ul rehman	45-60	Faislabad Region	Sugar cane	65	26	MEDIUM	Profitable	725	67	1759	50000	791	No Government support, Exploita
26	abdul farooq	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
27	farooqi sb	45-60	Faislabad Region	Sugar cane	65	26	MEDIUM	Profitable	725	67	1759	50000	791	No Government support, Exploita
28	Asim Mufti	45-60	Faislabad Region	Sugar cane	55	22	MEDIUM	Profitable	725	67	1488	50000	791	No Government support, Exploita
29	Ghazanfar shahzad	45-60	Faislabad Region	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	50000	791	No Government support, Exploita
30	waqas bhatti	45-60	Faislabad Region	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	50000	791	No Government support, Exploita
31	anwar Ch	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
32	waris Ali	45-60	Faislabad Region	Sugar cane	70	28	MEDIUM	Profitable	725	67	1894	50000	791	No Government support, Exploita
33	farhan	45-60	Faislabad Region	Sugar cane	60	24	MEDIUM	Profitable	725	67	1624	50000	791	No Government support, Exploita
34	Anwar gaggoo	45-60	Faislabad Region	Sugar cane	50	20	MEDIUM	Profitable	725	67	1353	50000	791	No Government support, Exploita
35	saqib dogar	45-60	Faislabad Region	Sugar cane	55	22	MEDIUM	Profitable	725	67	1488	50000	791	No Government support, Exploita
36	shariq khan	45-60	Faislabad Region	Sugar cane	65	26	MEDIUM	Profitable	725	67	1759	50000	791	No Government support, Exploita
37	Ijaz malik	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
38	Ijaz imtiaz	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
39	Imtiaz hassan khan	45-60	Faislabad Region	Sugar cane	85	34	MEDIUM	Profitable	725	67	2300	50000	791	No Government support, Exploita
40	furqan ahmed	45-60	Faislabad Region	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	50000	791	No Government support, Exploita
41	shamshad Ali	45-60	Faislabad Region	Sugar cane	95	38	MEDIUM	Profitable	725	67	2571	50000	791	No Government support, Exploita
42	salam shah	45-60	Faislabad Region	Sugar cane	100	40	LARGE	Profitable	775	71	2893	40000	633	No Government support, Exploita
43	bhutta	45-60	Faislabad Region	Sugar cane	105	42	LARGE	Profitable	775	71	3037	40000	633	No Government support, Exploita
44	Danish sahitto	45-60	Faislabad Region	Sugar cane	110	45	LARGE	Profitable	775	71	3182	40000	633	No Government support, Exploita
45	faisal rehman choha	45-60	Faislabad Region	Sugar cane	55	22	MEDIUM	Profitable	725	67	1488	50000	791	No Government support, Exploita
46	Munawar saleem	45-60	Faislabad Region	Sugar cane	85	34	MEDIUM	Profitable	725	67	2300	50000	791	No Government support, Exploita
47	mahr amir	45-60	Faislabad Region	Sugar cane	75	30	MEDIUM	Profitable	725	67	2030	50000	791	No Government support, Exploita
48	Javed sarfaraz	45-60	Faislabad Region	Sugar cane	80	32	MEDIUM	Profitable	725	67	2165	50000	791	No Government support, Exploita



	SELLING PRICE per Maund	SELLING PRICE PKR/MAUND AVERAGE	SELLING PRICE IN USD/MT	PROFITABILITY PER ACRE APPORX	PROFITABILITY USD/HA	OTHER USES OF THE CROP	ANY PRICE SUBSIDY	FUTURE PROSPECT	WILL YOU GROW AGAIN	ANY KNOWLEDGE OF ETHANOL
2	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
3	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
4	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
5	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
6	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
7	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
8	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
9	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	Yes
10	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
11	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
12	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
13	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
14	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
15	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
16	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	Yes
17	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	Yes
18	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
19	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
20	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
21	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
22	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
23	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
24	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
25	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
26	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
27	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
28	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
29	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
30	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
31	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
32	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
33	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
34	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
35	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
36	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
37	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
38	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
39	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
40	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
41	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
42	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
43	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
44	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	No
45	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	Yes
46	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	Yes
47	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and varie	Yes if Proper price is paid this year and no late payments	Yes



	O	P	Q	R	S	T	U	V	W	X	Y
1	SELLING MARKET	SELLING PRICE per Maund	SELLING PRICE PKR /MAUND AVERAGE	SELLING PRICE IN USD/MT	PROFITABILITY PER ACRE APPROX	PROFITABILITY USD/HA	OTHER USES OF THE CROP	ANY PRICE SUBSIDY	FUTURE PROSPECT	WILL YOU GROW AGAIN	ANY KNOWLEDGE OF ETHANOL
2	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
3	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
4	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
5	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
6	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
7	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
8	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
9	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
10	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
11	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
12	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
13	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
14	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
15	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
16	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
17	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
18	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
19	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
20	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
21	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
22	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
23	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
24	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
25	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
26	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	yes
27	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
28	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
29	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
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33	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
34	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
35	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
36	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
37	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
38	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
39	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
40	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
41	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
42	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
43	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
44	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
45	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
46	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
47	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
48	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
49	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
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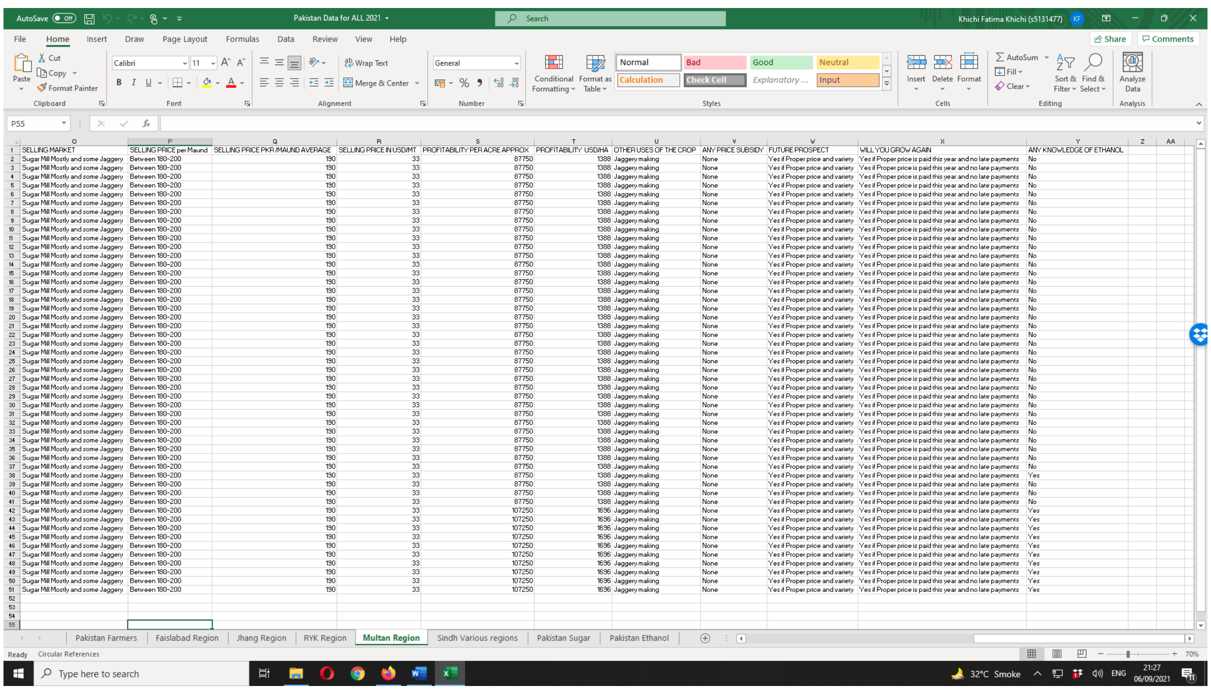
51	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
52	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes



	O	P	Q	R	S	T	U	V	W	X	Y
1	SELLING MARKET	SELLING PRICE per Maund	SELLING PRICE PKR /MAUND AVERAGE	SELLING PRICE IN USD/MT	PROFITABILITY PER ACRE APPROX	PROFITABILITY USD/HA	OTHER USES OF THE CROP	ANY PRICE SUBSIDY	FUTURE PROSPECT	WILL YOU GROW AGAIN	ANY KNOWLEDGE OF ETHANOL
2	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
3	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
4	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
5	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
6	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
7	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
8	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
9	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
10	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
11	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
12	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
13	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
14	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
15	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
16	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
17	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
18	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
19	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
20	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
21	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
22	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
23	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
24	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
25	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
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32	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
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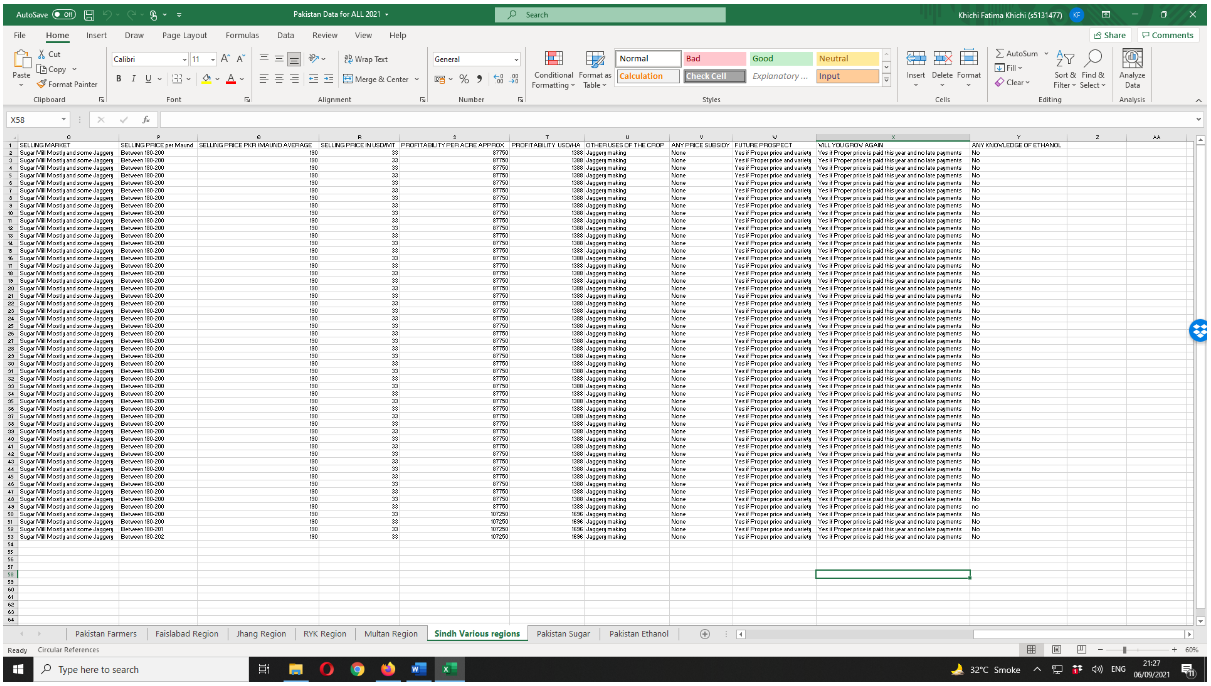
35	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
36	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
37	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
38	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
39	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
40	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
41	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
42	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
43	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
44	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
45	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
46	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
47	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
48	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
49	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
50	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes
51	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	Yes



	O	P	Q	R	S	T	U	V	W	X	Y
1	SELLING MARKET	SELLING PRICE per Maund	SELLING PRICE PKR /MAUND AVERAGE	SELLING PRICE IN USD/MT	PROFITABILITY PER ACRE APPROX	PROFITABILITY USD/HA	OTHER USES OF THE CROP	ANY PRICE SUBSIDY	FUTURE PROSPECT	WILL YOU GROW AGAIN	ANY KNOWLEDGE OF ETHANOL
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4	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
5	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
6	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
7	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
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12	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
13	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
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15	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
16	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	87750	1388	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
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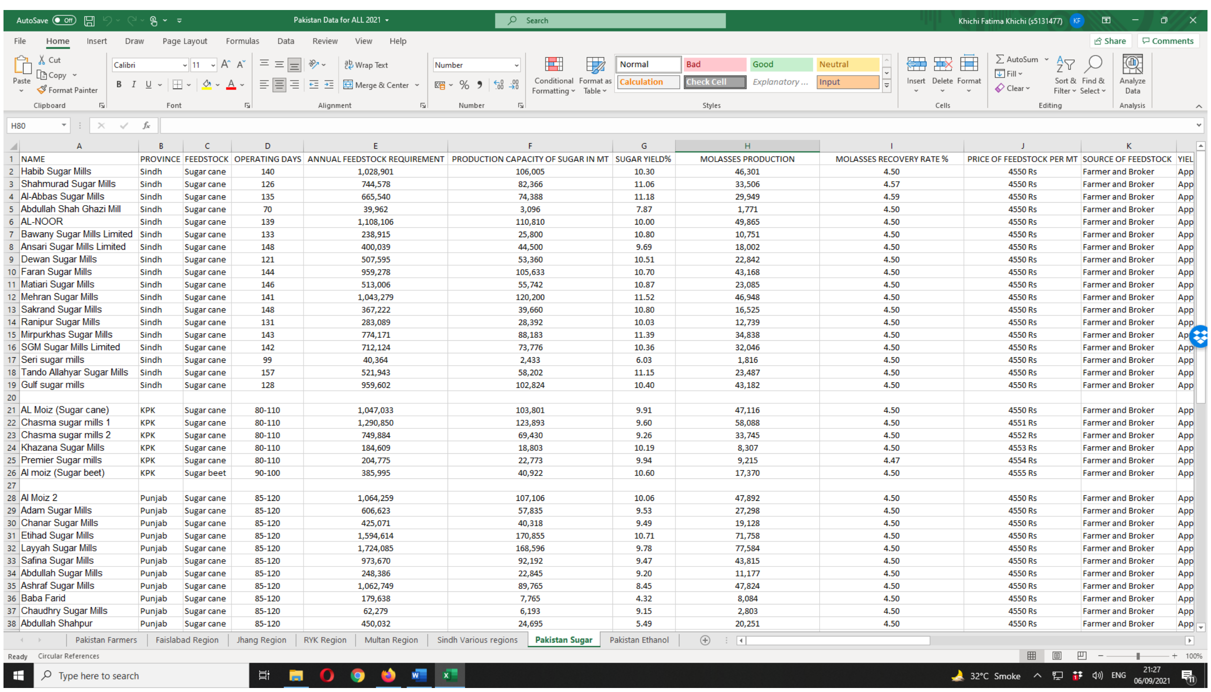
51	Sugar Mill Mostly and some Jaggery	Between 180-200	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
52	Sugar Mill Mostly and some Jaggery	Between 180-201	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No
53	Sugar Mill Mostly and some Jaggery	Between 180-202	190	33	107250	1696	Jaggery making	None	Yes if Proper price and variety	Yes if Proper price is paid this year and no late payments	No

Annex-18

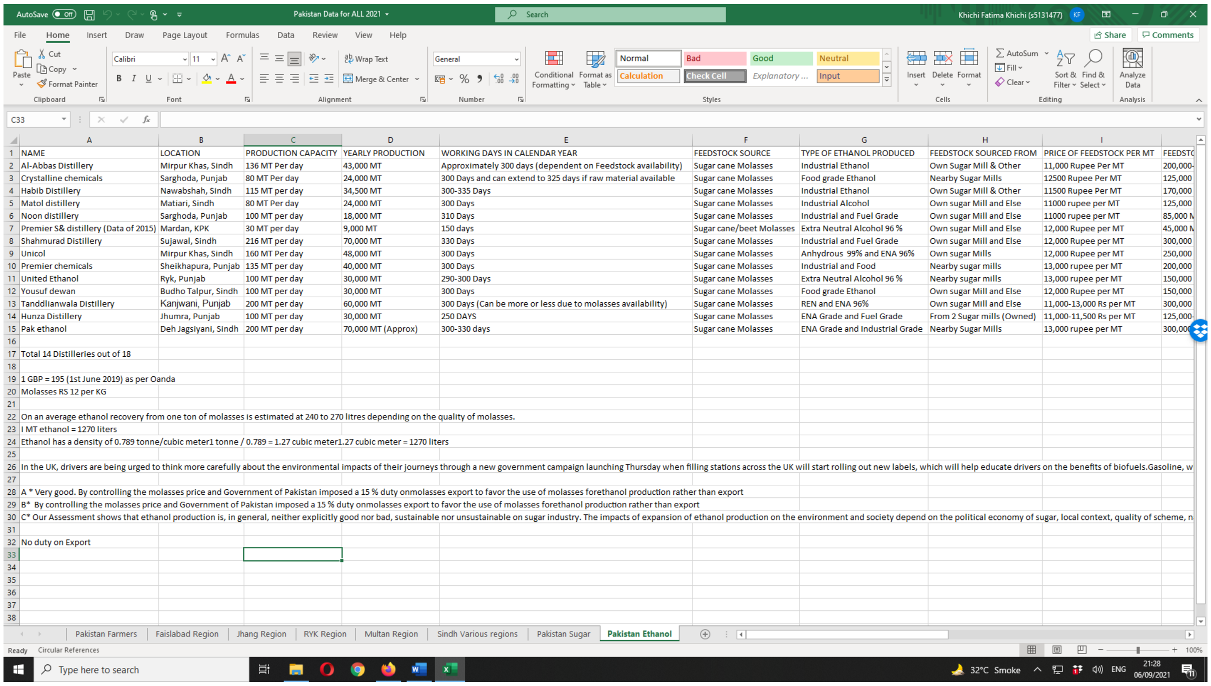
Pakistan sugar industry surveys



	A	B	C	D	E	F	G	H	I	J	K	
1	NAME	PROVINCE	FEEDSTOCK	OPERATING DAYS	ANNUAL FEEDSTOCK REQUIREMENT	PRODUCTION CAPACITY OF SUGAR IN MT	SUGAR YIELD%	MOLASSES PRODUCTION	MOLASSES RECOVERY RATE %	PRICE OF FEEDSTOCK PER MT	SOURCE OF FEEDSTOCK	YIEL
2	Habib Sugar Mills	Sindh	Sugar cane	140	1,028,901	106,005	10.30	46,301	4.50	4550 Rs	Farmer and Broker	App
3	Shahmurad Sugar Mills	Sindh	Sugar cane	126	744,578	82,366	11.06	33,506	4.57	4550 Rs	Farmer and Broker	App
4	Al-Abbas Sugar Mills	Sindh	Sugar cane	135	665,540	74,388	11.18	29,949	4.59	4550 Rs	Farmer and Broker	App
5	Abdullah Shah Ghazi Mill	Sindh	Sugar cane	70	39,962	3,096	7.87	1,771	4.50	4550 Rs	Farmer and Broker	App
6	AL-NOOR	Sindh	Sugar cane	139	1,108,106	110,810	10.00	49,865	4.50	4550 Rs	Farmer and Broker	App
7	Bawany Sugar Mills Limited	Sindh	Sugar cane	133	238,915	25,800	10.80	10,751	4.50	4550 Rs	Farmer and Broker	App
8	Ansari Sugar Mills Limited	Sindh	Sugar cane	148	400,039	44,500	9.69	18,002	4.50	4550 Rs	Farmer and Broker	App
9	Dewan Sugar Mills	Sindh	Sugar cane	121	507,595	53,360	10.51	22,842	4.50	4550 Rs	Farmer and Broker	App
10	Faran Sugar Mills	Sindh	Sugar cane	144	959,278	105,633	10.70	43,168	4.50	4550 Rs	Farmer and Broker	App
11	Matiari Sugar Mills	Sindh	Sugar cane	146	513,006	55,742	10.87	23,085	4.50	4550 Rs	Farmer and Broker	App
12	Mehran Sugar Mills	Sindh	Sugar cane	141	1,043,279	120,200	11.52	46,948	4.50	4550 Rs	Farmer and Broker	App
13	Sakrand Sugar Mills	Sindh	Sugar cane	148	367,222	39,660	10.80	16,525	4.50	4550 Rs	Farmer and Broker	App
14	Ranipur Sugar Mills	Sindh	Sugar cane	131	283,089	28,392	10.03	12,739	4.50	4550 Rs	Farmer and Broker	App
15	Mirpurkhas Sugar Mills	Sindh	Sugar cane	143	774,171	88,183	11.39	34,838	4.50	4550 Rs	Farmer and Broker	App
16	SGM Sugar Mills Limited	Sindh	Sugar cane	142	712,124	73,776	10.36	32,046	4.50	4550 Rs	Farmer and Broker	App
17	Seri sugar mills	Sindh	Sugar cane	99	40,364	2,433	6.03	1,816	4.50	4550 Rs	Farmer and Broker	App
18	Tando Allahyar Sugar Mills	Sindh	Sugar cane	157	521,943	58,202	11.15	23,487	4.50	4550 Rs	Farmer and Broker	App
19	Gulf sugar mills	Sindh	Sugar cane	128	959,602	102,824	10.40	43,182	4.50	4550 Rs	Farmer and Broker	App
20												
21	AL Moiz (Sugar cane)	KPK	Sugar cane	80-110	1,047,033	103,801	9.91	47,116	4.50	4550 Rs	Farmer and Broker	App
22	Chasma sugar mills 1	KPK	Sugar cane	80-110	1,290,850	123,893	9.60	58,088	4.50	4551 Rs	Farmer and Broker	App
23	Chasma sugar mills 2	KPK	Sugar cane	80-110	749,884	69,430	9.26	33,745	4.50	4552 Rs	Farmer and Broker	App
24	Khazana Sugar Mills	KPK	Sugar cane	80-110	184,609	18,803	10.19	8,307	4.50	4553 Rs	Farmer and Broker	App
25	Premier Sugar mills	KPK	Sugar cane	80-110	204,775	22,773	9.94	9,215	4.47	4554 Rs	Farmer and Broker	App
26	Al moiz (Sugar beet)	KPK	Sugar beet	90-100	385,995	40,922	10.60	17,370	4.50	4555 Rs	Farmer and Broker	App
27												
28	Al Moiz 2	Punjab	Sugar cane	85-120	1,064,259	107,106	10.06	47,892	4.50	4550 Rs	Farmer and Broker	App
29	Adam Sugar Mills	Punjab	Sugar cane	85-120	606,623	57,835	9.53	27,298	4.50	4550 Rs	Farmer and Broker	App
30	Chanar Sugar Mills	Punjab	Sugar cane	85-120	425,071	40,318	9.49	19,128	4.50	4550 Rs	Farmer and Broker	App
31	Etihad Sugar Mills	Punjab	Sugar cane	85-120	1,594,614	170,855	10.71	71,758	4.50	4550 Rs	Farmer and Broker	App
32	Layyah Sugar Mills	Punjab	Sugar cane	85-120	1,724,085	168,596	9.78	77,584	4.50	4550 Rs	Farmer and Broker	App
33	Safina Sugar Mills	Punjab	Sugar cane	85-120	973,670	92,192	9.47	43,815	4.50	4550 Rs	Farmer and Broker	App
34	Abdullah Sugar Mills	Punjab	Sugar cane	85-120	248,386	22,845	9.20	11,177	4.50	4550 Rs	Farmer and Broker	App
35	Ashraf Sugar Mills	Punjab	Sugar cane	85-120	1,062,749	89,765	8.45	47,824	4.50	4550 Rs	Farmer and Broker	App
36	Baba Farid	Punjab	Sugar cane	85-120	179,638	7,765	4.32	8,084	4.50	4550 Rs	Farmer and Broker	App
37	Chaudhry Sugar Mills	Punjab	Sugar cane	85-120	62,279	6,193	9.15	2,803	4.50	4550 Rs	Farmer and Broker	App
38	Abdullah Shahpur	Punjab	Sugar cane	85-120	450,032	24,695	5.49	20,251	4.50	4550 Rs	Farmer and Broker	App

Annex-19

Pakistan ethanol industry surveys



NAME	LOCATION	PRODUCTION CAPACITY	YEARLY PRODUCTION	WORKING DAYS IN CALENDAR YEAR	FEEDSTOCK SOURCE	TYPE OF ETHANOL PRODUCED	FEEDSTOCK SOURCED FROM	PRICE OF FEEDSTOCK PER MT	FEEDSTO
Al-Abbas Distillery	Mirpur Khas, Sindh	136 MT Per day	43,000 MT	Approximately 300 days (dependent on Feedstock availability)	Sugar cane Molasses	Industrial Ethanol	Own Sugar Mill & Other	11,000 Rupee Per MT	200,000-
Crystalline chemicals	Sarghoda, Punjab	80 MT Per day	24,000 MT	300 Days and can extend to 325 days if raw material available	Sugar cane Molasses	Food grade Ethanol	Nearby Sugar Mills	12500 Rupee Per MT	125,000
Habib Distillery	Nawabshah, Sindh	115 MT per day	34,500 MT	300-335 Days	Sugar cane Molasses	Industrial Ethanol	Own Sugar Mill & Other	11500 Rupee Per MT	170,000
Matol distillery	Matiari, Sindh	80 MT Per day	24,000 MT	300 Days	Sugar cane Molasses	Industrial Alcohol	Own sugar Mill and Else	11000 rupee per MT	125,000
Noon distillery	Sarghoda, Punjab	100 MT per day	18,000 MT	310 Days	Sugar cane Molasses	Industrial and Fuel Grade	Own sugar Mill and Else	11000 rupee per MT	85,000 M
Premier S& distillery (Data of 2015)	Mardan, KPK	30 MT per day	9,000 MT	150 days	Sugar cane/beet Molasses	Extra Neutral Alcohol 96 %	Own sugar Mill and Else	12,000 Rupee per MT	45,000 M
Shahmurad Distillery	Sujawal, Sindh	216 MT per day	70,000 MT	330 Days	Sugar cane Molasses	Industrial and Fuel Grade	Own sugar Mill and Else	12,000 Rupee per MT	300,000
Unicol	Mirpur Khas, Sindh	160 MT Per day	48,000 MT	300 Days	Sugar cane Molasses	Anhydrous 99% and ENA 96%	Own sugar Mills	12,000 Rupee per MT	250,000
Premier chemicals	Sheikhapura, Punjab	135 MT per day	40,000 MT	300 Days	Sugar cane Molasses	Industrial and Food	Nearby sugar mills	13,000 rupee per MT	200,000
United Ethanol	Ryk, Punjab	100 MT per day	30,000 MT	290-300 Days	Sugar cane Molasses	Extra Neutral Alcohol 96 %	Nearby sugar mills	13,000 rupee per MT	150,000
Yousuf dewan	Budho Talpur, Sindh	100 MT per day	30,000 MT	300 Days	Sugar cane Molasses	Food grade Ethanol	Own sugar Mill and Else	12,000 Rupee per MT	150,000
Tanddlianwala Distillery	Kanjwani, Punjab	200 MT per day	60,000 MT	300 Days (Can be more or less due to molasses availability)	Sugar cane Molasses	REN and ENA 96%	Own sugar Mill and Else	11,000-13,000 Rs per MT	300,000
Hunza Distillery	Jhumra, Punjab	100 MT per day	30,000 MT	250 DAYS	Sugar cane Molasses	ENA Grade and Fuel Grade	From 2 Sugar mills (Owned)	11,000-11,500 Rs per MT	125,000-
Pak ethanol	Deh Jagsiyani, Sindh	200 MT per day	70,000 MT (Approx)	300-330 days	Sugar cane Molasses	ENA Grade and Industrial Grade	Nearby Sugar Mills	13,000 rupee per MT	300,000

Total 14 Distilleries out of 18

1 GBP = 195 (1st June 2019) as per Oanda

Molasses RS 12 per KG

On an average ethanol recovery from one ton of molasses is estimated at 240 to 270 litres depending on the quality of molasses.

I MT ethanol = 1270 liters

Ethanol has a density of 0.789 tonne/cubic meter1 tonne / 0.789 = 1.27 cubic meter1.27 cubic meter = 1270 liters

In the UK, drivers are being urged to think more carefully about the environmental impacts of their journeys through a new government campaign launching Thursday when filling stations across the UK will start rolling out new labels, which will help educate drivers on the benefits of biofuels.Gasoline, w

A * Very good. By controlling the molasses price and Government of Pakistan imposed a 15 % duty onmolasses export to favor the use of molasses forethanol production rather than export

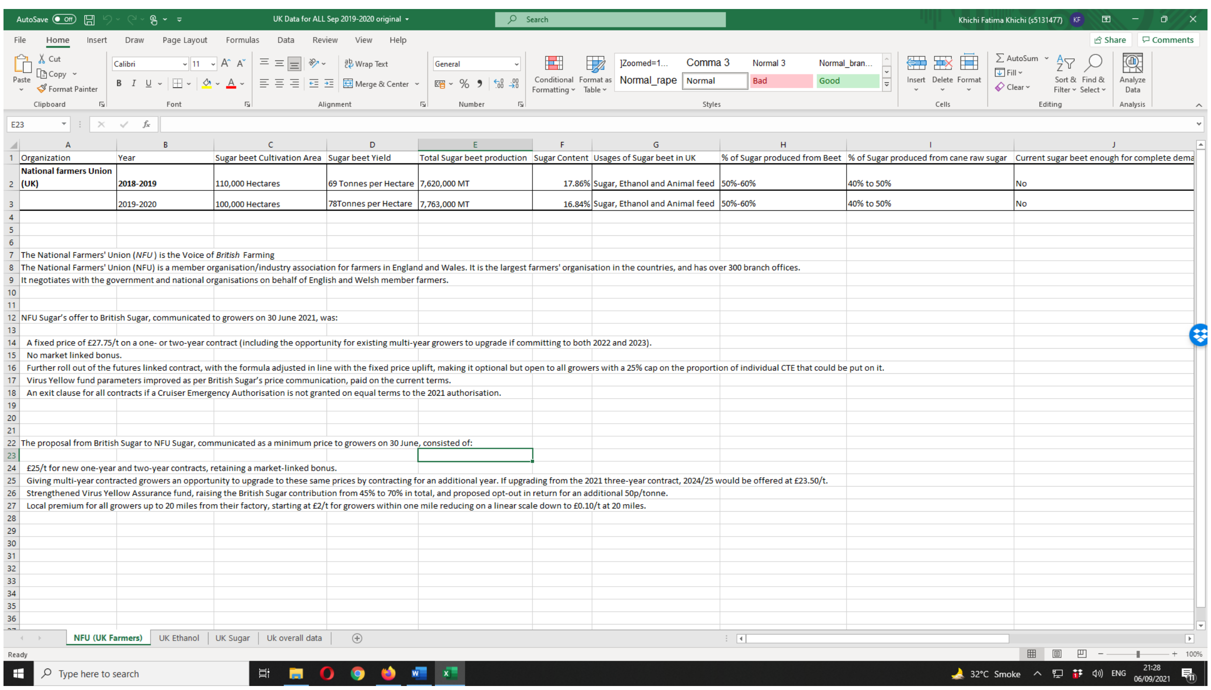
B* By controlling the molasses price and Government of Pakistan imposed a 15 % duty onmolasses export to favor the use of molasses forethanol production rather than export

C* Our Assessment shows that ethanol production is, in general, neither explicitly good nor bad, sustainable nor unsustainable on sugar industry. The impacts of expansion of ethanol production on the environment and society depend on the political economy of sugar, local context, quality of scheme, n

No duty on Export

Annex-20

UK Farmers (NFU) surveys



Organization	Year	Sugar beet Cultivation Area	Sugar beet Yield	Total Sugar beet production	Sugar Content	Usages of Sugar beet in UK	% of Sugar produced from Beet	% of Sugar produced from cane raw sugar	Current sugar beet enough for complete dema
National farmers Union (UK)	**2018-2019**	110,000 Hectares	69 Tonnes per Hectare	7,620,000 MT	17.86%	Sugar, Ethanol and Animal feed	50%-60%	40% to 50%	No
	2019-2020	100,000 Hectares	78Tonnes per Hectare	7,763,000 MT	16.84%	Sugar, Ethanol and Animal feed	50%-60%	40% to 50%	No

The National Farmers' Union (*NFU*) is the Voice of *British* Farming

The National Farmers' Union (NFU) is a member organisation/industry association for farmers in England and Wales. It is the largest farmers' organisation in the countries, and has over 300 branch offices.

It negotiates with the government and national organisations on behalf of English and Welsh member farmers.

NFU Sugar's offer to British Sugar, communicated to growers on 30 June 2021, was:

A fixed price of £27.75/t on a one- or two-year contract (including the opportunity for existing multi-year growers to upgrade if committing to both 2022 and 2023).

No market linked bonus.

Further roll out of the futures linked contract, with the formula adjusted in line with the fixed price uplift, making it optional but open to all growers with a 25% cap on the proportion of individual CTE that could be put on it.

Virus Yellow fund parameters improved as per British Sugar's price communication, paid on the current terms.

An exit clause for all contracts if a Cruiser Emergency Authorisation is not granted on equal terms to the 2021 authorisation.

The proposal from British Sugar to NFU Sugar, communicated as a minimum price to growers on 30 June, consisted of:

£25/t for new one-year and two-year contracts, retaining a market-linked bonus.

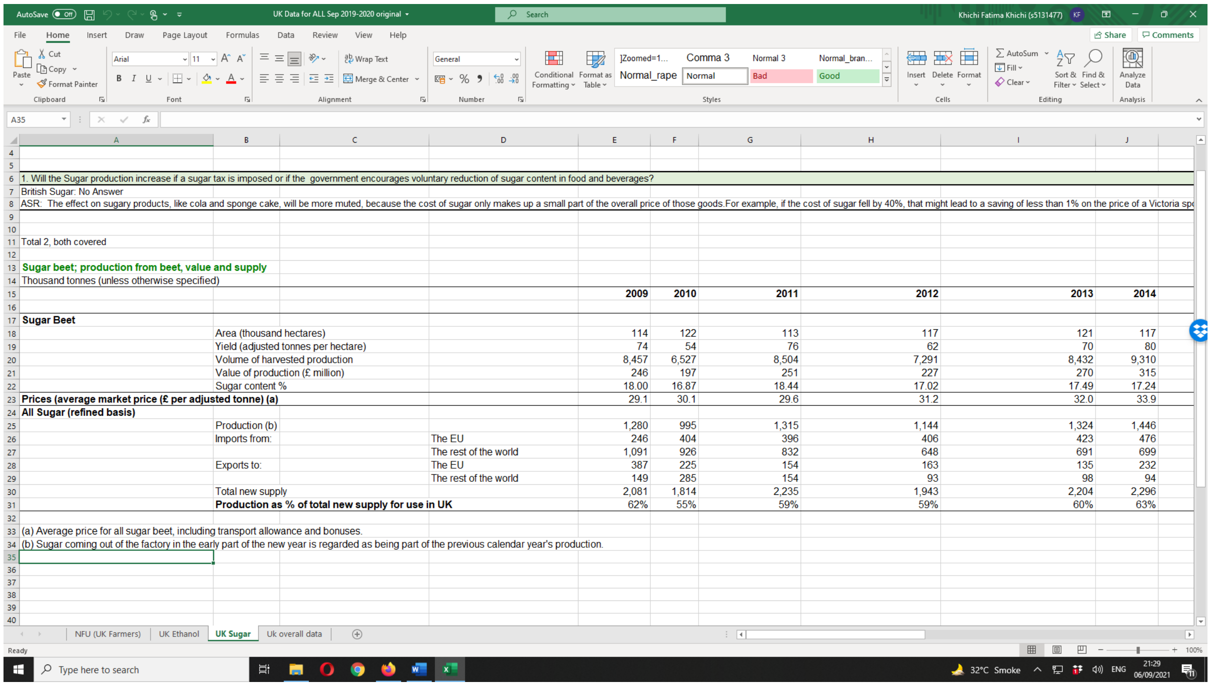
Giving multi-year contracted growers an opportunity to upgrade to these same prices by contracting for an additional year. If upgrading from the 2021 three-year contract, 2024/25 would be offered at £23.50/t.

Strengthened Virus Yellow Assurance fund, raising the British Sugar contribution from 45% to 70% in total, and proposed opt-out in return for an additional 50p/tonne.

Local premium for all growers up to 20 miles from their factory, starting at £2/t for growers within one mile reducing on a linear scale down to £0.10/t at 20 miles.

Annex-21

UK sugar industry surveys



1. Will the Sugar production increase if a sugar tax is imposed or if the government encourages voluntary reduction of sugar content in food and beverages?

British Sugar: No Answer

ASR: The effect on sugary products, like cola and sponge cake, will be more muted, because the cost of sugar only makes up a small part of the overall price of those goods.For example, if the cost of sugar fell by 40%, that might lead to a saving of less than 1% on the price of a Victoria sp

Total 2, both covered

Sugar beet; production from beet, value and supply

Thousand tonnes (unless otherwise specified)

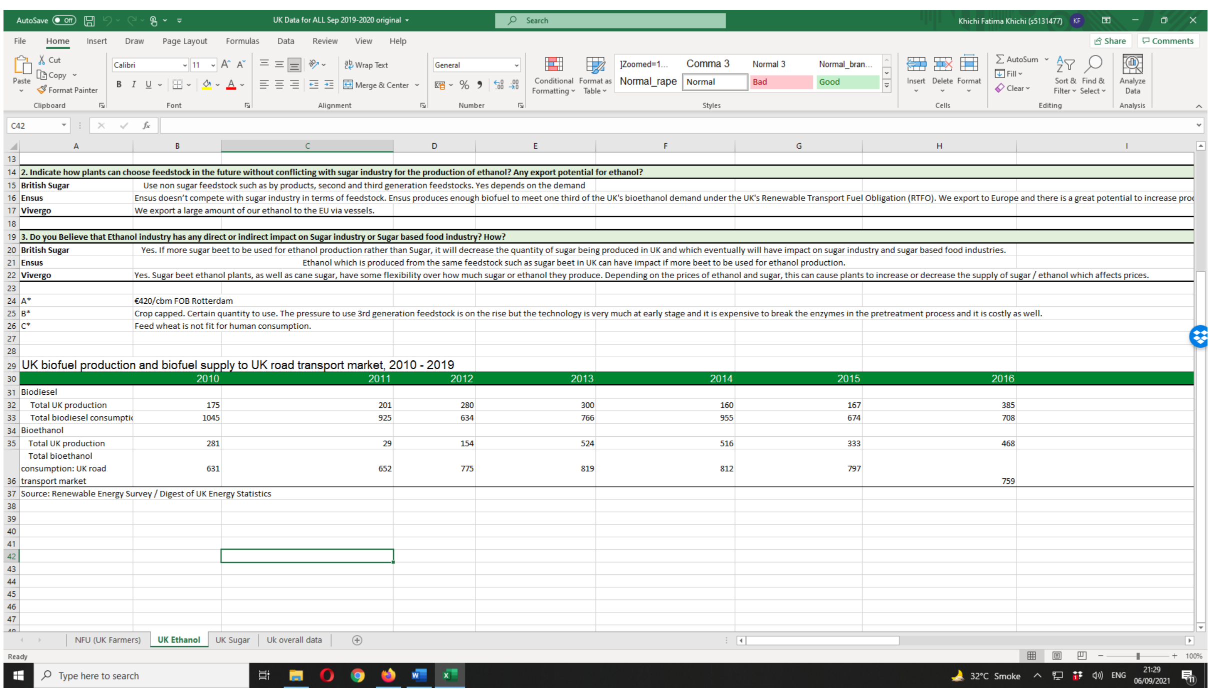
			2009	2010	2011	2012	2013	2014
Sugar Beet								
	Area (thousand hectares)		114	122	113	117	121	117
	Yield (adjusted tonnes per hectare)		74	54	76	62	70	80
	Volume of harvested production		8,457	6,527	8,504	7,291	8,432	9,310
	Value of production (£ million)		246	197	251	227	270	315
	Sugar content %		18.00	16.87	18.44	17.02	17.49	17.24
Prices (average market price (£ per adjusted tonne) (a)			29.1	30.1	29.6	31.2	32.0	33.9
All Sugar (refined basis)								
	Production (b)		1,280	995	1,315	1,144	1,324	1,446
	Imports from:	The EU	246	404	396	406	423	476
		The rest of the world	1,091	926	832	648	691	699
	Exports to:	The EU	387	225	154	163	135	232
		The rest of the world	149	285	154	93	98	94
	Total new supply		2,081	1,814	2,235	1,943	2,204	2,296
	Production as % of total new supply for use in UK		62%	55%	59%	59%	60%	63%

(a) Average price for all sugar beet, including transport allowance and bonuses.

(b) Sugar coming out of the factory in the early part of the new year is regarded as being part of the previous calendar year's production.

Annex-22

UK ethanol industry surveys



2. Indicate how plants can choose feedstock in the future without conflicting with sugar industry for the production of ethanol? Any export potential for ethanol?

British Sugar Use non sugar feedstock such as by products, second and third generation feedstocks. Yes depends on the demand

Ensus Ensus doesn't compete with sugar industry in terms of feedstock. Ensus produces enough biofuel to meet one third of the UK's bioethanol demand under the UK's Renewable Transport Fuel Obligation (RTFO). We export to Europe and there is a great potential to increase pro

Vivergo We export a large amount of our ethanol to the EU via vessels.

3. Do you Believe that Ethanol industry has any direct or indirect impact on Sugar industry or Sugar based food industry? How?

British Sugar Yes. If more sugar beet to be used for ethanol production rather than Sugar, it will decrease the quantity of sugar being produced in UK and which eventually will have impact on sugar industry and sugar based food industries.

Ensus Ethanol which is produced from the same feedstock such as sugar beet in UK can have impact if more beet to be used for ethanol production.

Vivergo Yes. Sugar beet ethanol plants, as well as cane sugar, have some flexibility over how much sugar or ethanol they produce. Depending on the prices of ethanol and sugar, this can cause plants to increase or decrease the supply of sugar / ethanol which affects prices.

A* €420/cbm FOB Rotterdam

B* Crop capped. Certain quantity to use. The pressure to use 3rd generation feedstock is on the rise but the technology is very much at early stage and it is expensive to break the enzymes in the pretreatment process and it is costly as well.

C* Feed wheat is not fit for human consumption.

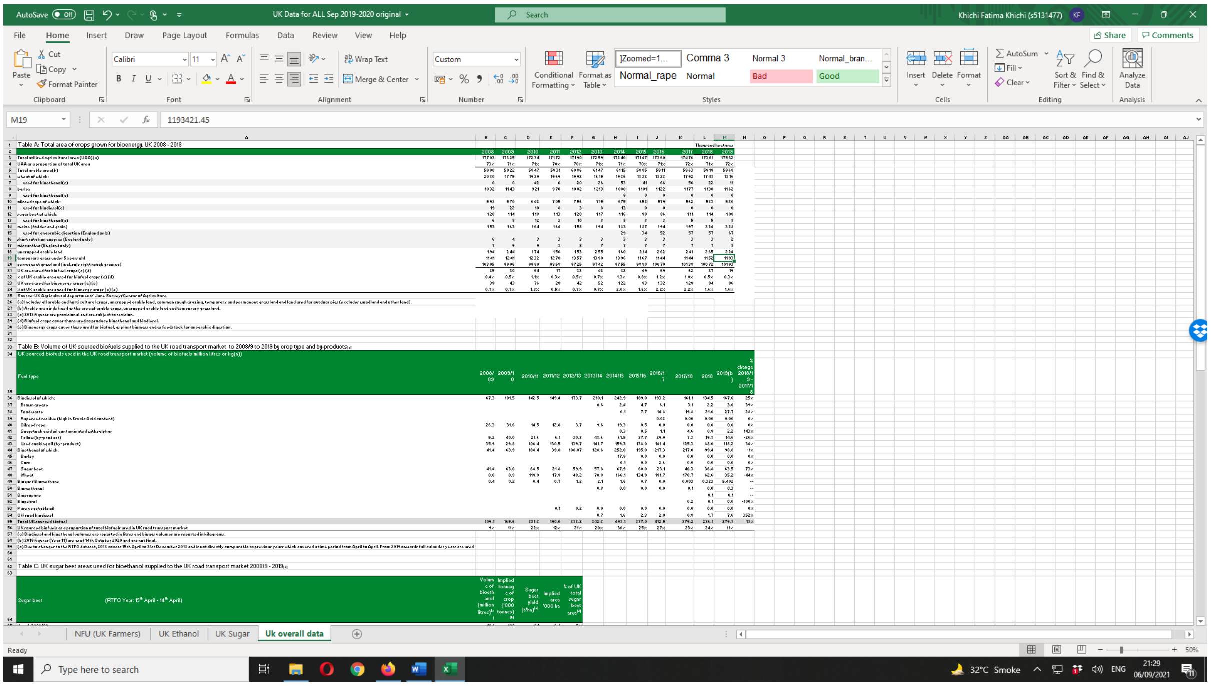
UK biofuel production and biofuel supply to UK road transport market, 2010 - 2019

	2010	2011	2012	2013	2014	2015	2016
Biodiesel							
Total UK production	175	201	280	300	160	167	385
Total biodiesel consumptic	1045	925	634	766	955	674	708
Bioethanol							
Total UK production	281	29	154	524	516	333	468
Total bioethanol consumption: UK road transport market	631	652	775	819	812	797	759

Source: Renewable Energy Survey / Digest of UK Energy Statistics

Annex-23

UK sugar and ethanol overall data



Annex-24

Financial statement for Pakistan

30 MT / Day Ethanol Plant

MENU

1	General Information
	30 MT / Day Ethanol Plant
1	Planned to be operated in December, 2018
2	
3	Energy will be never a dead investment
4	The project has a vital role in the Government development policy
5	
6	

Assumptions

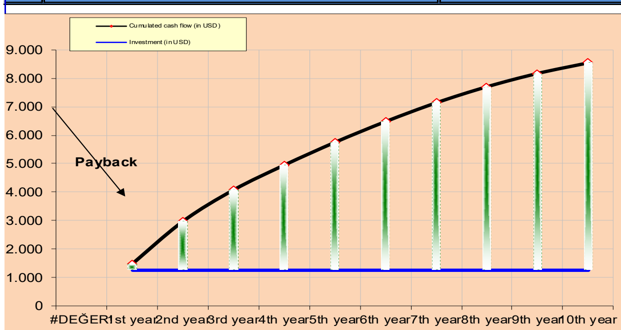
1st year sales	**2.493,00**	**k$**
Price/Mt:	**$700,000**	
Mean IBITDA :	**56,51%**	
Actualization rate	**6%**	

2 Investment Details

	Description	Amount(usd)
A-	Legal Expenses	26.800
B-	Constructions	156.250
C-	Equipment	760.000
D-	Land Acquisition	115.780
E-	Installation	40.000
F-	Insuarance	160.805
G-		
	Total in USD	1.259.635

3 Funding scheme

		Amount(usd)	Ressources	Amount(usd)
1	Legal Expenses	26.800	**Capital**	**377.891**
2	Constructions	156.250	**Bank Credit**	**881.745**
3	Consruction Equipment	760.000		
4	Decoration	115.780		
5	Furniture	40.000		
6	Insuarance	160.805		
7	0	0		
8	Total in USD	1.259.635	Total in USD	1.259.635



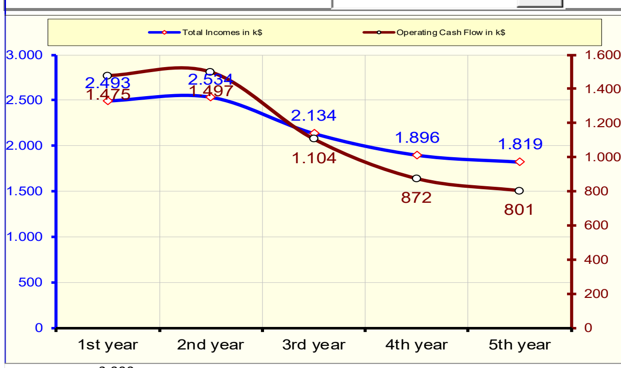
Performance indicators

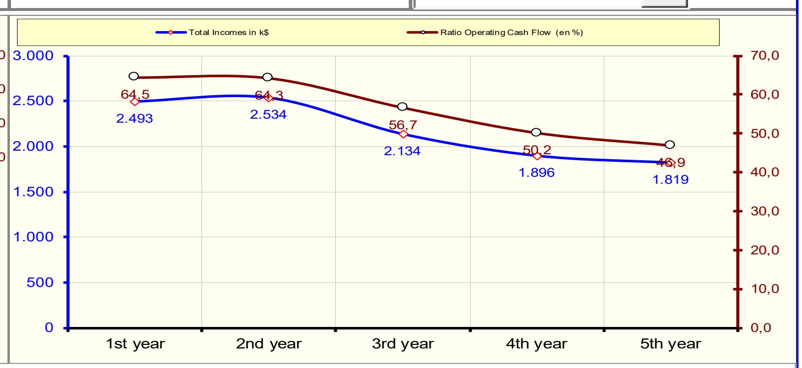
	Criterion	Réalisation
1	**Payback**	**0 years and 10 months**
2	**Internal Rate of Return of investment (%) 6 years**	**73,91%**
3	**Internal Rate of Return of investment (%) 10 years**	**74,92%**
4	**Internal Rate of Return of investment (%) 15 years**	**74,96%**
5	**Net Present Value "NPV" (k$) 6 years**	**$3.699.842**
6	**Net Present Value "NPV" (k$) 10 years**	**$5.005.290**
7	**Net Present Value "NPV" (k$) 15 years**	**$5.211.177**

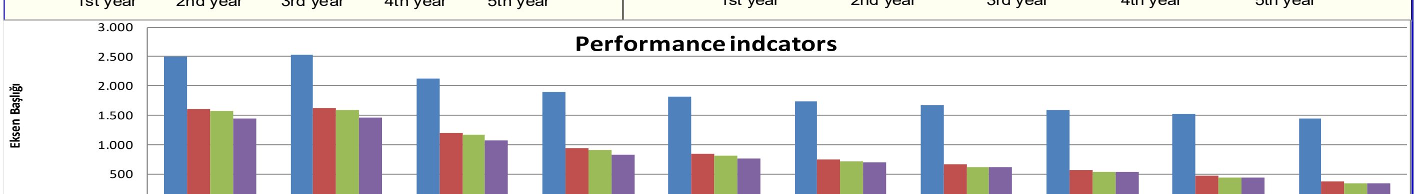
NB: Evaluation sur 5 ans

choose your criterion : Total Incomes

choose your criterion : Operating Cash Flow







	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Gross margin	2.493	2.534	2.134	1.896	1.819	1.743	1.669	1.595	1.523	1.451
EBITDA	1.607	1.629	1.210	951	854	757	660	564	468	373
EBIT	1.574	1.596	1.176	917	820	723	627	531	435	339
Net income	1.441	1.463	1.070	838	767	697	627	531	435	339

	Operating Account for 10 years										
	Description	7.200	7.143	6.714	6.312	5.933	5.577	5.242	4.928	4.632	4.354
	Unit Price :	Value in USD									
	Section	1.year	2. years	3. years	4. years	5. years	6. years	7. years	8. years	9. years	10. years
	Working Days in Year	300,00	298,00	296,00	294,00	292,00	290,00	288,00	286,00	284,00	282,00
	Capacity of Ethanol Plant (MT/Day)	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**
	Production Capacity (%)	80,00%	85,00%	95,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
	Annual Production Capacity (MT)	**7.200,00**	**7.599,00**	**8.436,00**	**8.820,00**	**8.760,00**	**8.700,00**	**8.640,00**	**8.580,00**	**8.520,00**	**8.460,00**
	By-Product Fusel Oil Production (Mt)	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15	0,15
	Annual By-Product Fusel Oil Production (Mt)	**45,00**	**42,30**	**39,76**	**37,38**	**35,13**	**33,03**	**31,04**	**29,18**	**27,43**	**25,78**
	Yearly Deficiency (%)	0,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%
	Annual Ethanol Total Production (Mt)	**7.200**	**7143,06**	**6714,48**	**6311,61**	**5932,91**	**5576,94**	**5242,32**	**4927,78**	**4632,11**	**4354,19**
	Domestic Sales Price for Ethanol ($/Mt)	700,00	735,00	771,75	810,34	850,85	893,40	938,07	984,97	1034,22	1085,93
	Export Sales Price of Ethanol ($/Mt)	750,00	787,50	826,88	868,22	911,63	957,21	1005,07	1055,33	1108,09	1163,50
	Domestic Sales of Ethanol (%70/Mt)	7.200,00	7.143,06	6.714,48	6.311,61	5.932,91	5.576,94	5.242,32	4.927,78	4.632,11	4.354,19
	Export Sales of Ethanol (%30/Mt)	-	-	-	-	-	-	-	-	-	-
	By-Product Fusel Oil Sales Price ($/Mt)	400,00	428,00	457,96	490,02	524,32	561,02	600,29	642,31	687,27	735,38
	Annual Domestic Sales of Ethanol ($)	5.040.000,00	5.250.149,10	5.181.897,16	5.114.532,50	5.048.043,58	4.982.419,01	4.917.647,56	4.853.718,14	4.790.619,81	4.728.341,75
	Annual Export Sales of Ethanol ($)	-	-	-	-	-	-	-	-	-	-
	Annual Sales of By-Product ($)	18.000,00	18.104,40	18.209,41	18.315,02	18.421,25	18.528,09	18.635,55	18.743,64	18.852,35	18.961,70
	Annual Total Income from Sales ($)	**5.058.000,00**	**5.268.253,50**	**5.200.106,57**	**5.132.847,52**	**5.066.464,82**	**5.000.947,10**	**4.936.283,12**	**4.872.461,78**	**4.809.472,16**	**4.747.303,45**
	Molasses Price ($/Mt)	75,00	75,75	76,51	77,27	78,05	78,83	79,61	80,41	81,21	82,03
	Annual Need of Molasses for Production (Mt)	34.200,00	36.095,25	40.071,00	41.895,00	41.610,00	41.325,00	41.040,00	40.755,00	40.470,00	40.185,00
	Annual Cost of Feedstock ($)	**2.565.000,00**	**2.734.215,19**	**3.065.732,03**	**3.237.334,53**	**3.247.464,96**	**3.257.474,27**	**3.267.359,02**	**3.277.115,72**	**3.286.740,82**	**3.296.230,70**
1	Revenue Before Tax	2.493.000,00	2.534.038,31	2.134.374,53	1.895.512,99	1.818.999,86	1.743.472,83	1.668.924,09	1.595.346,06	1.522.731,35	1.451.072,75
2	Total Incomes	2.493.000,00	2.534.038,31	2.134.374,53	1.895.512,99	1.818.999,86	1.743.472,83	1.668.924,09	1.595.346,06	1.522.731,35	1.451.072,75
	Chemical	202.200,00	206.244,00	210.368,88	214.576,26	218.867,78	223.245,14	227.710,04	232.264,24	236.909,53	241.647,72
	Utilities	302.370,00	310.251,15	318.452,30	326.989,45	335.877,36	345.132,55	354.772,34	364.814,92	375.279,34	386.185,61
	Electricity	79.920,00	83.916,00	88.111,80	92.517,39	97.143,26	102.000,42	107.100,44	112.455,47	118.078,24	123.982,15
	Water	6.300,00	6.615,00	6.945,75	7.293,04	7.657,69	8.040,57	8.442,60	8.864,73	9.307,97	9.773,37
	Steam	29.700,00	31.185,00	32.744,25	34.381,46	36.100,54	37.905,56	39.800,84	41.790,88	43.880,43	46.074,45
	Rent	60.000,00	61.200,00	62.424,00	63.672,48	64.945,93	66.244,85	67.569,75	68.921,14	70.299,56	71.705,55
	Repair & Maintenance	126.450,00	127.335,15	128.226,50	129.124,08	130.027,95	130.938,15	131.854,71	132.777,70	133.707,14	134.643,09
	Insurance	50.000,00	50.500,00	51.005,00	51.515,05	52.030,20	52.550,50	53.076,01	53.606,77	54.142,84	54.684,26
	Other Operational Expenses	120.000,00	122.400,00	124.848,00	127.344,96	129.891,86	132.489,70	135.139,49	137.842,28	140.599,13	143.411,11
	Marketing	120.000,00	122.400,00	124.848,00	127.344,96	129.891,86	132.489,70	135.139,49	137.842,28	140.599,13	143.411,11
12	**Expenditures**	**674.570,00**	**689.395,15**	**704.674,18**	**720.425,72**	**736.667,21**	**753.417,89**	**770.697,88**	**788.528,21**	**806.930,83**	**825.928,70**
13	Added Value	1.818.430,00	1.844.643,16	1.429.700,36	1.175.087,27	1.082.332,65	990.054,94	898.226,21	806.817,86	715.800,52	625.144,05
14	Salaries	211.200,00	215.424,00	219.732,48	224.127,13	228.609,67	233.181,87	237.845,50	242.602,41	247.454,46	252.403,55
15	**Operational Expenses**	**211.200,00**	**215.424,00**	**219.732,48**	**224.127,13**	**228.609,67**	**233.181,87**	**237.845,50**	**242.602,41**	**247.454,46**	**252.403,55**
16	EBITDA	1.607.230,00	1.629.219,16	1.209.967,88	950.960,14	853.722,98	756.873,07	660.380,71	564.215,44	468.346,06	372.740,50
18	Financial Expenses	132.261,68	132.261,68	105.809,34	79.357,01	52.904,67	26.452,34	-	-	-	-
17	Depreciation	33.715,38	33.715,38	33.715,38	33.715,38	33.715,38	33.715,38	33.715,38	33.715,38	33.715,38	33.715,38
19	**Structural Cost**	**165.977,05**	**165.977,05**	**139.524,72**	**113.072,38**	**86.620,05**	**60.167,71**	**33.715,38**	**33.715,38**	**33.715,38**	**33.715,38**
20	Gross Income	1.441.252,95	1.463.242,11	1.070.443,16	837.887,76	767.102,94	696.705,36	626.665,33	530.500,07	434.630,68	339.025,12
21	Operating Cash Flow	1.474.968,33	1.496.957,49	1.104.158,54	871.603,14	800.818,31	730.420,74	660.380,71	564.215,44	468.346,06	372.740,50
22	Cumulative Cash Flow	1.474.968,33	2.971.925,81	4.076.084,35	4.947.687,49	5.748.505,80	6.478.926,53	7.139.307,24	7.703.522,68	8.171.868,74	8.544.609,24

Finacial statement											
	Year N	Year N+1	Year N + 2	Year N + 3	Year N + 4	Year N + 5	Year N + 6	Year N + 7	Year N + 8	Year N + 9	Year N + 10
In k$											
Sales	2.493	2.534	2.134	1.896	1.819	1.743	1.669	1.595	1.523	1.451	1.380
WIP and finished goods inventories changes	0	0	0	0	0	0	0	0	0	0	0
Production	**2.493**	**2.534**	**2.134**	**1.896**	**1.819**	**1.743**	**1.669**	**1.595**	**1.523**	**1.451**	**1.380**
Cost of sales	0	0	0	0	0	0	0	0	0	0	0
Gross Margin	**2.493**	**2.534**	**2.134**	**1.896**	**1.819**	**1.743**	**1.669**	**1.595**	**1.523**	**1.451**	**1.380**
Operating expenses	675	689	705	720	737	753	771	789	807	826	846
Salaries & Wages	211	215	220	224	229	233	238	243	247	252	257
Taxes	0	0	0	0	0	0	0	0	0	0	0
Others operating income (add-backs)	0	0	0	0	0	0	0	0	0	0	0
(provisions on reciecvables and invetories)	0	0	0	0	0	0	0	0	0	0	0
Overheads	**886**	**905**	**924**	**945**	**965**	**987**	**1.009**	**1.031**	**1.054**	**1.078**	**1.103**
EBITDA	**1.607**	**1.629**	**1.210**	**951**	**854**	**757**	**660**	**564**	**468**	**373**	**277**
Depreciation of Assets	34	34	34	34	34	34	34	34	34	34	34
EBIT	**1.574**	**1.596**	**1.176**	**917**	**820**	**723**	**627**	**531**	**435**	**339**	**244**
Financial expenses ST		0	0	0	0	0	0	0	0	0	0
Financial expenses LT	132	132	106	79	53	26	0	0	0	0	0
Financial income	0	0	0	0	0	0	0	0	0	0	0
Financial Result	132	132	106	79	53	26	0	0	0	0	0
EBT	**1.441**	**1.463**	**1.070**	**838**	**767**	**697**	**627**	**531**	**435**	**339**	**244**
Exceptional income	0	0	0	0	0	0	0	0	0	0	0
Income Tax	0	0	0	0	0	0	0	0	0	0	0
Net income	**1.441**	**1.463**	**1.070**	**838**	**767**	**697**	**627**	**531**	**435**	**339**	**244**
Key Financial Indicators as% of Sales											
Gross margin	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EBITDA	64%	64%	57%	50%	47%	43%	40%	35%	31%	26%	20%
EBIT	63%	63%	55%	48%	45%	41%	38%	33%	29%	23%	18%
Net income	58%	58%	50%	44%	42%	40%	38%	33%	29%	23%	18%

Repayment schedule

	Amount		881.745	Intrest	15%	MENU
	Term		7	Grace	2	
Date		Drawdown	Princ.	CAP. Resid.	Intrest	Total
1	st year	881.745	0	881.745	132.262	132.262
2	nd year	881.745	0	881.745	132.262	132.262
3	rd year	0	176.349	705.396	105.809	282.158
4	th year		176.349	529.047	79.357	255.706
5	th year		176.349	352.698	52.905	229.254
6	th year		176.349	176.349	26.452	202.801
7	th year		176.349	0	0	176.349
8	th year		0	0	0	0
9	th year		0	0	0	0
10	th year				0	0
			881.745		529.047	1.410.791

Depreciation

	Valeur	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Legal Expenses	26.800	0	0	0	0	0	0	0	0	0	0	0
Constructions	156.250	3.906	3.906	3.906	3.906	3.906	3.906	3.906	3.906	3.906	3.906	3.906
Equipment	760.000	19.000	19.000	19.000	19.000	19.000	19.000	19.000	19.000	19.000	19.000	19.000
Land Acquisition	115.780	5.789	5.789	5.789	5.789	5.789	5.789	5.789	5.789	5.789	5.789	5.789
Installation	40.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Insuarance	160.805	4.020	4.020	4.020	4.020	4.020	4.020	4.020	4.020	4.020	4.020	4.020
0	0	0	0	0	0	0	0	0	0	0	0	0
Total Amortissement	1.259.635	33.715	33.715	33.715	33.715	33.715	33.715	33.715	33.715	33.715	33.715	33.715

Annex-25

Financial statement for UK

30 MW Ethanol Plant	MENU

1	General Information
	30 MW Ethanol Plant
1	Planned to be operated in December, 2018
2	
3	Energy will be never a dead investment
4	The project has a vital role in the Government development and RED Policy
5	
6	

Assumptions

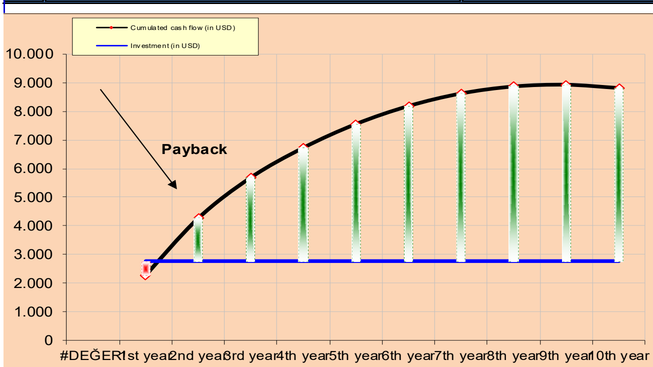
1st year sales	**4.915,08**	**k$**
Price/Mt:	**$795,00**	
Mean IBITDA :	**36,28%**	
Actualization rate	**6%**	

2 Investment Details

	Description	Amount(usd)
A-	Legal Expenses	61.250
B-	Constructions	280.000
C-	Equipment	1.100.000
D-	Land Acquisition	970.000
E-	Installation	100.000
F-	Insuarance	245.000
G-		
	Total in USD	2.756.250

3 Funding scheme

		Amount(usd)	Ressources	Amount(usd)
1	Legal Expenses	61.250	**Capital**	**826.875**
2	Constructions	280.000	**Bank Credit**	**1.929.375**
3	Consruction Equipment	1.100.000		
4	Decoration	970.000		
5	Furniture	100.000		
6	Insuarance	245.000		
7	0	0		
8	Total in USD	2.756.250	Total in USD	2.756.250



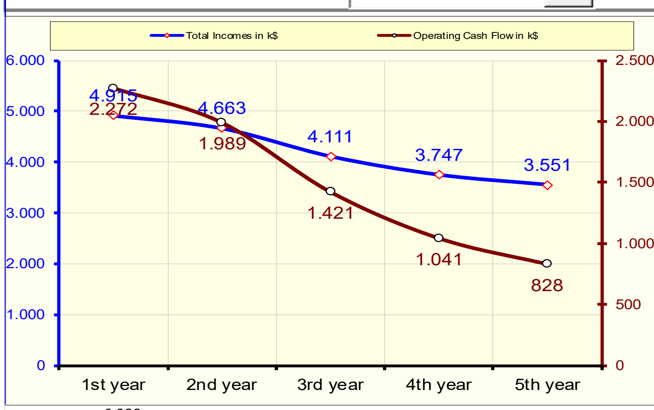
Performance indicators

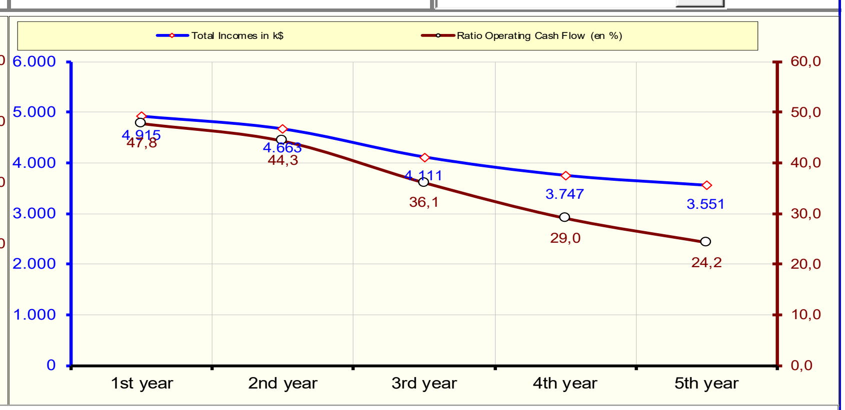
	Criterion	Réalisation
1	**Payback**	**1 years and 3 months**
2	**Internal Rate of Return of investment (%) 6 years**	**45,58%**
3	**Internal Rate of Return of investment (%) 15 years**	**46,29%**
4	**Internal Rate of Return of investment (%) 20 years**	**2,45%**
5	**Net Present Value "NPV" (k$) 6 years**	**$3.697.084**
6	**Net Present Value "NPV" (k$) 15 years**	**$3.339.656**
7	**Net Present Value "NPV" (k$) 20 years**	**$1.412.255**

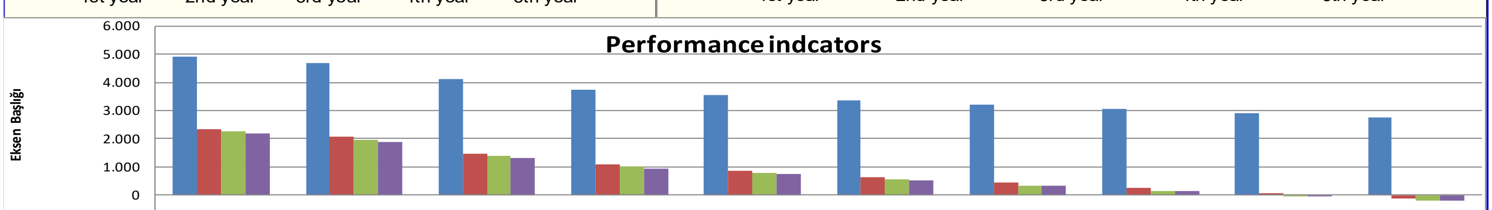
NB: Evaluation sur 5 ans

choose your criterion : Total Incomes

choose your criterion : Operating Cash Flow







	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Gross margin	4.915	4.663	4.111	3.747	3.551	3.368	3.197	3.037	2.887	2.747
EBITDA	2.349	2.067	1.483	1.087	859	643	439	245	61	-114

	Operating Account for 10 years										
	Description	7.200	7.143	6.714	6.312	5.933	5.577	5.242	4.928	4.632	4.354
	Unit Price :	Value in USD									
	Section	1.year	2. years	3. years	4. years	5. years	6. years	7. years	8. years	9. years	10. years
	Working Days in Year	300,00	298,00	296,00	294,00	292,00	290,00	288,00	286,00	284,00	282,00
	Capacity of Ethanol Plant (MT/Day)	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**	**30,00**
	Production Capacity (%)	80,00%	85,00%	95,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
	Annual Production Capacity (MT)	**7.200,00**	**7.599,00**	**8.436,00**	**8.820,00**	**8.760,00**	**8.700,00**	**8.640,00**	**8.580,00**	**8.520,00**	**8.460,00**
	By-Product DDGS Production (Mt)	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00	22,00
	Annual By-Product DGGS Production (Mt)	**6.600,00**	**6.204,00**	**5.831,76**	**5.481,85**	**5.152,94**	**4.843,77**	**4.553,14**	**4.279,95**	**4.023,15**	**3.781,77**
	By-Product Corn Distiller Production (Mt)	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	Annual By-Product Corn Distiller Production (Mt)	**300,00**	**282,00**	**265,08**	**249,18**	**234,22**	**220,17**	**206,96**	**194,54**	**182,87**	**171,90**
	Yearly Deficiency (%)	0,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%	6,00%
	Annual Ethanol Total Production (Mt)	**7.200**	**7143,06**	**6714,48**	**6311,61**	**5932,91**	**5576,94**	**5242,32**	**4927,78**	**4632,11**	**4354,19**
	Sales Price for Ethanol ($/Mt)	795,00	796,05	797,10	798,15	799,20	800,25	801,30	802,35	803,40	804,45
	By-Product DDGS Sales Price ($/Mt)	240,00	252,00	264,60	277,83	291,72	306,31	321,62	337,70	354,59	372,32
	By-Product Corn Distiller Sales Price ($/Mt)	510,00	535,50	562,28	590,39	619,91	650,90	683,45	717,62	753,50	791,18
	Annual Sales of Ethanol ($)	5.724.000,00	5.686.232,91	5.352.109,14	5.037.609,78	4.741.582,75	4.462.943,57	4.200.671,39	3.953.805,28	3.721.440,68	3.502.726,14
	Annual Sales of DDGS By-Product ($)	1.584.000,00	1.563.408,00	1.543.083,70	1.523.023,61	1.503.224,30	1.483.682,39	1.464.394,51	1.445.357,39	1.426.567,74	1.408.022,36
	Annual Sales of Corn Distiller By-Product ($)	153.000,00	151.011,00	149.047,86	147.110,23	145.197,80	143.310,23	141.447,20	139.608,38	137.793,47	136.002,16
	Annual Total Income from Sales ($)	**7.461.000,00**	**7.400.651,91**	**7.044.240,69**	**6.707.743,62**	**6.390.004,85**	**6.089.936,18**	**5.806.513,10**	**5.538.771,05**	**5.285.801,89**	**5.046.750,65**
	Feedstock Price ($/Mt)	170,00	173,40	176,87	180,41	184,01	187,69	191,45	195,28	199,18	203,17
	Annual Need of Molasses for Production (Mt)	14.976,00	15.786,16	16.584,76	16.410,18	15.425,57	14.500,04	13.630,03	12.812,23	12.043,50	11.320,89
	Annual Cost of Feedstock ($)	**2.545.920,00**	**2.737.320,59**	**2.933.312,75**	**2.960.484,49**	**2.838.512,53**	**2.721.565,81**	**2.609.437,30**	**2.501.928,48**	**2.398.849,03**	**2.300.016,45**
1	Revenue Before Tax	4.915.080,00	4.663.331,32	4.110.927,94	3.747.259,13	3.551.492,32	3.368.370,37	3.197.075,80	3.036.842,56	2.886.952,86	2.746.734,20
2	Total Incomes	4.915.080,00	4.663.331,32	4.110.927,94	3.747.259,13	3.551.492,32	3.368.370,37	3.197.075,80	3.036.842,56	2.886.952,86	2.746.734,20
	Chemical	297.000,00	302.940,00	308.998,80	315.178,78	321.482,35	327.912,00	334.470,24	341.159,64	347.982,84	354.942,49
	Utilities	363.525,00	368.370,68	373.296,29	378.304,32	383.395,29	388.570,72	393.832,18	399.181,28	404.619,64	410.148,92
	Electricity	77.000,00	78.540,00	80.110,80	81.713,02	83.347,28	85.014,22	86.714,51	88.448,80	90.217,77	92.022,13
	Water	10.000,00	10.200,00	10.404,00	10.612,08	10.824,32	11.040,81	11.261,62	11.486,86	11.716,59	11.950,93
	Steam	30.000,00	30.600,00	31.212,00	31.836,24	32.472,96	33.122,42	33.784,87	34.460,57	35.149,78	35.852,78
	Rent	60.000,00	61.200,00	62.424,00	63.672,48	64.945,93	66.244,85	67.569,75	68.921,14	70.299,56	71.705,55
	Repair & Maintenance	186.525,00	187.830,68	189.145,49	190.469,51	191.802,79	193.145,41	194.497,43	195.858,91	197.229,93	198.610,54
	Insurance	50.000,00	50.500,00	51.005,00	51.515,05	52.030,20	52.550,50	53.076,01	53.606,77	54.142,84	54.684,26
	Other Operational Expenses	120.000,00	122.400,00	124.848,00	127.344,96	129.891,86	132.489,70	135.139,49	137.842,28	140.599,13	143.411,11
	Marketing	120.000,00	122.400,00	124.848,00	127.344,96	129.891,86	132.489,70	135.139,49	137.842,28	140.599,13	143.411,11
12	**Expenditures**	**830.525,00**	**844.210,68**	**858.148,09**	**872.343,11**	**886.799,70**	**901.522,91**	**916.517,92**	**931.789,97**	**947.344,43**	**963.186,79**
13	Added Value	4.084.555,00	3.819.120,64	3.252.779,85	2.874.916,02	2.664.692,63	2.466.847,46	2.280.557,88	2.105.052,59	1.939.608,43	1.783.547,42
14	Salaries	1.735.200,00	1.752.552,00	1.770.077,52	1.787.778,30	1.805.656,08	1.823.712,64	1.841.949,77	1.860.369,26	1.878.972,96	1.897.762,69
15	**Operational Expenses**	**1.735.200,00**	**1.752.552,00**	**1.770.077,52**	**1.787.778,30**	**1.805.656,08**	**1.823.712,64**	**1.841.949,77**	**1.860.369,26**	**1.878.972,96**	**1.897.762,69**
16	EBITDA	2.349.355,00	2.066.568,64	1.482.702,33	1.087.137,73	859.036,55	643.134,82	438.608,12	244.683,33	60.635,47	- 114.215,27
18	Financial Expenses	77.175,00	77.175,00	61.740,00	46.305,00	30.870,00	15.435,00	-	-	-	-
17	Depreciation	91.625,00	91.625,00	91.625,00	91.625,00	91.625,00	91.625,00	91.625,00	91.625,00	91.625,00	91.625,00
19	**Structural Cost**	**168.800,00**	**168.800,00**	**153.365,00**	**137.930,00**	**122.495,00**	**107.060,00**	**91.625,00**	**91.625,00**	**91.625,00**	**91.625,00**
20	Gross Income	2.180.555,00	1.897.768,64	1.329.337,33	949.207,73	736.541,55	536.074,82	346.983,12	153.058,33	- 30.989,53	- 205.840,27
21	Operating Cash Flow	2.272.180,00	1.989.393,64	1.420.962,33	1.040.832,73	828.166,55	627.699,82	438.608,12	244.683,33	60.635,47	- 114.215,27
22	Cumulative Cash Flow	2.272.180,00	4.261.573,64	5.682.535,98	6.723.368,70	7.551.535,25	8.179.235,07	8.617.843,19	8.862.526,52	8.923.161,99	8.808.946,73

Finacial statement											
	Year N	Year N+1	Year N + 2	Year N + 3	Year N + 4	Year N + 5	Year N + 6	Year N + 7	Year N + 8	Year N + 9	Year N + 10
In k$											
Sales	4.915	4.663	4.111	3.747	3.551	3.368	3.197	3.037	2.887	2.747	2.616
WIP and finished goods inventories changes	0	0	0	0	0	0	0	0	0	0	0
Production	**4.915**	**4.663**	**4.111**	**3.747**	**3.551**	**3.368**	**3.197**	**3.037**	**2.887**	**2.747**	**2.616**
Cost of sales	0	0	0	0	0	0	0	0	0	0	0
Gross Margin	**4.915**	**4.663**	**4.111**	**3.747**	**3.551**	**3.368**	**3.197**	**3.037**	**2.887**	**2.747**	**2.616**
Operating expenses	831	844	858	872	887	902	917	932	947	963	979
Salaries & Wages	1.735	1.753	1.770	1.788	1.806	1.824	1.842	1.860	1.879	1.898	1.917
Taxes	0	0	0	0	0	0	0	0	0	0	0
Others operating income (add-backs)	0	0	0	0	0	0	0	0	0	0	0
(provisions on recievables and invetories)	0	0	0	0	0	0	0	0	0	0	0
Overheads	**2.566**	**2.597**	**2.628**	**2.660**	**2.692**	**2.725**	**2.758**	**2.792**	**2.826**	**2.861**	**2.896**
EBITDA	**2.349**	**2.067**	**1.483**	**1.087**	**859**	**643**	**439**	**245**	**61**	**-114**	**-281**
Depreciation of Assets	92	92	92	92	92	92	92	92	92	92	92
EBIT	**2.258**	**1.975**	**1.391**	**996**	**767**	**552**	**347**	**153**	**-31**	**-206**	**-372**
Financial expenses ST		0	0	0	0	0	0	0	0	0	0
Financial expenses LT	77	77	62	46	31	15	0	0	0	0	0
Financial income	0	0	0	0	0	0	0	0	0	0	0
Financial Result	77	77	62	46	31	15	0	0	0	0	0
EBT	**2.181**	**1.898**	**1.329**	**949**	**737**	**536**	**347**	**153**	**-31**	**-206**	**-372**
Exceptional income	0	0	0	0	0	0	0	0	0	0	0
Income Tax	0	0	0	0	0	0	0	0	0	0	0
Net income	**2.181**	**1.898**	**1.329**	**949**	**737**	**536**	**347**	**153**	**-31**	**-206**	**-372**
Key Financial Indicators as% of Sales											
Gross margin	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
EBITDA	48%	44%	36%	29%	24%	19%	14%	8%	2%	-4%	-11%
EBIT	46%	42%	34%	27%	22%	16%	11%	5%	-1%	-7%	-14%
Net income	44%	41%	32%	25%	21%	16%	11%	5%	-1%	-7%	-14%

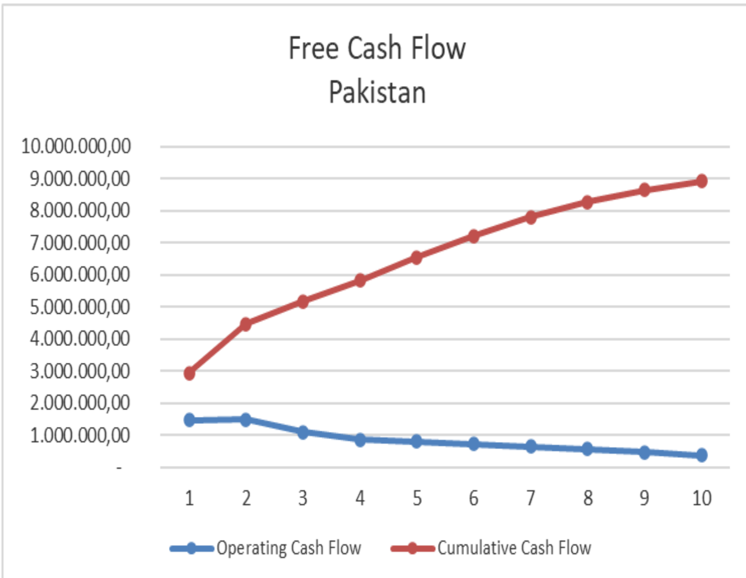
Repayment schedule

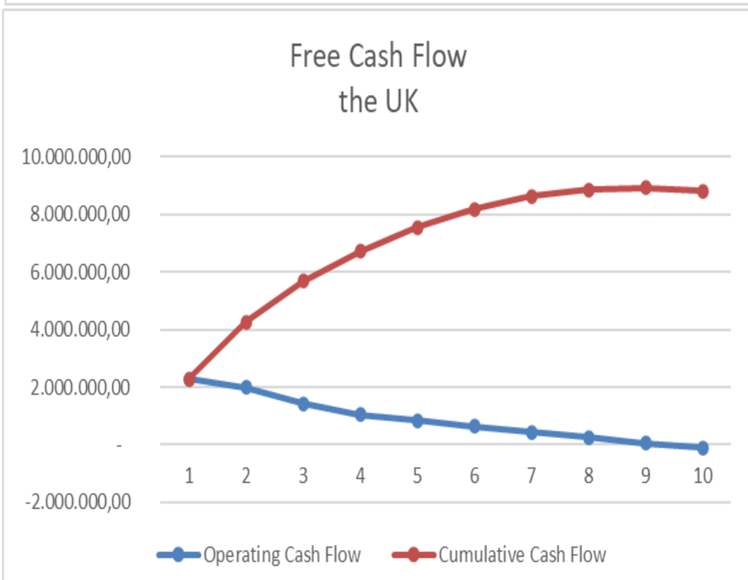
	Amount		1.929.375	Intrest	4%	MENU
	Term		7	Grace	2	
Date		Drawdown	Princ.	CAP. Resid.	Intrest	Total
1	st year	1.929.375	0	1.929.375	77.175	77.175
2	nd year	1.929.375	0	1.929.375	77.175	77.175
3	rd year	0	385.875	1.543.500	61.740	447.615
4	th year		385.875	1.157.625	46.305	432.180
5	th year		385.875	771.750	30.870	416.745
6	th year		385.875	385.875	15.435	401.310
7	th year		385.875	0	0	385.875
8	th year		0	0	0	0
9	th year		0	0	0	0
10	th year				0	0
			1.929.375		308.700	2.238.075

Depreciation

	Valeur	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Legal Expenses	61.250	0	0	0	0	0	0	0	0	0	0	0
Constructions	280.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
Equipment	1.100.000	27.500	27.500	27.500	27.500	27.500	27.500	27.500	27.500	27.500	27.500	27.500
Land Acquisition	970.000	48.500	48.500	48.500	48.500	48.500	48.500	48.500	48.500	48.500	48.500	48.500
Installation	100.000	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
Insuarance	245.000	6.125	6.125	6.125	6.125	6.125	6.125	6.125	6.125	6.125	6.125	6.125
0	0	0	0	0	0	0	0	0	0	0	0	0
Total Amortissement	2.756.250	91.625	91.625	91.625	91.625	91.625	91.625	91.625	91.625	91.625	91.625	91.625

Free cash-flows statement





Annex 26

PRICE SCHEDULE
30 KLPD ETHANOL PLANT

Sr No.	Description	FOB Mumbai Port Price in US $
	A. SUPPLY	
1.	Molasses storage & handling system	760,000/-
2.	Yeast propogation system	
3.	Fermentation section equipments	
4.	Multipressure distillation section	
5.	Condensor & coolers	
6.	Other equipments	
7.	Cooling tower	
8.	Air compressor	
	Total FOB Mumbai Port Price in US $	760,000/-
	Ocean freight insurance charges in US$	40,000/-
	Total CIF Price in US$	800,000/-

ANHYDROUS ALCOHOL SPECIFICATIONS

Sr. No.	Component	Unit	ENA Grade Limit
1.	Ethanol Content @ 15.6 deg C	% v/v	> 99.5
2.	Acidity as Acetic acid	ppm	10 Maximum
3.	Esters as Ethyl Acetate	ppm	10 Maximum
4.	Aldehydes as Acetaldehyde	ppm	10 Maximum
5.	Residue on Evaporation	ppm	5 Maximum
6.	Methanol	ppm	5 Maximum
7.	Butanol - 1	ppm	Nil
8.	Butanol - 2	ppm	Nil
9.	Iso-Butanol	ppm	5 Maximum
10.	N-Propanol & Iso-Propanol	ppm	5 Maximum
11.	Copper as Cu	ppm	0.3 Maximum
12.	Lead as Pb	ppm	0.05 Maximum
13.	Furfural	ppm	Nil

NO	ITEM	PRICE(USD)	PRICE (RMB TEN THOUSAND)	COMMENTS
1	equipments for molasses pretreatment work period	66271.2	39.1	
2	equipments for fermentation work period	341694.9	201.6	
3	equipment for diatillation work period	372881.4	220	
4	DCS controlling for all	305084.7	180	
5	pipes, valves, flange, bend etc	98305.1	58	
6	platform、ladder، pipes rack、cable rack	30508.5	18	
7	auxiliary material (welding rod、standard component etc)	59322.0	35	excluding oxygen ,ethyne, and electric charge
8	installation cost、commissioning cost (15 staffs×100 days)	139830.5	82.5	excluding accommdation and round-trip cost
9	freight to QINGDAO	13559.3	8	
	TOTAL PRICE(USD)	1427457.6	842.2	FOB QINGDAO

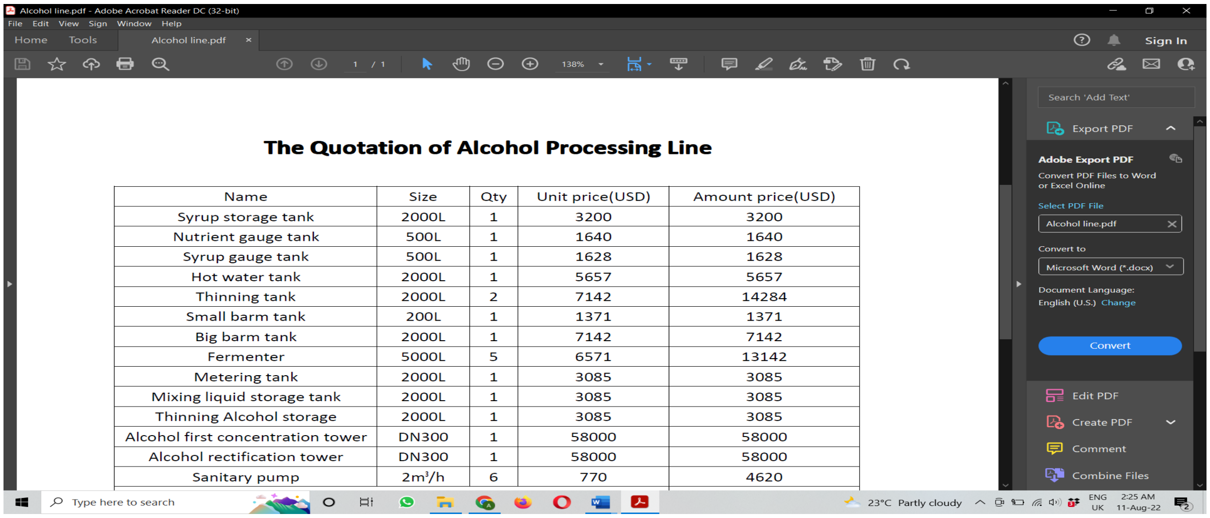
All period | distillation work period | Fermentation work period | Pretreatment work period

NO-1 Equipment List

Project Name: 30 t Per Day Super-grade Edible Ethanol Device Project with Corn as Feedstock

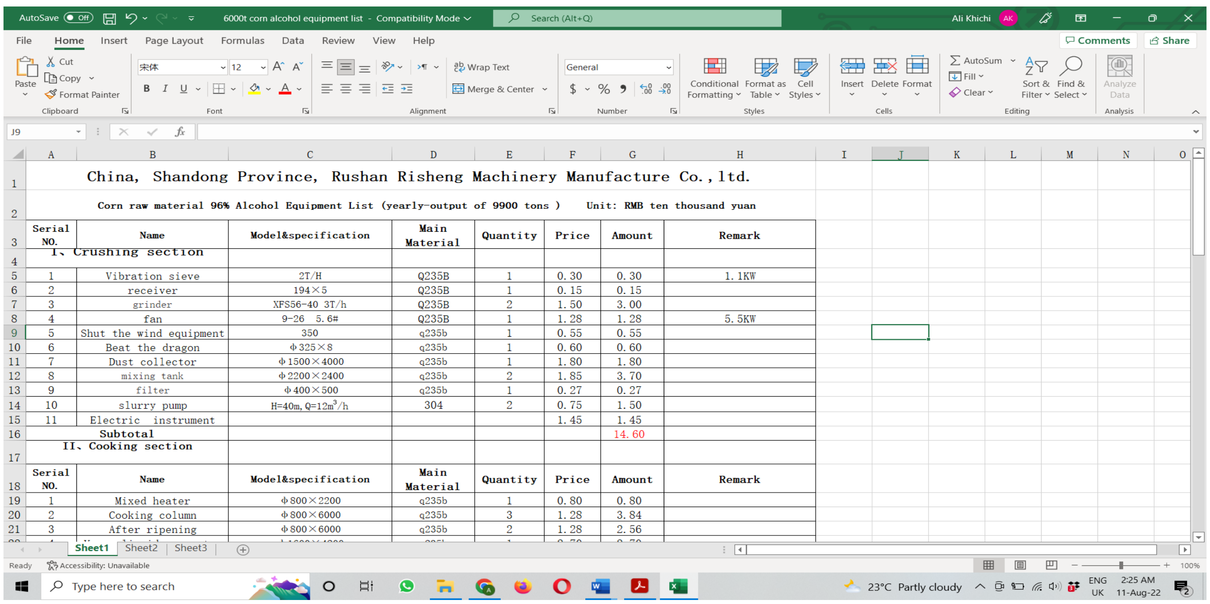
No	Equipment manufacture & purchasing: Equipment name	Equipment manufacture & purchasing: Specand Type	Material	Quantity
	Liquefaction + Saccharification Section			
	Equipment			
1	Material Mixing tank	DN1000x1500	SUS 304	1
2	Material mixing tank agitator		SUS 304	1
3	Pre-liquefying tank	DN1000x1500	SUS 304	1
4	Pre-liquefaction tank agitator		SUS 304	1
5	Keeping tank	DN100x60000	SUS 304	1
6	Liquefaction tank	DN1600x2500	SUS 304	1
7	Liquefaction tank agitator		SUS 304	1
8	Saccharification tank	DN1000x1500	SUS 304	1
9	Saccharification tank agitator		SUS 304	1
10	Reuse water tank	DN800x1000	SUS 304	1
11	Lye high level tank	DN400x500	SUS 304	1
12	Sulfuric acid high level tank	DN400x500	CS Q235-B	1
13	Liquefaction ejector	Q=3m3/h	SUS 304	1
14	Pre-liquefaction pump	Q=4m3/h H=50m	SUS 304	1
15	Liquefaction pump	Q=4m3/h H=40	SUS 304	1
16	Saccharification pump	Q=4m3/h H=50m	SUS 304	1
17	Liquefied mash cooler	FN=8m2	SUS 304	1

Sheet1 | Sheet2 | Sheet3



The Quotation of Alcohol Processing Line

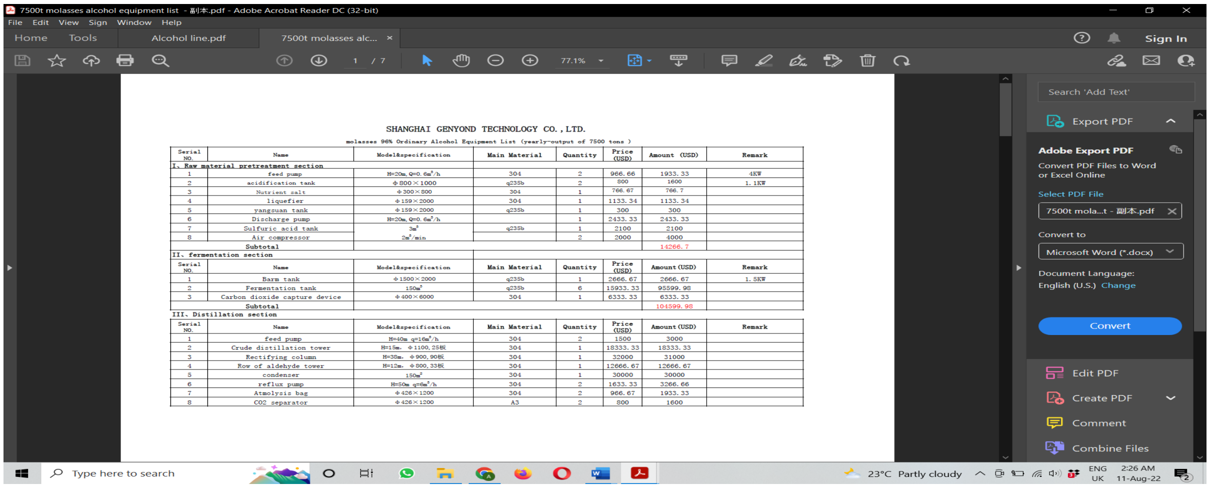
Name	Size	Qty	Unit price(USD)	Amount price(USD)
Syrup storage tank	2000L	1	3200	3200
Nutrient gauge tank	500L	1	1640	1640
Syrup gauge tank	500L	1	1628	1628
Hot water tank	2000L	1	5657	5657
Thinning tank	2000L	2	7142	14284
Small barm tank	200L	1	1371	1371
Big barm tank	2000L	1	7142	7142
Fermenter	5000L	5	6571	13142
Metering tank	2000L	1	3085	3085
Mixing liquid storage tank	2000L	1	3085	3085
Thinning Alcohol storage	2000L	1	3085	3085
Alcohol first concentration tower	DN300	1	58000	58000
Alcohol rectification tower	DN300	1	58000	58000
Sanitary pump	$2m^3/h$	6	770	4620



China, Shandong Province, Rushan Risheng Machinery Manufacture Co., ltd.

Corn raw material 96% Alcohol Equipment List (yearly-output of 9900 tons) Unit: RMB ten thousand yuan

Serial NO.	Name	Model&specification	Main Material	Quantity	Price	Amount	Remark
I、Crushing section							
1	Vibration sieve	2T/H	Q235B	1	0.30	0.30	1.1KW
2	receiver	194×5	Q235B	1	0.15	0.15	
3	grinder	XFS56-40 3T/h	Q235B	2	1.50	3.00	
4	fan	9-26 5.6#	Q235B	1	1.28	1.28	5.5KW
5	Shut the wind equipment	350	q235b	1	0.55	0.55	
6	Beat the dragon	Φ325×8	q235b	1	0.60	0.60	
7	Dust collector	Φ1500×4000	q235b	1	1.80	1.80	
8	mixing tank	Φ2200×2400	q235b	2	1.85	3.70	
9	filter	Φ400×500	q235b	1	0.27	0.27	
10	slurry pump	H=40m, $Q=12m^3/h$	304	2	0.75	1.50	
11	Electric instrument				1.45	1.45	
Subtotal						14.60	
II、Cooking section							
Serial NO.	Name	Model&specification	Main Material	Quantity	Price	Amount	Remark
1	Mixed heater	Φ800×2200	q235b	1	0.80	0.80	
2	Cooking column	Φ800×6000	q235b	3	1.28	3.84	
3	After ripening	Φ800×6000	q235b	2	1.28	2.56	



SHANGHAI GENYOND TECHNOLOGY CO., LTD.

molasses 96% Ordinary Alcohol Equipment List (yearly-output of 7500 tons)

Serial NO.	Name	Model&specification	Main Material	Quantity	Price (USD)	Amount (USD)	Remark
I、Raw material pretreatment section							
1	feed pump	H=20m, Q=0.6m³/h	304	2	966.66	1933.33	4KW
2	acidification tank	Φ800×1000	q235b	2	800	1600	1.1KW
3	Nutrient salt	Φ300×800	304	1	766.67	766.7	
4	liquefier	Φ159×2000	304	1	1133.34	1133.34	
5	yangsuan tank	Φ159×2000	q235b	1	300	300	
6	Discharge pump	H=20m, Q=0.6m³/h		1	2433.33	2433.33	
7	Sulfuric acid tank	3m³	q235b	1	2100	2100	
8	Air compressor	2m³/min		2	2000	4000	
Subtotal						14266.7	
II、fermentation section							
Serial NO.	Name	Model&specification	Main Material	Quantity	Price (USD)	Amount (USD)	Remark
1	Barm tank	Φ1500×2000	q235b	1	2666.67	2666.67	1.5KW
2	Fermentation tank	150m³	q235b	6	15933.33	95599.98	
3	Carbon dioxide capture device	Φ400×6000	304	1	6333.33	6333.33	
Subtotal						104599.98	
III、Distillation section							
Serial NO.	Name	Model&specification	Main Material	Quantity	Price (USD)	Amount (USD)	Remark
1	feed pump	H=40m q=16m³/h	304	2	1500	3000	
2	Crude distillation tower	H=15m, Φ1100, 25板	304	1	18333.33	18333.33	
3	Rectifying column	H=38m, Φ900, 90板	304	1	32000	31000	
4	Row of aldehyde tower	H=12m, Φ800, 33板	304	1	12666.67	12666.67	
5	condenser	150m²	304	1	30000	30000	
6	reflux pump	H=50m q=6m³/h	304	2	1633.33	3266.66	
7	Atmolysis bag	Φ426×1200	304	2	966.67	1933.33	
8	CO2 separator	Φ426×1200	A3	2	800	1600	