



Sugar Industry of Pakistan

Business Project - II

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Introduction

Sugarcane is the main source of sugar production in Pakistan and accounts for almost 99% of the total sugar produced in the country. Sugar is the primary sweetener used in most Pakistani beverages and soft drinks and is also used in bakery items, sweetmeats, confectionaries, as well as by the pharmaceutical industry. Per capita consumption of sugar in Pakistan stands close to 25 Kg/year which is highest among the developing countries. In terms of sugarcane production, Pakistan stands at No 5 in the world; whereas in terms of sugar production and consumption, we stand at No 8. However, when it comes to yield per hectare, we fall behind top 50 and according to some sources; we are No 60 in the world.

It is estimated that demand of sugar would grow at pace with the increase in population and is projected to be at around 2% per annum. With the present yield per hectare and percentage recovery from sugarcane crushed, within next 10 to 12 years, Pakistan is likely to run short of enough sugar for its internal requirements. To generate enough sugar, it would require considerable increase in cultivated area and yield per hectare. At the contrary, a recent study suggests that almost 65% of the farmers have reduced the area for cultivating sugarcane crop. There is ever growing confrontation between mill owners and farmers over the sugarcane price and lack of planning for water reservoirs points towards a possible water shortage in the future. Together, all these issues signal towards a big challenge for the sugar industry in the near future.

Aim

Aim of the project is to identify the reasons behind the present issues being faced by the sugar industry of Pakistan, evaluate the options of increasing sugarcane cultivated area vis-à-vis increasing per hectare yield, as well as other possible alternatives and give suitable recommendations to tackle the future challenges.

Scope

The project intends to cover following aspects within the framework:-

- ✚ Industrial landscape and performance parameters of sugar industry in Pakistan.
- ✚ Comparison of Pakistan in terms of sugar & sugarcane production with other countries of the world.

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- ✦ Identification of present problems and future challenges for the sugar industry using different management tools.
 - ✦ Evaluate the viability of possible options regarding increase in cultivated area and increasing per hectare yield of sugarcane in context of local climate and other factors.
 - ✦ Possibility of introducing beet as an input for sugar production.
 - ✦ Possibility of introducing other sweeteners as an alternative of cane sugar.
 - ✦ Giving viable recommendations to tackle the future challenges faced by the sugar industry of Pakistan.

Scheme of Research

To cover the scope of project in a systematic manner while keeping it simple and comprehensive, the work has been subdivided into four major sections. In **Section I**, industry statistics from various sources along with some management tools are utilized to analyze the industry performance and its competitiveness in comparison to other leading sugar producing countries. **Section II** covers the present challenges faced by the industry and few viable solutions to address those issues. **Section III** focuses on analysis of Sugar Beet as an alternative to sugarcane for sugar production while considering all the related pros and cons, and **Section IV** tries to identify alternate sweeteners to reduce reliance on sucrose or table sugar in context of the related health issues.

Section I – Analysis of Pakistan Sugar Industry

Pakistan Sugar Industry

In 1947 there were only two sugar mills in Pakistan; One at Rahwali, in Punjab and second in Takhat Bai, in Khyber Pakhtunkhwa province. Since then the industry has come a long way with steady progress and at present there are 84 mills in different provinces of the country including Azad Kashmir. The province wise distribution of these mills is as following:-

Region	No of Mills	Percentage of National Capacity
Punjab	44	52.38%
Sindh	32	38.10%
KPK	7	8.32%
Baluchistan	Nil	Nil
Azad Kashmir	1	1.20%
Total	84	100%

Source: Lahore Chamber of Commerce and Industry (LCCI)

The industry is ranked second in agricultural based industries of Pakistan after the Textile industry. The sugar sector makes significant contributions to the economy. Some important figures indicating contribution of industry to the national economy are as listed below:-

- ✚ Total value addition to the agricultural output by Sugar industry is about 3.2%.
- ✚ Total contribution to the GDP is about 0.7 %.
- ✚ The sector contributes close to 4.2% in national manufacturing output.
- ✚ There are around 1.5 Million people employed including skilled and non skilled workers, managers, engineers, financial experts etc.

Common Usage of Sugar

Sugar is the commonly used sweetener in traditional cuisine all over the country. Most of the population is used to the taste of sugar in the regular desserts and is fairly resistant to switching over to any other alternative. Other than its normal use in homemade desserts and use as a sweetener in homemade hot and cold beverages like tea, coffee, lassi etc, the sugar is also consumed heavily as an input in various other industrial made products. Few of the common uses of sugar are listed below:-

-
- ✚ Sugar is consumed heavily by the food and beverage industry.
 - ✚ Sugar is the main ingredient in most of the baking products.
 - ✚ All the products of confectionary industry rely heavily on sugar; including candies, traditional mithai, chocolates etc.
 - ✚ Sugar is also used in producing biscuits, jams and fruit juices.
 - ✚ Pakistan also has a sizeable cordial industry with prominent brands like Nuaras, Samarqand, Jam-e-Shirin, Roof Afza etc. The industry also depends solely on sugar as sweetener in these products.
 - ✚ The pharmaceutical industry also has a high demand for sugar for use mainly in syrups etc.

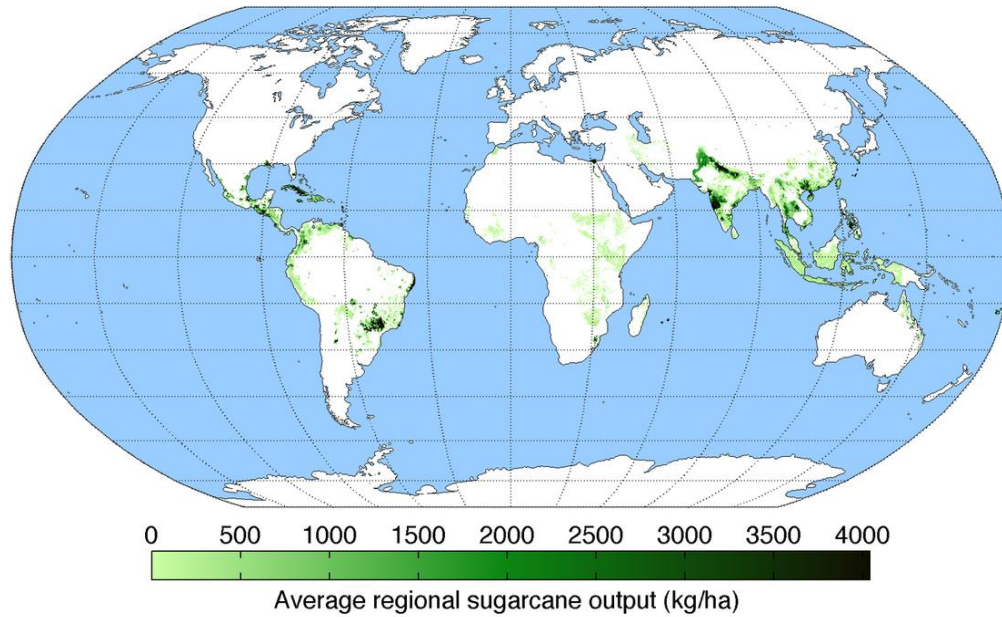
Sugarcane is the main source of producing sugar all over the world. In Pakistan also, the sugarcane amounts for almost 99% of the total sugar production; whereas the beet sugar amounts for a meager 1% of the total national production.

Pakistan and Sugar World

Before making any further deliberations, it is imperative to analyze where does Pakistan stand in terms of sugar and sugarcane production. In terms of average regional sugarcane output, following are the regions with significant sugarcane production:-

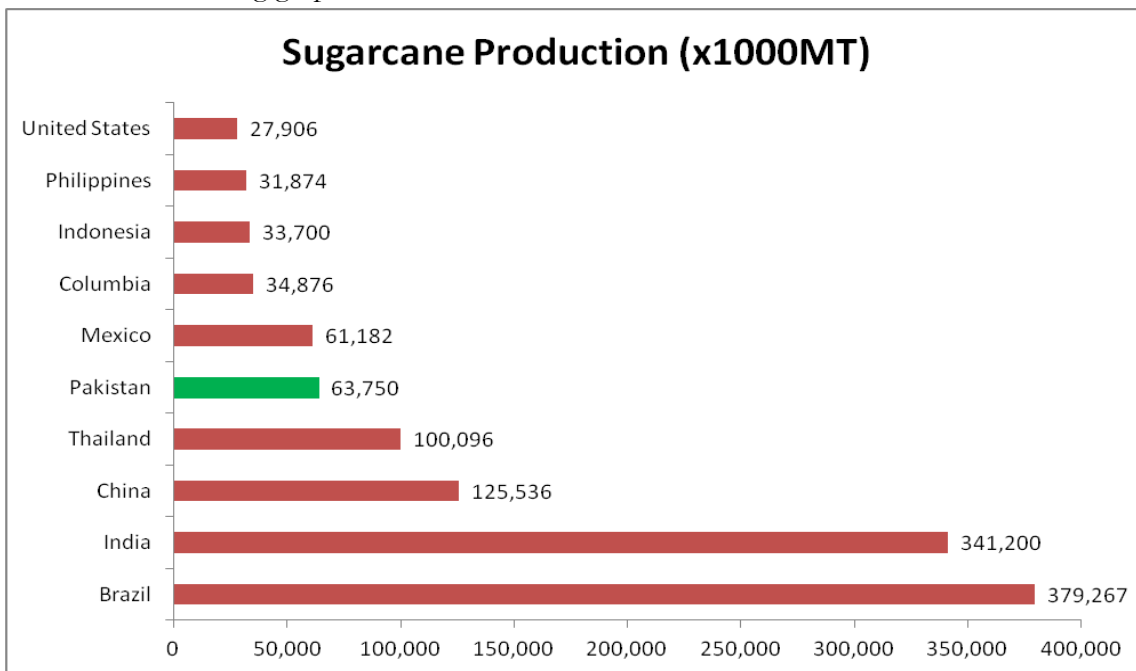
- ✚ Region comprising Mexico and Columbia.
- ✚ Latin American region comprising various parts of Brazil.
- ✚ The African region distributed over different African countries.
- ✚ South East Asian region comprising Pakistan, India and China.
- ✚ Far East region including Thailand, Indonesia, Malaysia and Brunei.

The regional output of sugarcane from these areas in terms of yield per hectare is shown in the following diagram.



Source: www.wikipedia.org

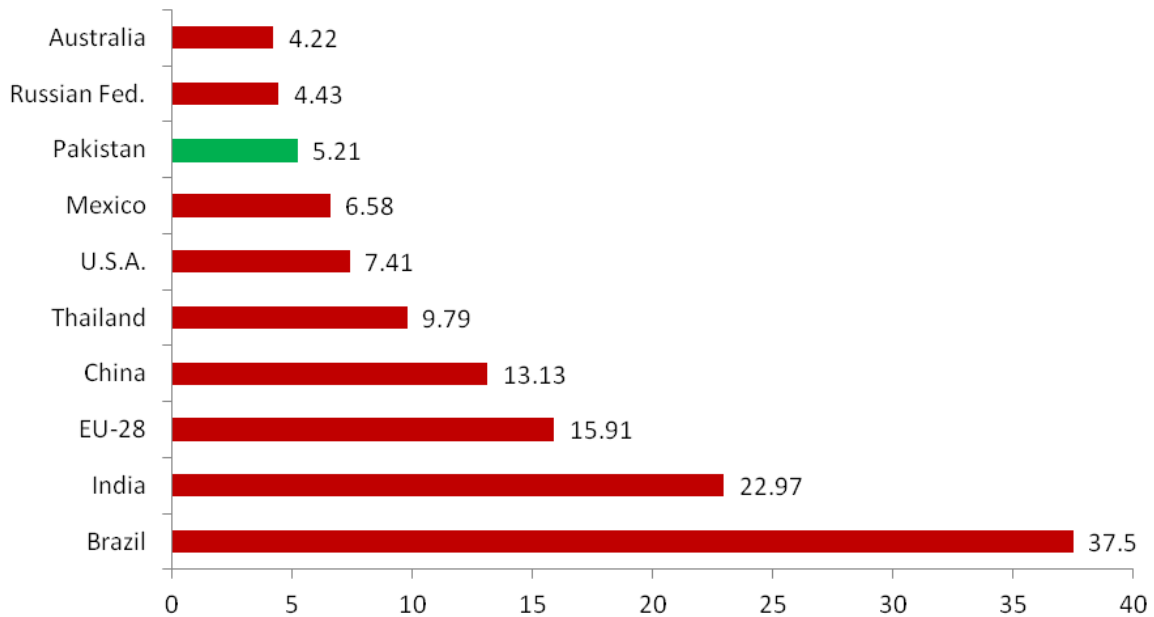
The total sugarcane production of 10 leading sugarcane producing countries of the world in 2013 is depicted in the following graph.



Source: Data from Wikipedia.org

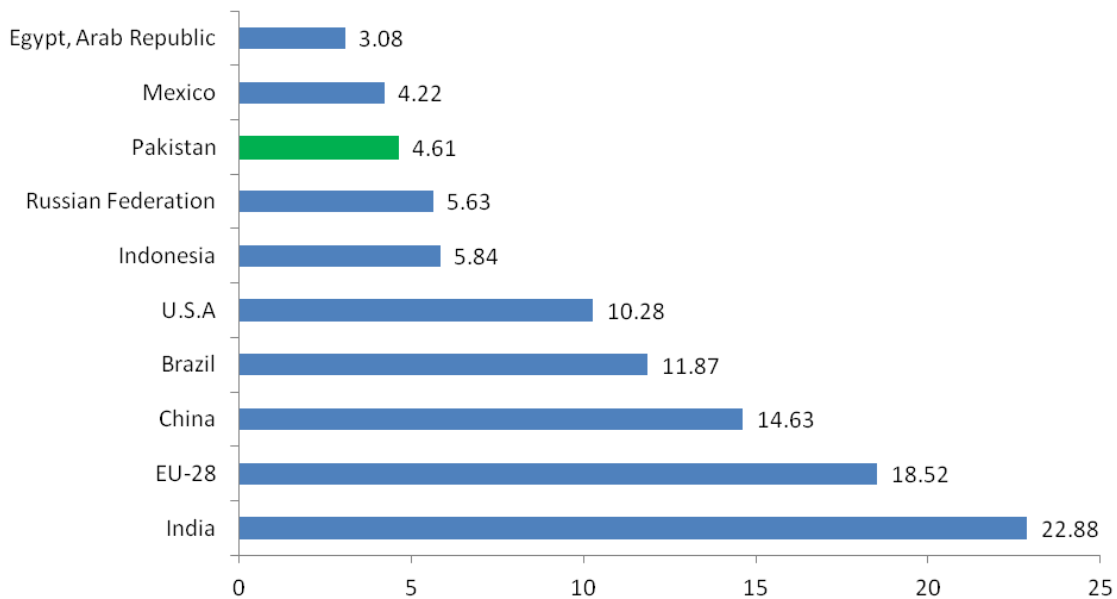
In terms of total sugarcane production we fall at No 5 in the world. The statistics of top 10 countries in terms of sugar production and consumption are shown in the following graphs.

Sugar Production MMT



Source: Data from Pakistan Sugar Mills Association

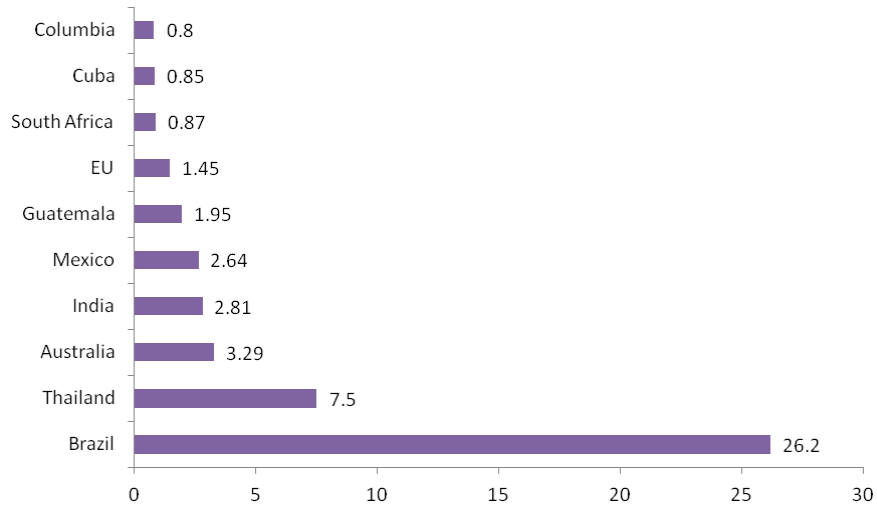
Sugar Consumption MMT



Source: Data from Pakistan Sugar Mills Association

Both in terms of production and consumption, Pakistan falls at No 8 in the world. Once we have a look at the top 10 sugar exporting countries of the world in 2013/14 as shown below, we find Pakistan nowhere in the list.

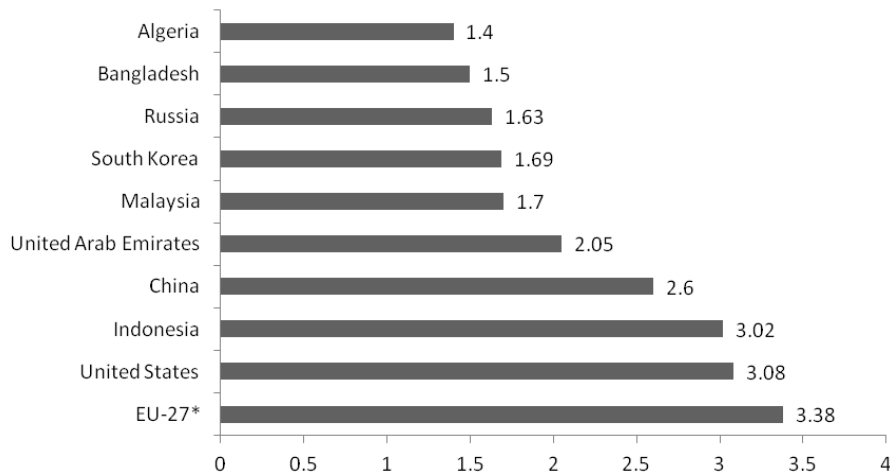
Sugar Export (MMT)



Source: <http://www.statista.com>

The following table represents the average sugar imports of leading sugar importing countries of the world. The figures represent the average yearly imports for the 5 year period between 2008/09 to 2012/13.

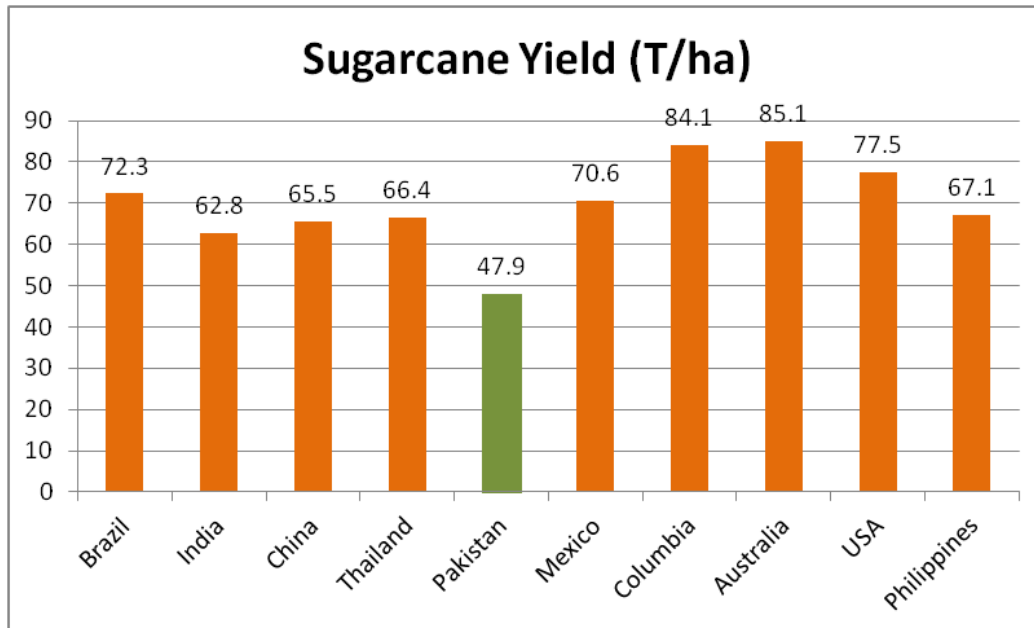
Average Sugar Imports (MMT)



*All 27 countries of European Union are considered one unit for the purpose of analysis.

Source: <http://americansugar.wpengine.netdna-cdn.com>

The area under cultivation, total sugarcane production and yield per hectare of the major sugarcane producing countries are given in **Exhibit 1**. Following graph shows a comparison of yield per hectare for top 10 producers of sugarcane.



*All figures from statistics of 2008-09
Source: <http://agridr.in>

It is important to note that although Pakistan is ranked No 5 in terms of total sugar production, the yield of sugarcane crop lags far behind other countries which are not even on the list in terms of total production. Examples are North African country of Sudan with an average yield of 78 tons/ha and South African country of Zambia with a yield of 115 tons/ha.

Sugarcane Crop in Pakistan

It is worth mentioning that although in Pakistan sugarcane accounts for 99% of the sugar production, globally the ratio of contribution by the sugarcane to overall sugar production is around 65%. Sugarcane is the major cash crop in Pakistan. Support price for the sugarcane by the government makes it even more preferable for the farmers which tend to prefer cultivation of sugarcane over other food crops of the season. It is therefore important to analyze the performance parameters related to the sugarcane crop in Pakistan over the Past few years to elaborate the industry dynamics.

Important agricultural crops of Pakistan are subdivided into three categories namely food crops, cash crops and fiber crops. Five major crops with maximum contribution to GDP are closely monitored by Pakistan Bureau of Statistics. Sugarcane is the most important cash crop of the country with almost 13% contribution to the total output of these five major crops. Statistics of the complete group and percentage contribution is as shown in the following table.

Crop		% Share	Total Share
Food Crops	Wheat	40.15	60.54
	Maize	8.30	
	Rice	12.09	
Cash Crop	Sugarcane	13.16	13.16
Fiber Crop	Cotton	26.30	26.30

Source: Pakistan Bureau of Statistics

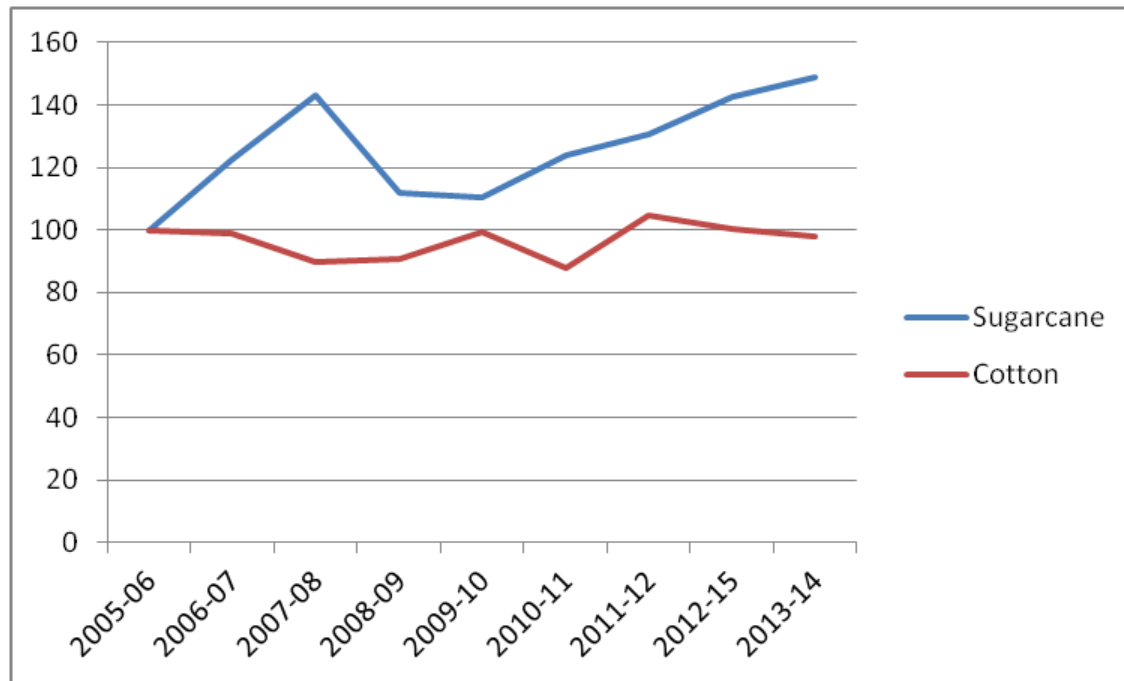
Index of Agricultural Production

Following table shows the index of agricultural production for these five major crops of Pakistan taking 2005-06 as the base year for comparison.

Fiscal Year	Wheat	Maize	Rice	Sugarcane	Cotton
2005-06	100.0	100.0	100.0	100.0	100.0
2006-07	109.5	99.3	98.0	122.6	98.7
2007-08	98.5	115.9	100.3	143.1	89.5
2008-09	113.0	115.5	125.3	112.0	90.8
2009-10	109.6	104.9	124.1	110.5	99.2
2010-11	118.5	119.2	87.0	123.8	88.0
2011-12	110.3	139.5	111.1	130.7	104.4
2012-15	113.8	135.7	99.8	142.7	100.1
2013-14	118.8	145.6	122.6	148.8	98.1

Source: Pakistan Bureau of Statistics

Following graph shows the comparison of sugarcane crop with cotton crop which in the major fiber (non food) crop of Pakistan. The graphs represent the fluctuations in crop production as compared to the crop of base year (2005-06) and give an idea about consistency of output.

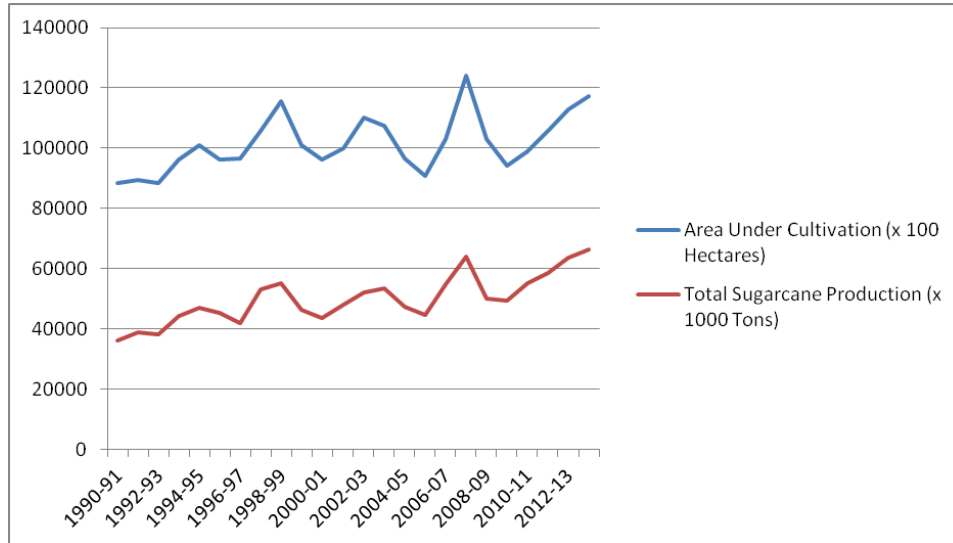


Source: Pakistan Bureau of Statistics

The graph shows a steady crop of cotton with little fluctuations over these years, whereas, in case of sugarcane, there are very prominent fluctuations. Although the output never decreased below the base year datum, however the large fluctuation up to a magnitude of 48% indicates inconsistency and unpredictability of this major cash crop in Pakistan.

Total Cultivated area for Sugarcane

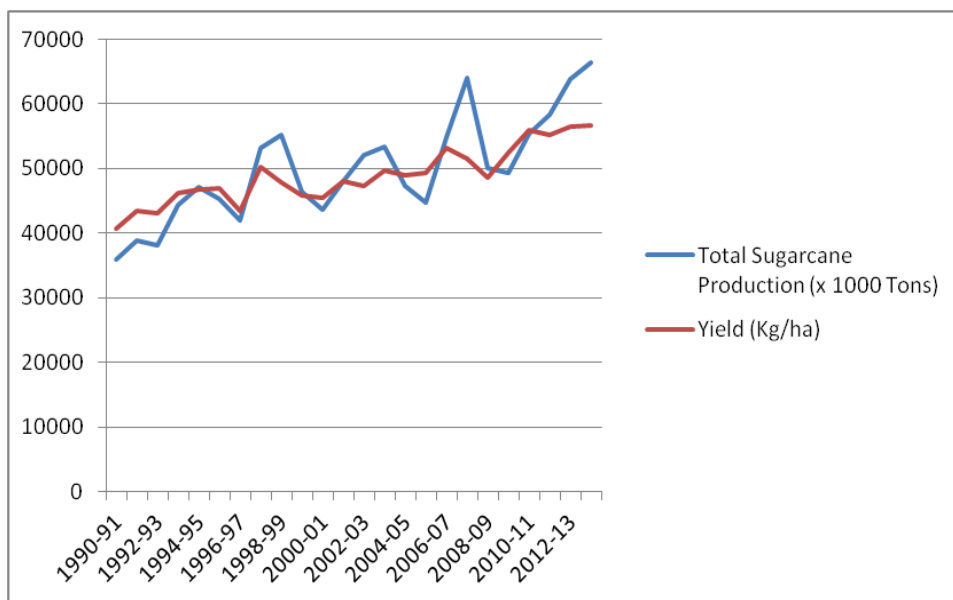
Total cultivated area for sugarcane, total sugarcane production and yield per hectare for Pakistan is given in **Exhibit 2**. The following graph shows comparison of total area under sugarcane cultivation and total sugarcane production in Pakistan from 1990 till 2013



Source: Data from Pakistan Bureau of Statistics

The graph highlights considerable fluctuations in area under cultivation which indicates high propensity of farmers to covert to other crops in response to government policies and other related factors. There is however an identical expression in the overall production in response to increase in area under cultivation.

Following graph represents the relationship between total production of sugarcane and yield per hectare during the same period.



Source: Data from Pakistan Bureau of Statistics

The graph represents a somewhat ambiguous relationship between total sugar production and the yield per hectare. The yield has however shown a steady increase in these years showing lesser fluctuations as compared to the total output.

Sugar Production in Pakistan

There are mainly three types of sugars commonly known and produced worldwide, namely raw sugar, brown sugar and white sugar.

Raw Sugar

Raw sugar is closest to the natural sugar and is produced by first extracting the juice of the input (sugarcane or sugar beet) and then mixing lime water to get desired pH balance to settle the impurities. The liquid is then reduced to get a solid mass and then put through a centrifuge to get the sugar crystals. Presence of molasses gives the sugar its signature light brown colour.

Brown Sugar

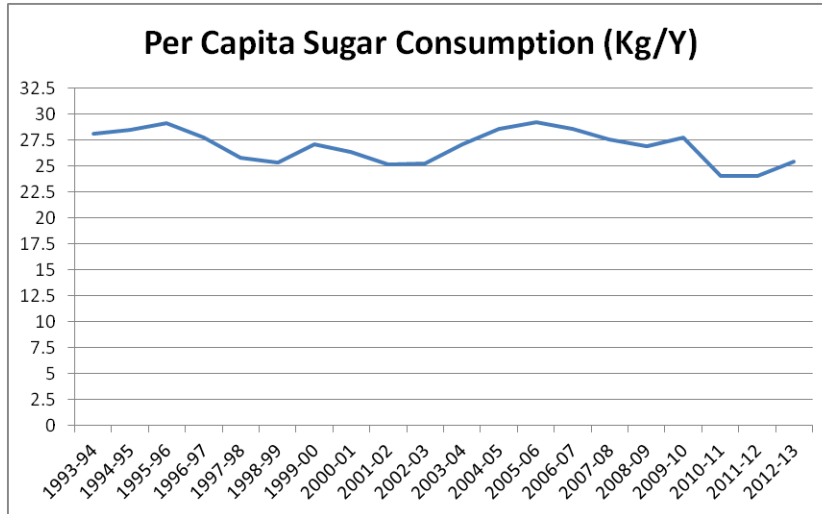
It is produced by mixing molasses syrup to the white refined sugar and then drying it again.

White Sugar

The white colour is achieved by adding Sulfur Dioxide to the juice to bleach it. The mixture thus does not turn brown and instead yield pure white crystals in the end. In addition, Phosphoric acid, carbon monoxide and calcium hydroxide are also used in the process at different stages.

Per Capita Sugar Consumption

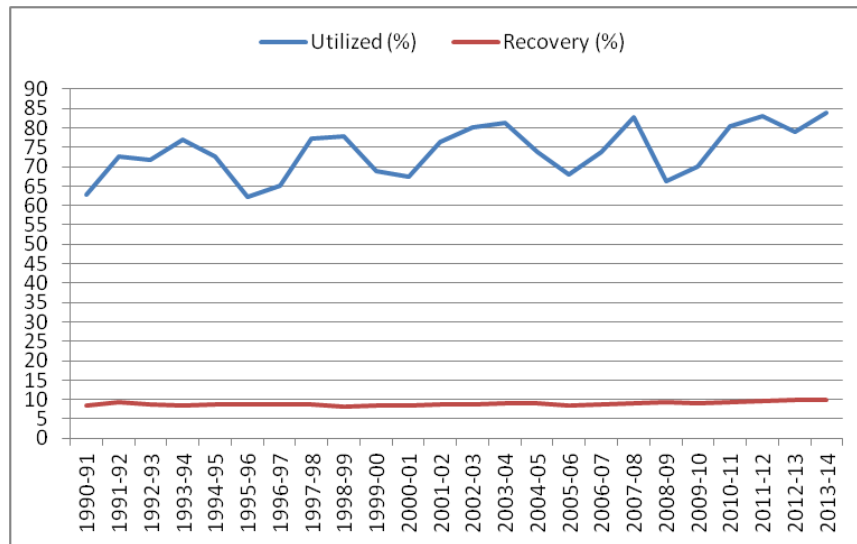
Yearly sugar production in Pakistan and per capita consumption of sugar is shown in **Exhibit 3**. The figures used are only for white sugar as production of raw sugar in the country is minimal due to very low demand; and for the last three years, no raw sugar has been produced in the country. Following graph shows the consumption trend of sugar in Pakistan over the last two decades.



Source: Pakistan Sugar Mills Association

The per capita consumption of Pakistan for the last 20 years ranges between 26 to 28 Kg/ person/ year. The figure is one of the highest in the developing countries of the world. For a comparison, per capita sugar consumption of few of the countries of the world is given in **Exhibit 4**.

Quantity crushed by the mills as percentage of total sugarcane produced and percentage recovery from the total sugarcane crushed is given as **Exhibit 5**. The graphical representation shows considerable fluctuations in the percentage utilization of sugarcane by the mills and ranges between 62 and 85%.



Source: Pakistan Sugar Mills Association

Manipulation by the sugar mills to control the quantity of sugar in the open market to influence the price can be a possible reason. The recovery percentage has hovered between 8.5 to 10% during the period with very less variation.

The percentage of crop not utilized for sugar production accounts for post harvest losses, the seed production for coming season and also for Gur production; a sector which amounts to more than Rs 8 billion Gur production per annum in the country and is also highly criticized by the mill owners for restricting availability of sugarcane for sugar production by the mills.

Installed capacity

As per the Ministry of Food, Agriculture and Livestock (MINFAL) of Pakistan, total crushing capacity of installed sugar mills in the country is about 505,000 Metric Tons per day. With an average crushing season or 150 days, the total capacity comes out to be around 75 Million Metric Tons. During the last year season, only 56 MMT of sugarcane was crushed by the mills, which indicate 19 MMT of idle installed capacity. In terms of percentage this idle capacity amounts to around 26% excess installation. There are studies however which suggest the overall installed capacity is in excess of 40 – 50 % than the actual present requirement.

Buy Products of Sugar Production

The process of sugar production used in Pakistan produces mainly two buy products which are bagasse and molasses. Bagasse is the dry pulp of sugarcane after the juice has been extracted. It is mainly used as burning material within the mills and is generally in excess for the mills using sugarcane. There is limited possibility to convert this into further value adds. The mills using sugar beet yield beet pulp instead of bagasse which can also be dried and used for burning, but the process is expensive and quantity is never enough to self sustain the fuel requirements of the mill. The Molasses is the dark colour liquid which is left over after extraction of sugar crystals. This is the most valuable byproduct. It can be exported in raw form, can be used in animal fodder and can also be turned into a whole range of value adds.

Value Addition to Sugar byproducts in Pakistan

At present major value addition to the byproducts takes place in the following areas:-

- ✚ Molasses is used to produce ethanol, which can be mixed with fuel to increase engine efficiency and reduce pollution.
- ✚ Ethanol is also converted to different chemicals which are then used in following industries:-
 - Paints
 - Medicines
 - Explosives
 - Bio degradable plastics
- ✚ Bagasse is utilized in light chip board manufacturing and paper production.
- ✚ Bagasse also has potential to be used as fuel for electricity generation.

However the potential at present is highly underutilized and most of the byproducts are either consumed or exported without turning them into value added products.

Ownership Structure of Sugar Mills

The ownership of sugar mills in Pakistan is predominantly controlled by the political families. It is estimated that almost 50% of presently installed sugar mills are directly owned by politicians or their close family members; with many other mills having these politicians as major stock owners. Because of these influences the Pakistan Sugar Mills Association (PSMA) becomes as a very dominant and strong player in the overall dynamics of sugar industry in the country. The sugar industry in the country has been traditionally heavily regulated by the central as well as the provincial governments, and PSMA due to its political muscle has been repeatedly criticized for manipulating these regulations in its favour as well as creating artificial shortage of sugar in the country to manipulate the prices and getting undue profits at the expense of the consumers.

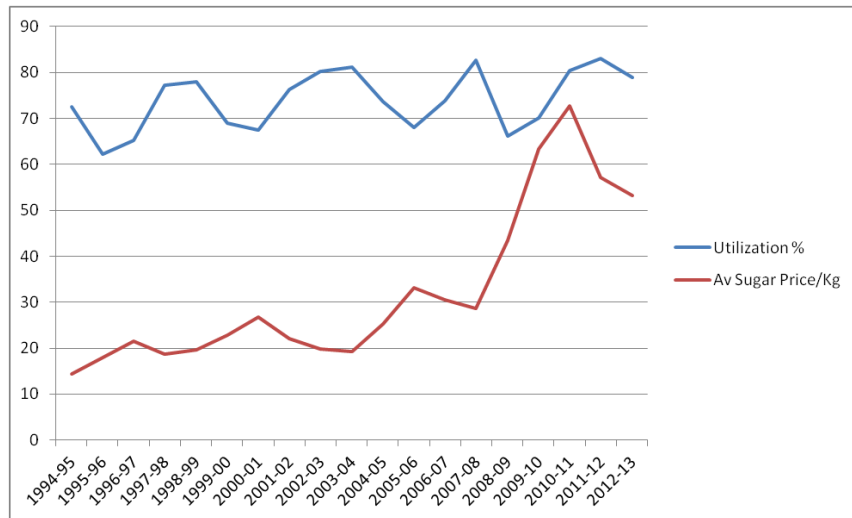
Dynamics of Sugar Industry in Pakistan

The government announces indicative price for the sugarcane at the beginning of the harvesting season to ensure a healthy return to the growers on the crop. The concept work like the support price and serves as a base point for the seasonal price of sugarcane per 40 Kg for the year.

The crop of sugarcane is perishable. Which mean it cannot be stored after harvest and therefore have to reach the mills within a couple of days or else it starts to rot slowly. The mill owners generally use delaying tactics with the farmers close to the harvesting season who cannot delay the harvesting beyond a certain point because of land requirement for the upcoming crops. Rotation crop in most of the cases is wheat which is also very sensitive to the timing of sowing in terms of yield per hectare. The farmers, especially the small scale ones suffer heavily as they are forced to sell the crop at lower prices and are de-motivated to cultivate the crop in the next season. This also works as a barrier in increasing the area under cultivation and there are studies which indicate that many farmers are switching their land for cultivating other crops and therefore offsetting efforts to increase the area under sugarcane cultivation. Moreover, farmers are not motivated to make efforts to cultivate better quality varieties of sugarcane which results in less sugar recovery percentage.

Government has also introduced a system of quality premium for the growers which require mill owners to pay a premium of 50 paisa per 40 Kg for every 0.1% of additional recovery of sugar above the benchmark figure of 8.7%. The basic premise for this is to incentivize the farmers to grow high quality sugarcane. However, the implementation of this also remains largely questionable as the amount due against quality premiums are generally held by the mill owners and paid after considerable delay to the farmers. Moreover, in my opinion, this rational of quality premium also act as a restraining factor for the mill owners who are not motivated to make efforts for increasing the quality of production process and increasing the recovery percentage. Comparison of Indicative/ Support price and the retail price per Kg is given as **Exhibit 6**.

Following graph gives a comparison of percentage of sugarcane crushed and the retail price Per Kg in the country.



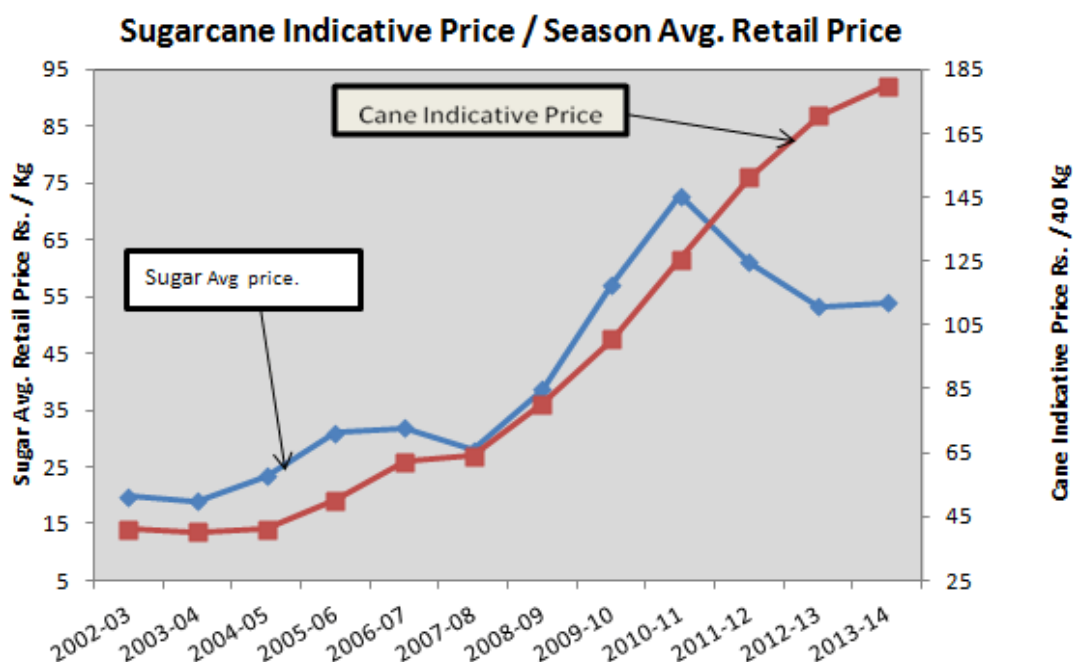
Source: Data from Pakistan Sugar Mills Association

Comparison of percentage consumed and the average retail price highlight an inverse relation between both variables. This gives a hint of manipulation by the sugar mills to create artificial shortage of sugar in the market to increase the demand of sugar and raise the price in the open market. Abnormal hike in price line in the year 2010 relates to the much talked sugar crises of the country which is also believed to be caused artificially through a collusion of sugar mills and other government officials. Other factors were also identified out of which acute shortage and abnormally high price of sugar in the international market was the most significant one and was effectively exploited by the sugar cult. The following graph shows price of refined sugar in the international market and supports the assumption for the period of 2010-2011.



Source: Pakistan Sugar Mills Association

However, there are positives as well. The following graph shows a comparison between the Indicative price announced by the government and the average retail price of the season.



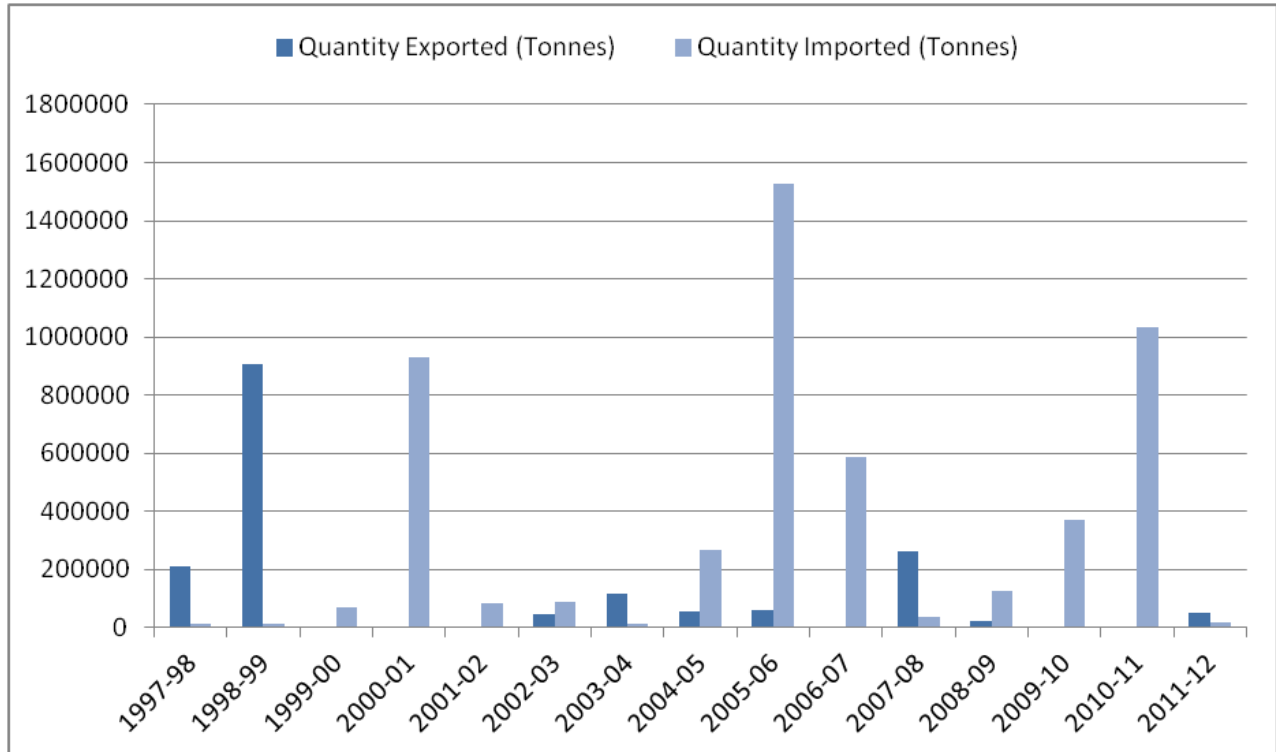
Source: Pakistan Sugar Mills Association

The graph shows a considerable reduction in the average retail price of the sugar despite increase in the indicative price. The reason behind was a good crop of sugarcane and excess sugar stock of around 1.0 Million Tonnes.

Role of Government

The government plays a very active part through various interventions to control the sugar availability in the open market at a reasonable price. Significant tools for intervention involve the announcement of support price/ indicative price, interventions by TCP by import of sugar and disembarassment at the right time, announcement of export policy to allow export of excess sugar and different subsidies to ease out pressure of price increase. Statistics of sugar imports and exports by Pakistan for the last 15 years are given in **Exhibit 7**.

Following graph shows a comparison of sugar exports and imports made by Pakistan during last 15 years.



Source: Overview of sugar industry in Pakistan (by LCCI)

The good production years with excess stocks result in considerable exports, whereas the years with shortage of sugar indicated heavy imports. At times sugar has to be imported in good production years as well to cater for shortage of supply due to over export and to maintain a balance between local demand and supply. However, whenever it happens, government is heavily criticized for the lack of governance, and the sugar has to be imported at a much higher price than the price it had been exported the same year.

Sugar Industry Performance at Present

As per the chairman PSMA, following are the statistics for the last year.

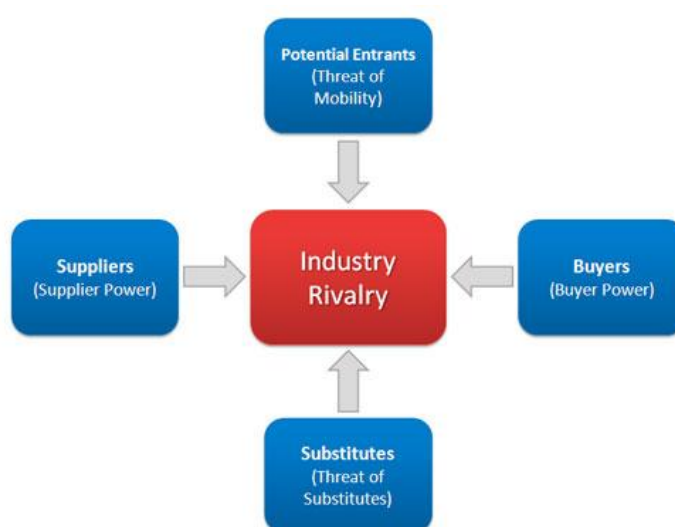
Total Sugar Produced	5.615 (Million Tonnes)
Carryover stocks (Mills & TCP)	0.844
Sugar availability for 2013-14	6.459
Availability for export	0.750
Domestic consumption 2013-14	4.512
Carry forward for 2014-15	1.197

Outlook for 2014-15

As per PSMA statistics, estimated area for sugarcane cultivation in the cycle of 2014-15 is estimated to be around 1.13 Million hectares. This shows a decrease of about 3.5% in total. At the provincial level, there is a decrease of 9.6% in Punjab and an increase of about 1% in Sindh. Total sugarcane production is estimated to be 64 Million tonnes, also showing a decrease of around 3.5%. With an estimated population of 191.79 million at an estimated per capita consumption of 24.6 Kg, total sugar consumption for the upcoming season is estimated to be 4.718 Million tonnes. However, in presence of excess stock in the country, the situation does not pose any immediate threat.

Analysis of Industry Competitiveness

Based on the available statistics the competitiveness of sugar industry can be analyzed using Porter Five Forces. The beet sugar and the related cultivation of beet sugar, being only 1% of the total industry is not considered while making these analyses.



Barriers to Entry (Threat of New Entrants)

The industry is heavily regulated by the government and political influence is predominant in the industry. The sugar mill installation requires a license from the government and is almost impossible to get without exercising a political muscle. The ownership is mostly with political families and moreover, PSMA also exercises its influence to protect the interests of mill owners. All these factors erect high barriers for entry of new players and make the threat of new entrants minimal. This factor at present is insignificant due to already over installed capacity which is estimated to be at least 25% in excess of the requires and is estimated to be 50% in excess by some studies.

Threat of Substitutes

The product is not at all differentiated which increase the threat of substitutes. However, local taste preference of the public which are used to the consumption of only refined white sugar makes the

demand of sugar highly inelastic and creates a strong barrier for switching to the other sweeteners as alternative.

Bargaining Power of Suppliers

The farmers producing sugarcane are the main suppliers of the industry. There are incentives provided by the government to promote more quantity of better quality sugarcane through support price and the quality premium, however, the implementation of these policies seems to fall well short of required. The mill owners due to their political background are generally able to use delay tactics prior to the purchasing and thus denying the farmers fair return on their investment. The farmers on the other hand are unable to delay the harvest of the perishable crop and land requirement for the subsequent crop and are forced to sell the crop at a lower price. In general, the bargaining power of the suppliers is fairly low and the protection of investor' rights emerges as a weak area.

Bargaining Power of Buyers

The buyers are less as compared to the growers, and have the capability to buy in large quantities. Political connections are frequently used to exploit the system weaknesses and circumventing the policies favouring the growers. In general, the bargaining power of the mill owners as the buyers is fairly high; not because of the product itself but because of the power it enjoys in policy making and undue protection provided by the politicians.

Competitive Rivalry

The competitors are equally balanced, the product is not differentiated and quality of product is not a concern. There are no switching costs involved both for the product as well as the production input. The installation of a sugar mill requires a huge capital investment.

All the above stated factors favours a high rivalry among the competitors, but yet again, due to the political cult and the government protection, the mill owners are able to form a sort of collusion among themselves and manipulate the industry in their favour; hence making the level of competitive rivalry among the main stake holders of the industry fairly low.

Experience Curve Analysis

The following table shows the sugarcane yield, percentage sugar recovery from the sugarcane crushed and sugar yield per hectare of cultivated land for major sugar producing countries.

Country	Cane yield (t/ha)	Sugar recovery (%)	Sugar yield (t/ha)
Australia	100.4	13.8	13.85
Egypt	110.8	11.5	12.74
Brazil	68.4	14.5	9.91
U.S.A.	80.2	11.7	9.38
Colombia	80.5	11.5	9.26
Mexico	79.5	11.6	9.22
India	66.9	9.9	6.62
Pakistan	50.3	9.2	4.63
World Avg.	64.4	10.6	6.82

Source: FAO Production Yearbook, 1998; Sugar and Sweetener, USDA, June 1997

In terms of yield per hectare we are at the bottom of the list of sugarcane growing countries. In terms of sugar recovery percentage, again we are at the lowest, though not very far from the world average. However in terms of sugar yield per hectare of cultivated sugarcane, Pakistan scores a meager 4.63 tonnes/ ha, which is way below the efficiency leader Australia. The data indicates that the industry, though producing a good amount of cane and the sugar but is not competitive enough to compete in international market.

If we look at the progress made by few of the countries in the same time frame, again we get a discouraging figure. Following table show comparison of progress made by few leading cane producers in terms of yield per hectare between years 1976 and 1996.

Countries	Yield in 1976 (t/ ha)	Yield in 1996 (t/ ha)	Change
Australia	81	97	16
China	31	52	21
Pakistan	36	46	10
India	51	72	21
Malaysia	35	68	33

Source: Fiji/Food & Agricultural Organization, 1997

The table clearly highlights very slow progress along the experience curve over a period of two decades as compared to other prominent figures. Not only the progress is slow, but those countries which were, at one time behind us in terms of yield per hectare, has left us far behind within these two decades. Country climate and soil conditions could become a barrier in increasing yield per hectare, which unfortunately is not true in case of Pakistan.

The following table shows the total country potential of Pakistan in terms of sugarcane production, percentage recovery, and sugar yield in tonnes/ hectare.

	Cane Yield (tons/ha)	Sugar Recovery (%)	Sugar Yield (tons/ ha)
Average	45.6	8.6	3.9
Potential	100	10.5	10.5

Source: Sugarcane Research & Development in Pakistan, by Dr Maqbool Akhtar (1998 figures)

The data represents an industry which is performing less than half of its true potential; and as the gap with its competitors is increasing, the chances to remain competitive are reducing and crisis of survival is gradually becoming more prominent.

SWOT Analysis

Based on the available data, SWOT can be used to analyze the sugar industry.

Strengths

- ✚ Over installed capacity.
- ✚ Considerable experience of sugar making.
- ✚ Less reliance on electricity and surplus availability of required fuel (Bagasse).

Weaknesses

- ✚ Non availability of enough sugarcane to utilize full capacity of sugar mills.
- ✚ High sensitivity of sugar crop to climatic/ environmental factors.
- ✚ Inability to add optimum value to the sugar byproducts.
- ✚ High reliance on sugarcane as input for sugar production.
- ✚ Use of inefficient techniques restricting output and recovery percentage.

Opportunities

- ✚ Possibility of converting byproducts to value adds, especially ethanol for export.

Threats

- ✚ High propensity of farmer to convert to other more profitable crops.
- ✚ Expected water shortage in the future for high delta sugarcane crop.



Section II – Present Challenges and their Solutions

Issues at Present

Overall, the analysis reveal a saturated industry, with at least 25% over installed capacity, weak protection of small investors and less competitive rivalry; and the situation is far from ideal. Few of the problems faced by the sugar industry of Pakistan viewed at the macro level are as following:-

Direct Subsidies

Government has a direct intervention policy in determination of sugar price by announcing indicative/ support price of the season. In other words, government gives direct subsidy on the output instead of giving indirect subsidy on the input materials. This direct subsidy though incentivizes the farmers to cultivate sugarcane to get better return on their investment, but on the other hand this restrict the market forces determine the equilibrium price of sugar in the open market. Rather, it restricts the farmers to adopt better techniques to increase per hectare production of the crop and don't let the experience curve economies to set in. The analyses of experience curve based on the available data also support this hypothesis.

To ensure enough sugarcane is produced to provide over installed capacity of sugar mills, the government have to increase support price of the sugarcane on regular basis, yet the area under cultivation has not been able to register significant increase during last two decades.

Moreover, the mills lying within the areas of low quality sugarcane production also pay the same support price as compared to the mills lying in high quality sugarcane production areas. This makes those mills difficult to compete on cost due to increased overheads.

Implementation of Policies

On the other hand, the implementation of support price policy is very weak, and small farmers invariably suffer. The mill owners due to their political influence are able to use delay tactics at the start of crushing season under the shadow of price negotiations. The farmers cannot delay harvesting due to requirement of land for other crops. The small farmers have limited financing and are generally hard pushed for credit pay back schedule suffer the most. Especially when the crop is harvested, the farmers are on the back foot. Due to inactive role of the government in ensuring payment of support price and delayed tactics played by the millers, the crop in transit start to lose its moisture content, or in other words, the recovery percentage. More delay mean even greater loss to

the grower who is ultimately pushed to sell the product at lesser price, have to forego the quality premium due to a dried up crop and is de-motivated to grow the crop in the next season. The millers on the other hand get the input raw material at a cheaper price, able to avoid the quality premium and also get more bagass (pulp) which can be used as the burning material in the mill as well as can be sold to the others. thus reducing the over head. The government off and on comes under pressure to increase the support price, and the cycle then repeats itself.

The quality premium which is actually introduced to incentivize the growers for producing better quality sugarcane is actually being exploited against them due to weak governance.

Ad-hoc Mechanism of Price Fixing and Ineffective Monitoring

The government is also highly criticized by all the stake holders (Farmers and millers) for not taking into account the production factors while fixing the sugar prices. Instead of doing proper research and cost analysis of the production factors, political point scoring remains the primary focus of this activity. Overall effect, as claimed by the millers is the eroding profit margins and financial difficulties causing problems in paying liabilities during the crushing season.

Even though the millers are able to fetch healthy profits without feeling any pressure for cost reduction, but due to non availability of reliable monitoring data, the government is not able to effectively negotiate and invariably have to bow to the demands of millers; thus resulting in a steady increase in support price.

Low Sugarcane Yield per Hectare

Despite being on No 5 in the world in terms of total sugarcane production, we fall nowhere in the list when it comes to yield per hectare. Following are few of the reasons for this low yield:-

- ✚ Improper land preparation before cultivation.
- ✚ Use of conventional methods for plantation.
- ✚ Late plantation.
- ✚ Early/ late harvesting.
- ✚ Poor control of weeds, pests and plant diseases.
- ✚ Use of low quality seed.
- ✚ Credit difficulties for buying pesticides and fertilizers.

Low Sugar Recovery Percentage

Sugar recovery per hectare is way below potential. Following are the prominent reasons behind this:-

- ✚ Use of sugarcane varieties with less sucrose content.
- ✚ Inability of the farmers to timely transport the crop to the factories.
- ✚ Reluctance to use advance technology to achieve process efficiencies.
- ✚ Delay tactics employed by the mill owners to avoid quality premium.

Fluctuation in Productivity

Being a high delta crop, sugarcane is highly sensitive to availability of irrigation water. Less rainfall creates water crisis and use of tube wells in that case increases the production cost making it non-viable to cultivate sugarcane. Moreover, being a Kharif crop, it coincides with the floods season and moving of earth due to floods also affects the yield seriously. Net result of these sensitivities is significant fluctuations in crop output with high level of uncertainty.

High Reliance on Sugarcane as Production Input

The industry solely relies on sugarcane crop as input for sugarcane production. It is estimated that 99% of total sugar produced in the country is made from sugarcane; whereas, beet sugar contributes to merely one percent of the total production. This high reliance, along with high sensitivity of sugarcane crop to the climatic/ environmental factors causes considerable fluctuations in annual figures and makes future forecasting difficult and unreliable.

De-zoning

Previously, the country was divided into different zones of sugarcane production areas. The sugarcane produced within the zone was not allowed to be taken outside the zone for commercial purposes and had to be utilized by the sugar mills located within that zone. Under the arrangement, mills used to loan money to the small farmers falling within the zone as an incentive to grow sugarcane and to help them use techniques and technology to develop better quality sugarcane and both could benefit as the sugarcane had to be utilized only within the zone. The arrangement however had some negatives as there were zones with excess production of better quality sugarcane and there were some zones with limited potential of production. It was difficult for the mills falling in low productivity zones to compete on equal terms. On the other hand it restricted the potential of farmers to get optimum price for their crop in free market. To provide equal opportunity to all the mills, the zones were abolished. This however had some cons as well. The growers have the

option to take their product to those who can offer them the best price, and mills can prolong their crushing season by having access to the sugarcane from other zones. But, the millers have no incentive now to lend money to the farmers in the vicinity as farmer is not bound to sell sugarcane to any particular mill; hence increasing already significant credit difficulties for the farmers.

Improper Management of Ratoon Crop

The sugarcane crop is harvested not once but number of times. After the first cropping of plant, the roots are allowed to stay in the soil which cause re-germination and give another crop. If looked after properly, the ratoon crop gives almost the same yield as of original crop. It is a normal practice to have 2-4 ratoon crops, and in few parts of the world, it goes even up to 8 crops.

Unfortunately, in Pakistan the ratoon crop, which amounts to about 50% of total output, is considered mostly a free crop and is therefore not given due importance. Due to poor weed control and neglected management, we end up losing a significant amount of output every year.

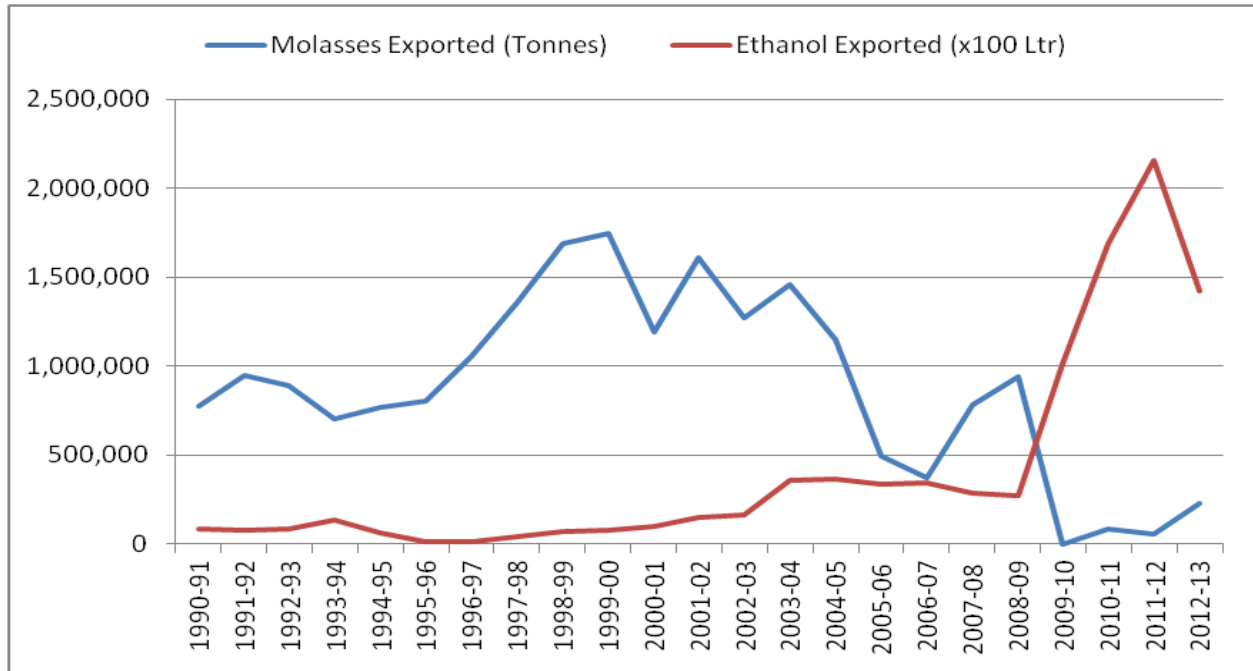
Under Developed Infrastructure of Roads

Road network is under developed especially in the rural areas which make it difficult for the farmers to timely/ economically transport the harvested crop to the sugar mills. Any delays cause the crop to lose moisture, which means low recovery percentage, and in other words, loss of quality premium to the growers.

Under Utilization of By-products

The two major by-products of sugar production, bagasse and molasses both have a potential to be converted to a range of value added products; with ethanol being the most important and valuable of them all. However, at present major chunk of these by-products is not being converted to value adds. Out of 84 sugar mills, only 19 reported to have installed distilleries for converting molasses into ethanol. Rest of the molasses is either sold to local chemical industry or exported in raw form. The distilleries are operating at 60% of their installed capacity and only 6 have the capacity of producing fuel grade ethanol. Molasses to ethanol ratio is 5:1 which gives a yield of approximately 20%. Cost of production however varies depending on the type of technique used and quality of molasses used.

Statistics of molasses production, export of molasses and export of fermentation ethyl alcohol (ethanol) are shown in **Exhibit 8 , 9 and 10 respectively**. With a trend in installation of distilleries by the sugar mills, the export of raw molasses has taken a significant dip since 2010 and the export of ethanol has picked up significantly, as shown in the following graph.



Source: Data from Pakistan Sugar Mills Association

However, still it is estimated that potential of converting raw molasses into ethanol worth millions of rupees is still untapped. By adding value to the waste/ by-products, the millers can reduce their overheads thus increasing the competitiveness of the industry and price of the sugar can be kept at an acceptable limit. Instead, at present they don't find enough incentives or are not bothered to do so. Ever increasing support price of sugarcane by the government is used as a plea by the millers to increase the price of sugar and there is hardly any pressure to compete on price.

Despite all these issues if we look at the past performance of the overall industry, we don't find many issues. Most of the issues highlighted above are related to the governance rather than resources or infrastructure. Pakistan is blessed with favourable land and climate and despite being at No 50 in the world in terms of yield per hectare; we fall within top ten countries of the world in terms of total sugarcane and sugar production. Installed crushing capacity of sugar mills is in excess by around 30-40% and there is no immediate requirement of huge capital investment for additional sugar mills. Beside some tough years and crises of 2010 resulting in abnormally high prices of sugar

in the open market, there had been no major crisis in the country. Although the industry is performing way below its true potential, it has been able to produce good enough sugar for the local needs most of the times. There had been considerable exports as well in good production years.

The Future Outlook

Although there are present issues which need to be fixed, the projection of the available figures in the near future highlights a major crisis waiting for the industry.

With a population of 185 Million people, with a per capita consumption of 26 Kg/ year, we consumed 4.813 million tons of sugar out of total production of 5.587 million tonnes. Total consumption was around 85% of total sugar production. Rest of the about .77 million tonnes are either available for export or they are used as a buffer stock. Recommended reserves of sugar to be maintained by Government is 1.0 million tonnes.

Within next ten years (by 2025), the population of Pakistan is expected to grow to an estimated 220 million. And with a projected per capita consumption of 28 Kg/ year, total consumption would increase to 6.16 million tonnes of sugar. Applying the same hypothesis of 85% consumption, the total production requirement would be 7.24 million tonnes. This would mean an additional production of 1.653 million tonnes. With an average recovery rate of 10%, this would require an additional sugarcane quantity of 16.53 million tonnes for crushing. And with an average utilization of 80% of the total production by the mills, this would mean a total increase of about 21 million tonnes in total sugarcane crop. Using the yield per hectare of year 2014 (56,660 Kg/ ha), there would be an additional requirement of about 370,000 hectares of land for cultivation and the present 1.173 million hectares would required to be increased to 1.543 million hectares (about 32% more). Keeping the cultivated area unchanged, the yield would require to be increased to 74,568 Kg/ ha from the present 56,660 Kg/ ha (32% more). In other words, either the cultivated area would have to be increased by 32%, or the yield would have to be increased by the same percentage.

Keeping in view the pattern of increase in these two factors in last two decades, both options seems very unlikely to materialize. Expected shortage of water due to mismanagement of water resources and reluctance to build new reservoirs due to political scoring; along with inherent vulnerability of crop the weather uncertainties and floods in going to make the situation even worse.

In addition government would have to draw a fine balance while announcing the support price of sugarcane in a bid to increase cultivated area, as a blind increase would create a miss match between international sugar price and the price of locally produced sugar.

Therefore, there is an immediate need not only to address the existing issues, but also to plan ahead to prepare ourselves for the difficult times in the near future.

The Way Forward

Based on the available data and analysis we can make out that the sugar industry of Pakistan is facing numerous challenges at present which needs to be addressed. However, there are even bigger challenges which lie ahead. After 10 years, Pakistan would require an additional 32% land under sugarcane cultivation if it continues to rely on sugarcane for sugar production. Keeping in view the previous trends cultivation and expected shortage of water in future, it wouldn't be an easy proposition. On the other hand, increasing yield by 32% within 10 years would mean coming almost at par with Brazil in terms of yield per hectare, which is the present world leader for sugar and sugarcane production. The real solution would obviously lie somewhere in between.

Provided sincere efforts are put in to increase the cultivated area, and increase the per hectare yield, of sugarcane, the total sugarcane production will still fall below the yearly local requirement and need would be there to look for substitute of sugarcane for the installed sugar mills which are already in excess. Moreover, in Pakistan sugar is the only sweetener known publically and consumed heavily in many forms. Elsewhere in the world, the story is bit different. There is definitely a need to explore possible sugar alternatives and educate the public about their health benefits. Less reliance on sugar as the only sweetener is also likely to produce some breathing space for high sugar demand in near future.

To tackle the challenges, a three prong strategy is recommended to be adopted simultaneously in following major areas:-

- ✚ Addressing the present issues of sugar industry, mainly in terms of sugarcane availability to the mills, increasing yield per hectare, and ensuring optimum utilization of byproducts through maximum value addition.
- ✚ Reducing reliance on sugarcane as sole input for sugar production.
- ✚ Looking for possible alternative of sugar as sweeteners and creating awareness in the public.

From here on the project is focused on providing possible options to address the areas highlighted above.

Addressing the Existing Issues

To address the existing issues of the sugar industry, following are recommended as short term measures:-

Indirect Subsidies

Instead of giving direct subsidies in form of support price on the product/ output, the government must consider giving indirect subsidies on input materials like seeds, fertilizers, pesticides and herbicides etc. This will incentivize the farmers to strive for better techniques and get more output hence increasing yield and also moving further on the experience curve.

Implementation of Policies

The government would have to play an active and sincere part for protection of farmer's rights in terms of ensuring timely procurement of the sugarcane by the sugar mills and the payment of quality premium. The true implementation of these policies would motivate the farmers to bring more area under sugarcane cultivation and will also accrue the true benefits of support price for both the industry as well as the farmers.

Effective Mechanism of Fixing Support Price

Government needs to evolve the methodology to set realistic support price at the start of the season keeping in view all the production factors like the prices of fertilizers, pesticides, and the weather/ rainfall pattern during the season etc. A combination of indirect subsidies and realistic support price putting a little pressure on the farmers to strive for better efficiency can work best in increasing the per hectare yield by motivating farmers to utilize the available resources most efficiently.

Increasing Sugarcane Yield per Hectare

There is a dire need to increase yield per hectare as we fall far behind the leading sugarcane producers. There are few major areas which need to be addressed in this regard.

Education/ Awareness of Farmers

The farmers need to be educated on the appropriate methods of land preparation, pest/ weed control, seed preparation and exact plantation time keeping in view the expected weather forecast for the season. For example, only by applying the deep plough in addition to the conventional

plough, the crop yield is reported to increase by about 14 percent. In addition, other techniques like laser land leveling, chisel plough, ridger, cultivator and rotavator etc have their own utilities. There are enough studies available on the subject and the tools/ techniques are available in the market (Details of tactical level are omitted to maintain the focus at macro level). What actually needed is to convey the benefits of these techniques as per their suitability and envisaged benefits to the less educated farmers of the rural areas. There are unlimited possibilities in exploiting print and electronic media in this regard; especially the radio.

Mobile Teams

Mobile teams sent by the government departments before the sowing season can play an effective role. The teams can collect the soil samples and latter can communicate the results and recommended use of fertilizers through mobile messaging or through email. This will especially benefit the small farmers which otherwise cannot reach the research facilities in far off cities.

Use of Better Quality Seed

As per a source person, the use of low quality seed is the single most important factor behind the low per hectare output. In most of the countries with higher yields, the seeds are specifically prepared and the seed crop is exclusively used for sowing. This provides better pest/ disease resistance and more output. However, in Pakistan, part of the crop from previous season is kept to be used as seeds for next season. Use of good quality seed of appropriate crop variety can help us increase the yield considerably. This will however, require an effective role by the government.

Pakistan is blessed with a long list of national agricultural universities (**Exhibit 11**). In addition to 15 dedicated universities, faculties for agricultural sciences are also working in various renowned universities of the country. Apart from these educational institutions, there is a long list of research facilities and laboratories working all over the country with capabilities specific to the crop generation and soil analysis. **Exhibit 12** provides list of R&D facilities related to crop research. Small R&D facilities available at the agriculture faculties of different universities are in addition to these independent laboratories. This excellent infrastructure can do the required job, and to some extent it is already doing as well. However, this sector requires more funding and incentives to exploit its true potential. Use of better quality seed of a variety with high sucrose content can also help solve the problem of low recovery percentage of crushed sugarcane.

Financing Facilities for Small Farmers

Educating farmers on techniques to increase yield would not be enough as they would require finance to utilize those expansive techniques. The provision of required capital to small farmers on easy terms can help the industry as a whole. For expensive equipment like laser land leveler, mechanical cultivator and sugarcane harvester, the machinery can be provided on lease to the farmers for short duration.

Intercropping

The experiments have been carried out with intercropping, a methodology of cultivating two or more crops in close vicinity for better economical output and optimum land utilization. The experiments of incorporating Barseen (fodder crop) and Wheat within ratoon cane crop has shown a reduction of 3.05% and 9.61% respectively, but at the same time the economical output of combined crop was far better than the single crop.

Intercropping with wheat can make it possible to achieve additional ratoon crops of sugarcane which at present farmers forego to make the land available for the wheat crop. This will however require use of special techniques, and use of special mechanized vehicles for harvesting separated crops; which means significant capital investment would be required to turn this concept into reality.

Improvement in Road Infrastructure

A better connectivity of the rural areas with the sugar mills through road network can make timely transportation of sugarcane to the mills and can motivate the farmers to bring additional land under cultivation.

Carbon Finance

Emission of green house gases, mainly Carbon Dioxide (CO₂) and Carbon Mono Oxide (CO) is gradually destroying the atmosphere and in resulting into global warming. In last 100 years, the average temperature of the planet is reported to have risen by 1.33 degrees. In 1997, the world has signed Kyoto protocol to limit the gas emissions. The protocol provokes the developed countries of the world to support finance in the developing countries in lieu of Certified Emission Reduction (CER). The finance thus raised is named as Carbon Finance. World Bank and other major financial institutions has already developed their terms and conditions for carbon finance, and India and China are believed to have raised finances up to \$7 billion and \$12 billion respectively in lieu of carbon finance.

By adding value to the by-products, the sugar industry can earn CERs and thus become eligible for carbon financing. 1 CER is roughly estimated to be equivalent to \$15. Total potential of Pakistan in terms of CER is estimated to be 8.65 million CERs per year which means a finance of about \$130 million per year. The move to convert by-products into value adds using carbon finance can solve the problem of huge capital investment and bring in additional revenues through export of value adds. Possible areas of value addition are discussed in following paragraphs.

Value Addition to the Sugar By-products

The two major by-products of sugar production from sugarcane are bagasse, or pulp left over after juice extraction, and molasses. Both have ample potential to be converted into value adds. This is particularly important as value addition can greatly help the mill owners to reduce their overhead costs and contribute to the national economy by creating additional jobs and saving foreign exchange which is wasted in importing these products. Additionally it can also help bringing stability in sugar prices. Possible areas for value addition for these buy products, which are mostly untapped in Pakistan, are discussed in following paragraphs.



Bagasse

For each 10 tonnes of crushed sugar, the mill produces about three tonnes of wet bagasse. The chemical analysis of a bagasse is as under:-

Cellulose	45–55%
Hemicellulose	20–25%
Lignin	18–24%
Ash	1–4%
Waxes	<1%

Cellulose is the fibrous material used in paper production. The paper produced form the bagasse is more environmental friendly as the source is easily renewable, and also reduces the waste of wood forests thus reducing the greenhouse effect.

Value Added Products of Bagasse

The cellulose content of bagasse can provide raw material for a wide range of products. Few of these are listed below:-

- ✚ Paper for writing.
- ✚ Tissue papers.
- ✚ Paper for newspaper printing.
- ✚ Paper cups, plates and boxes.
- ✚ Different types of lids.
- ✚ Chip board.
- ✚ Light building material.
- ✚ Different types of partitions.
- ✚ Ultra light weight composite boards.
- ✚ Soil erosion control mats.

Electricity Generation

The bagasse can also be used as a fuel in furnaces and is already used by the sugar mills as the heating material during sugar making process. The bagasse produced during crushing is however surplus and can also be used as a heating fuel for variety of purposes. As per a recent study, there is enough potential to generate about 2000 Megawatts of additional electricity within 1.5 to 2 years using bagasse. The electricity would however be available for only 3-4 months after beginning of crushing season and would require installation of energy efficient boilers at the mills.

At present most of the mills in Pakistan are operating inefficient 26 bar, low cost boilers, whereas electricity production would require installation of energy efficient 50 bar or above boilers to. Most of the sugar mills in India have already converted to efficient boilers of 50 bar plus.

Bagasse can also be used as a supplement fuel in co-generation. The example is Florida Crystals Corporation. Being among the largest sugar companies of Northern America, it runs a plant of 140 MW using bagasse and waste of urban wood, and produces enough electricity for its own use as well as for almost 60,000 households.

Fuel Pallets

The bagasse also has the potential to be converted into dense fuel pellets and research is already on the way to produce cost efficient dense fuel pellets using bagasse, capable of being used as a replacement of coal in furnaces.



The pellets could also be used as a portable, safe fuel to be used during camping etc.

Molasses

Molasses is the viscous byproduct of refining process during sugar making. The word is basically derived from “mel”, which in Portuguese and Latin means honey. The syrup is sweet with its typical taste and amount of molasses produced varies depending upon the process used, amount of sugar extracted and also the age of the sugarcane used. It has some amount



of left over sugars mostly sucrose, but also has glucose and fructose. It also contains traces of vitamins and is very rich in minerals including Calcium, Iron and Magnesium. For a very long time the molasses has been used as a food supplement, and also used heavily to supplement animal fodder; however, the introduction of ethanol as a fuel supplement for vehicles has created an entirely new use for molasses.

Ethanol

Molasses is the second major raw material used in the world for producing ethanol alongside corn. Up to 10% ethanol is mixed with regular fuel for normal use and can reduce the price of fuel by approximately 5-7 Rs/ Ltr. Besides this, it also helps decline of ever reducing world natural oil reserves. Up to 10% mixing does not require any engine alteration and due to its high octane value the engine runs cooler; increasing the vehicle performance and the carbon emission is also reduced by almost 35%.



Two main types of ethanol are:-

- ✚ Hydrous Ethanol (94-96% by volume)
- ✚ Anhydrous Ethanol – (Fuel Grade, 99% or more pure)

In Pakistan 19 sugar mills have already installed distilleries to produce sugar from molasses; and total investment amounts to around \$1 Billion. Worldwide, the export of anhydrous ethanol has increased by almost 250% within last 5 years. However, in Pakistan only 6 out of 19 distilleries have the capability to produce anhydrous fuel grade ethanol.

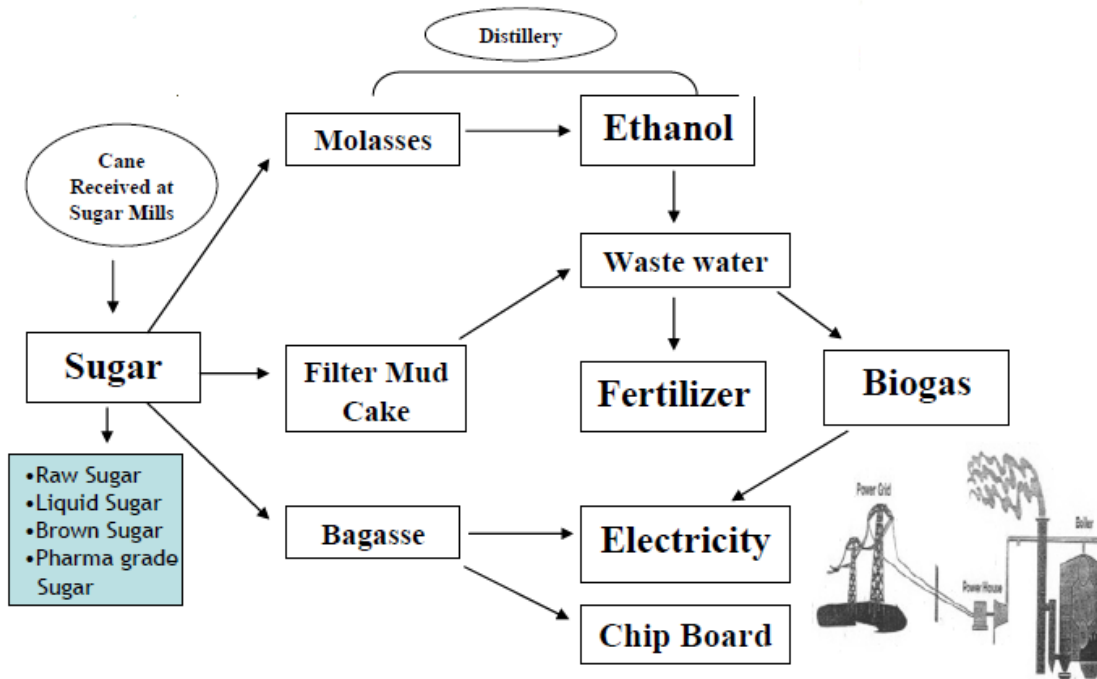
Other Byproducts of Distillation Process

The ethanol is not the only product which can be extracted from molasses. Following are few important products which can be extracted during the process:-

- ✚ Acetic Acid
- ✚ Other Alcohols
- ✚ Supplements for Animal Fodder
- ✚ Herbal Medicine
- ✚ Bio Degradable Plastics
- ✚ Ethyl Acetate Acid
- ✚ Xanthan Gum – A food thickening agent and stabilizer for cosmetic products

Moreover, the waste water produced during the distillation process is also used for production of fertilizers and production of biogas which can further be used as fuel for household use as well as for electricity production. Even the mud cake filtered during molasses production can be used as fertilizer and also as supplement to animal fodder.

The future outlook of sugar industry worldwide is of a zero waste industry where all the byproducts are converted into value adds. Following is a rough sketch of the complete process:-



Source: Dewan Mushtaq Group of Pakistan (Sugar Operations)

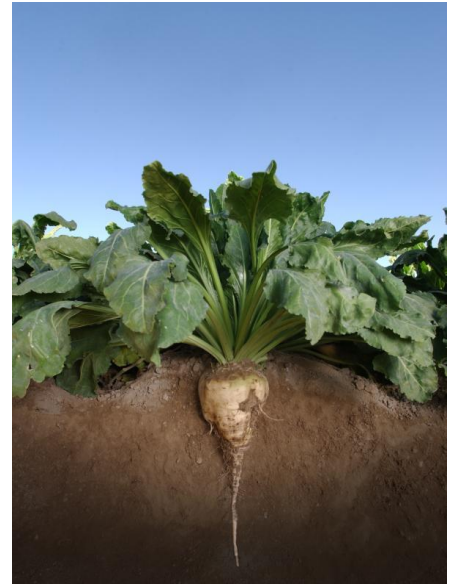
It is worth motioning that molasses produced from sugarcane and sugar beet has almost the same characteristics and can be used in exactly the similar way without any modifications to the distillery.

Section III – Analysis of Sugar Beet as an Alternative

Alternative Input Material for Sugar Mills

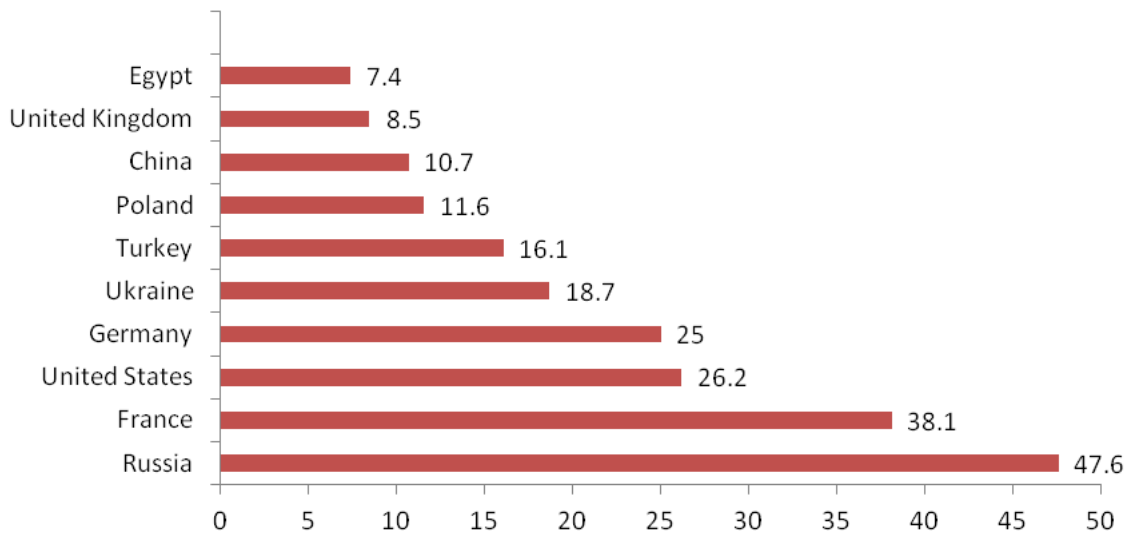
Provided we start our efforts today, the required increase in under cultivation area for sugarcane or increase in yield per hectare is likely to fall short of local a reservoirs, the situation is likely to get even worse. It is therefore imperative to find alternate resources to provide raw material for sugar production.

If we talk about sugar mills, the second most common crop used for sugar production worldwide is sugar beet. With the botanical name of Beta Vulgaris, this plant has a sucrose concentration stored in its roots which can be used to extract crystalline sugar.



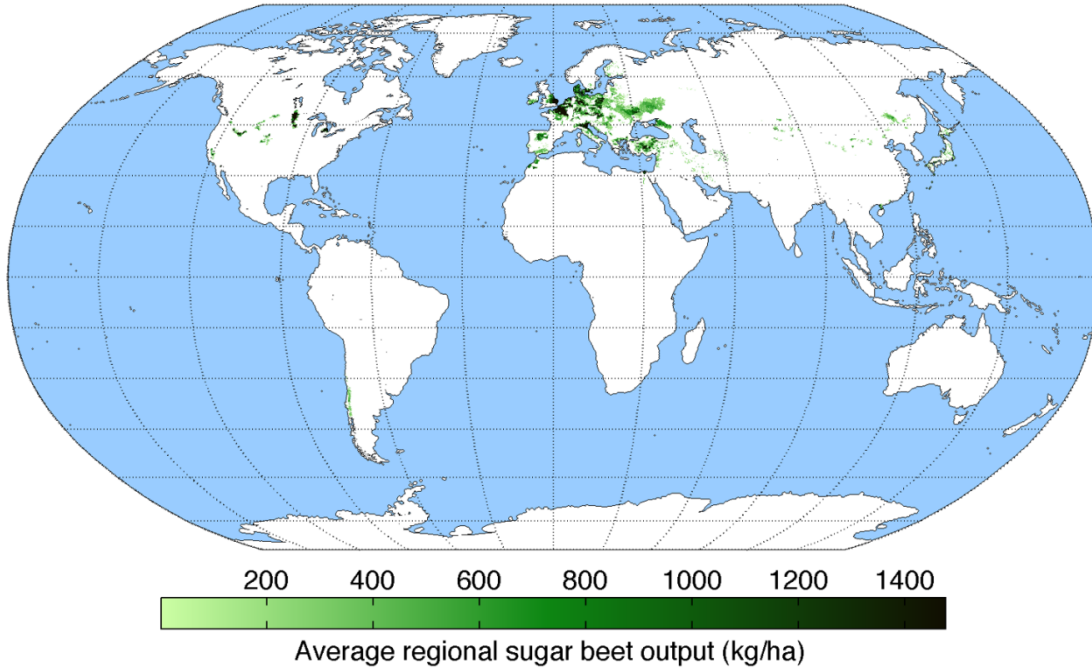
Top ten producers of sugar beet are as following:-

Beet Production (MMT)



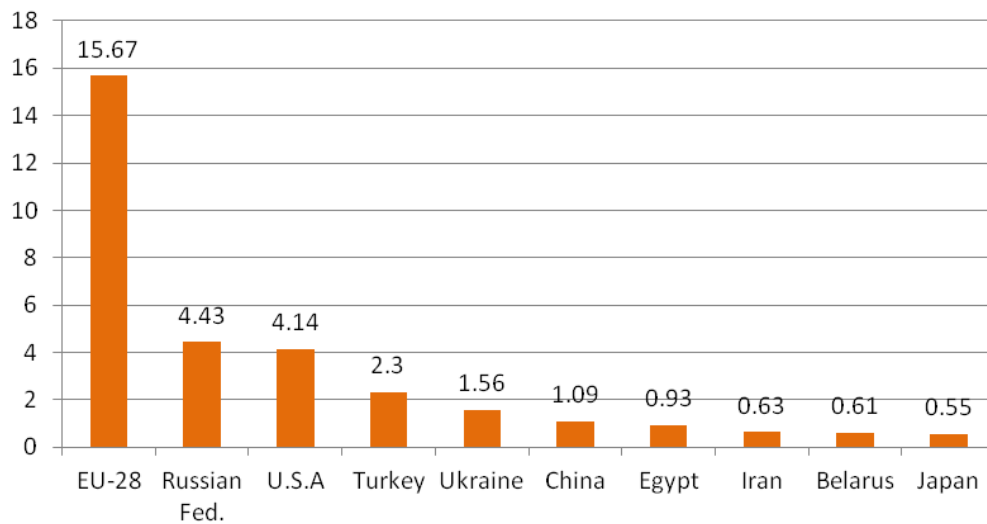
Source: Wikipedia.org (Figures for 2011)

Geographical representation of regional sugar beet output indicates a high concentration of beet producing areas in Europe. Russia clearly tops the list with France, Germany, Poland and Turkey contributing maximum from European region.



Top ten beet sugar producing countries are as under.

Beet Sugar (MMT)



Source: Data from Pakistan Sugar Mills Association

Although 28 countries of European Union are collectively the biggest producer of beet sugar, individually, USA and Turkey are on top of list. There are varying studies which suggest different percentage share of beet sugar in overall sugar production. However a rough estimate is that about 25% of total sugar produced worldwide is beet sugar.

In case of Pakistan, the story is altogether different. Beet sugar is only produced in Khyber Pakhtunkhwa. Last year the beet sugar produced in the country was a meager 0.49% of the total sugar produced. The statistics of beet sugar production in Khyber Pakhtunkhwa are given in **Exhibit 13**. In 1991 there were three mills capable of crushing sugar beet. The number went up to a maximum of four in 1993-94, but then started to decline. Last year only one mill crushed sugar beet for sugar production. The production of sugar from beet requires some modification in the conventional mill using sugarcane, as beets are first thinly sliced and then shaken through hot water to extract the sugar content. The end product, however in both the cases is crystalline sugar with no difference in taste or chemical properties. It is also possible to use both sugar beet and sugarcane in the same sugar mill. Factories of Khyber Pakhtunkhwa also have the provision of using sugarcane and countries like Egypt and Sudan also have dual purpose sugar mills.

Yield of sugar beet in KPK (whatever quantity is cultivated) hovers around 34 tonnes/ ha and again falls well short of world average yield of around 53 tonnes/ ha (66% of world average).

Few of the vital characteristics of sugar beet crop in comparison to sugar cane are as following:-

Character	Sugar Beet	Sugarcane
Duration (Months)	6-7	10-12
Brix Reading (Percentage of Soluble Solids in Juice)	23-24%	18-20%
Pol % (Percentage of Sucrose in Juice)	20-22%	13-16%
Sugar Recovery Potential	15-16%	11-12%
Average Sugar Recovery	10-12%	8-10%
Potential Yield (T/ha)	60-80	100
Water Requirement	120 cm	200 cm
Irrigation Required	1/3 of Sugarcane	Throughout Year

All these parameters present sugar beet as an idea choice for sugar production as an alternate/ supplement. The beet has higher sucrose content and gives a better recovery percentage.

Advantages of Sugar Beet

There are also some specific advantages of growing sugar beets which can make them a preferred choice over sugarcane:-

High Tolerance to Salinity

Sugar beet has a much higher tolerance of salinity and can be grown in land with PH value of up to 9.0. This can make it possible to use reclaimed land for beet cultivation which otherwise may not be used for any other crop.

Better Moisture Absorption and Less Evaporation

The roots of beet sugar grow down to up to 2 meters below the ground level. This not only makes it drought resistant but also opens the way of moisture for rotation crops hence improving their yield. Moreover, the sugar is stored in root rather than the stem resulting in less water evaporation and thus less number of irrigations is required as compared to sugarcane.

Better Quality of Molasses

Beet Molasses has the similar properties as of cane molasses and can be used in same distilleries to produce same products. In addition, the beet molasses is even clearer and thinner and can even be sprayed directly in to the fields as a fertilizer.

Easier Conversion to Animal Fodder

Beet pulp mixed with molasses can be converted to fodder pellets which can be used as a food supplement especially for milk producing animals.

Extended Crushing Season

Except two months of monsoon with extensive rains, the sugar beet can be cultivated throughout the year. The water requirement for this crop is already low as compared to sugarcane. The farmers who have continuous access to irrigation water can have an additional crop of sugar beet thus compensating for a slightly low yield than sugarcane. As per a rough estimate, by growing beets for sugar production, at least 10,000 cubic meters of water/ hectare can be saved, while producing more sugar.

It has been calculated that use of a combination of beet and sugarcane for sugar production can give an additional 90-110 days of running time to the sugar mills; thus increasing the crushing season from usual 4-5 months to even 10 months.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Heavy Rain Period												
Beet Growing Period												
Beet Harvesting	240 days											
Beet Drilling Period												
Cane Harvesting Period	150 days											
Extra Operating Time				90 days								

Downside of Sugar Beet

While the use of sugar beet on papers looks far more viable than sugarcane, yet there are two major challenges:-

Time availability after Harvesting

The sugar beet is far more delicate to handle than sugarcane. The crop has to reach the mill for slicing within 24-48 hours of harvesting or else the sugar content starts to reduce very rapidly. This simply means efficient methods of harvesting, very good coordination with sugar mills so the

harvested crop goes straight to the slicer, cultivation of sugar beet in close vicinity of the mill, quick means of transport to ensure no delays



in transit, and hence also a comprehensive road link between cultivated area and sugar mill. In fact most of the countries depending on sugar beet have the beet fields almost adjacent to the sugar mill; so close that both fall within the visual range of each other.

Moreover, like sugarcane the government also announces support price for sugar beet, and above mentioned factors makes need for ensuring implementation of government policies even more important in case of sugar beet.

Dependence on Alternate Energy

Each sugar mill requires significant amount of fuel to be used as a heat source in the process. The mills using sugarcane are self sufficient using bagasse which is used as a wood alternative for burning, and despite using comparatively inefficient boilers; enough is still left over as surplus.

The beet pulp can also be dried and then used for burning. However, the drying process is complex and time consuming, adding to the overhead cost and making it a less viable solution. Even if all the pulp is dried and used for burning, yet it wouldn't be sufficient to fulfill the requirement. The mills using beet are therefore dependent on other energy sources like coal, gas or furnace oil etc.

Way Forward for Beet Cultivation

The use of beet is a viable option and has many visible advantages alongside significant challenges. The concept however, needs initial push and patronage from the government using an appropriate mix of incentives and assurances to succeed. It is highly recommended to introduce sugar beet as an alternate sugar source in Pakistan; and following measures can help in making it successful:-

- ✚ A comprehensive beet development policy needs to be developed by the government. Incentives are to be given on inputs and raw material through indirect subsidies especially in the initial period.
- ✚ Mills converting to dual operations may be given incentives in forms of tax free import of required equipment and other tax incentives on production of beet sugar.
- ✚ Mills opting to covert to dual operations may be given credit facility on easy terms as an incentive.
- ✚ External energy sources like coal and gas may also be subsidized to compensate for non availability of bagasse during production of beet sugar.
- ✚ Trial cultivation may be undertaken in different areas to find out suitable areas in terms of climate and yield per hectare.
- ✚ Research may be conducted to fix the optimal sugarcane Vs beet ratio for the sugar mills.

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- ✦ Option of consolidation may be worked out where groups of sugar mills can make an arrangement of using exclusively sugarcane or sugar beet for sugar production. While the mills using sugarcane can fulfill the energy requirement of the mills using sugar beet, which in turn can operate without the worry of arranging fuel for its operations. A typical arrangement can be groups of three with two mills on sugarcane and one on sugar beet.
 - ✦ Farmers and mill owners both need to be incentivized to get into agreements of pre-purchase of sugar beet crop prior to harvest.
 - ✦ Infrastructure of research institutes can help in production of suitable seed varieties and soil analysis for determining fertilizer requirements.
 - ✦ Government may step forward to establish a model sugar mill running on sugar beet to demonstrate the efficacy of concept.

Section IV – Alternate Sweetener Options for Pakistan

Need for an Alternate Sweetener

The level of consciousness of general public in Pakistan about health is generally way below that of developed countries. The sucrose or the refined table sugar is almost the sole source of sweetness for all the purposes i.e. the desserts, confectionary, drinks, baking, pharmaceutical etc. This not only puts additional demands on the sugar industry, but also raises some health concerns.

The trend is changing in developed countries which use a combination of different sweeteners. This trend not only promotes a healthier life style but also ensures a better distribution of natural resources resulting is less opportunity cost which would otherwise had to be paid by depending on a single source as we do.

There is a range of sweeteners available as an alternative to sugar, including natural (from different group of sugars), or artificial (with different chemical composition). The artificial sweeteners are readily available in market. Most of them have strong after taste, and generally lose their sweetness on heating; making them unsuitable for cooking and use in hot beverages. Moreover, these artificial sweeteners increase the craving for natural sugars which is then very difficult to resist. The use of these sweeteners therefore remains very limited to those of diabetics and the ones struggling to lose weight. An effort is therefore made to identify healthy natural sweeteners considering the sugar content, type of sugar they contain and availability of raw material for their production.

It is important to be introduced to few of the basic concepts for understanding the true benefits of natural alternatives. Only the relevant and bare essential information is provided omitting the literature details to keep it simple and easily understandable by the common person.

Types of Sugars

Simple Sugars

Simple sugars are also called monosaccharides. Three basic simple sugars are known as Glucose, Fructose and Galactose. The simple formula is $C_6H_{12}O_6$ with some difference in chemical structure.

Glucose

It is also called grape sugar. It is naturally found in fruit and plant juices and is the primary product of plant photosynthesis process. Glucose syrup is commonly used in food products as a sweetener and is the liquid equivalent of glucose.

Fructose

It is called fruit sugar. It is naturally found in fruits, few of the root vegetables, sugarcane, and honey. It is the sweetest of all simple sugars and most common form in which it is utilized in food industry is High Fructose Corn Syrup (HFCS).

Glactose

It is not found in Free State but makes a part of lactose or milk sugar. It is the least in sweetness in all sugars.

Compound Sugars

Compound sugars are also called disaccharides. These are formed by a combination of two molecules of monosaccharide sugars and have a general formula of $C_{12}H_{22}O_{11}$; whereas a single molecule of H_2O (Water) is released during the chemical process. During the digestion process these sugars are broken down into constituent parts by various enzymes.

Sucrose

Most commonly found in sugarcane and sugar beet. It is also found in some fruits and other plant parts. Each molecule of sucrose consists of a molecule of glucose and fructose.

Maltose

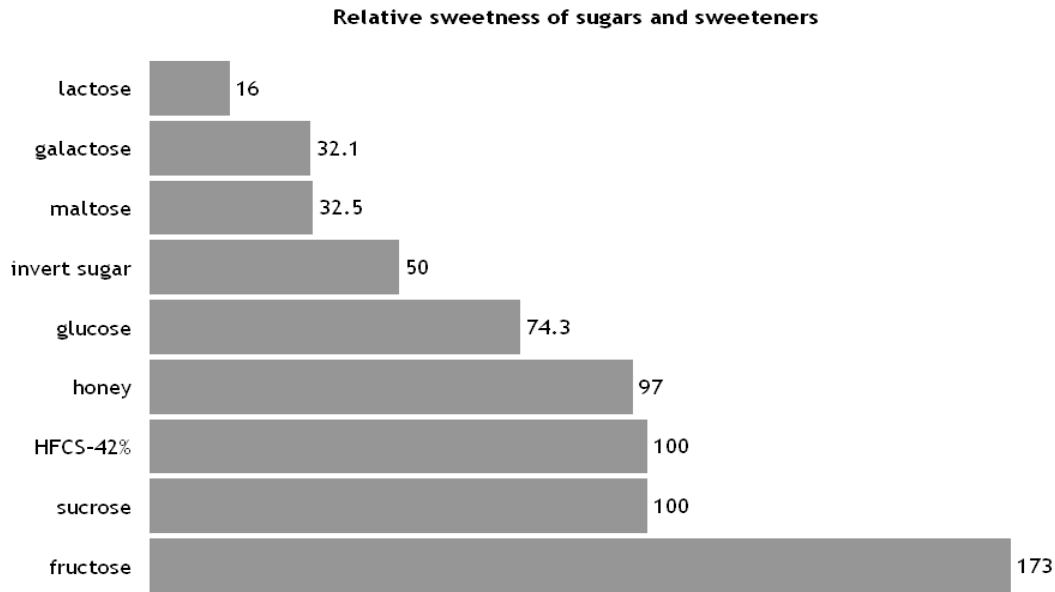
It is formed during the germination process of different grains. The most common source is barley. Barley is converted to Malt, which is where Maltose derives its name. Each molecule of maltose constitutes two molecules of glucose.

Lactose

It is also called milk sugar. Each molecule of lactose is formed by a combination of a molecule of glactose and glucose.

Relative Sweetness

Relative sweetness of different sugar sources comparing with the base line of sucrose as 100, is shown in the following figure.



Source: www.wikipedia.org

Glycaemic Index (GI)

Glycaemic Index (GI) is a reference number which is used to indicate the effect of a particular food or sugar on the level of blood glucose of a person. It is calculated by the response of the food intake on blood glucose after two hours following a fast of 12 hours. The reference values are calculated using GI of glucose as 100.

A high GI value means a sharp rise in blood glucose level. This in other words means more job requirement by the body and more insulin requirement from pancreas. Prolonged and consistent intake of high GI foods has been linked to early onset of diabetes. It is worth repeating here that the refined table sugar (available in Pakistan) is entirely sucrose which falls within medium to high GI group.

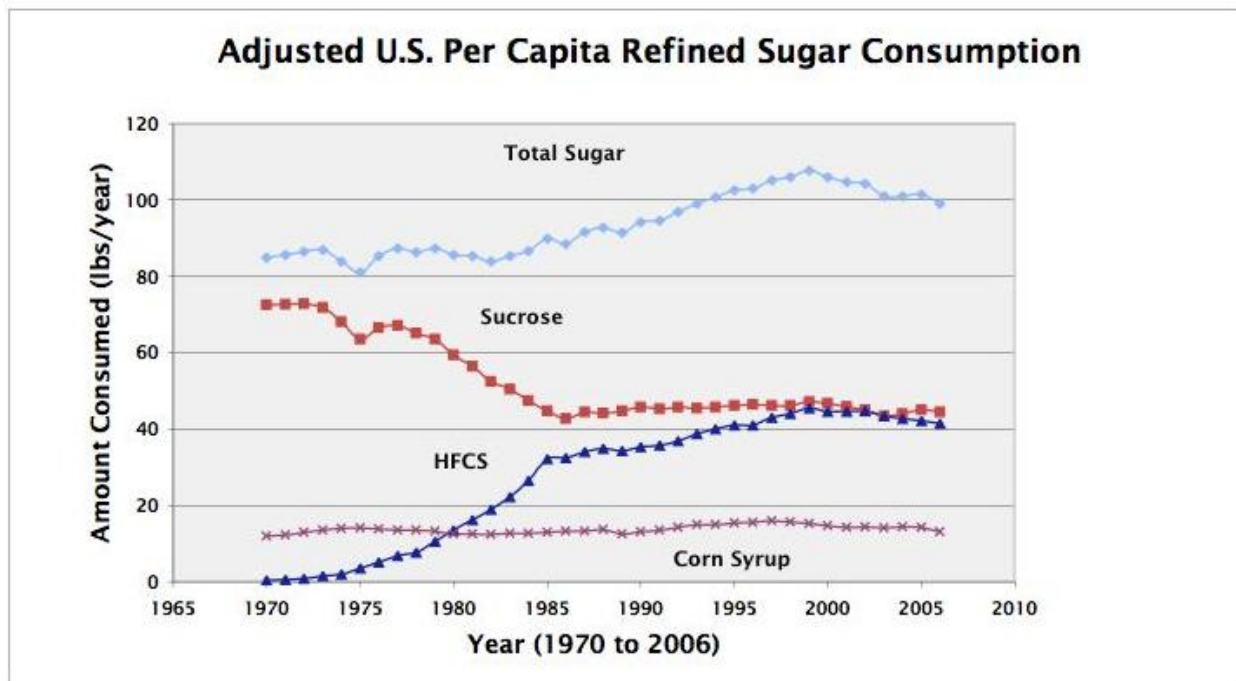
Glycaemic Index of different natural sugars is depicted in following table.

Classification	GI Range	Sugar
High GI	70 and above	Glucose, Maltose
Medium GI	56-69	Sucrose
Low GI	55 or less	Fructose

Source: www.wikipedia.org

Trend in Developed Countries

Due to the factors discussed above, the trend is rapidly changing in developed countries in pursuit of a healthy life style. Although the overall consumption of sugars shows an increase, consumption of sucrose as a sweetener is gradually decreasing. The effect is clearly visible in the per capita refined sugar consumption data of USA as shown in the following graph.



Source: www.wikipedia.org

Alternate Sweetener options for Pakistan

Based on the nutritional value, availability of ease for raw material in Pakistan, and local climate, few of the viable options for natural sugar alternatives are as following.

High Fructose Corn Syrup

First the corn starch is extracted from corn and is converted through enzymatic process into glucose syrup commonly known as corn syrup. This syrup is further converted through enzymes into high fructose corn syrup to produce required level of sweetness. HFCS is much lesser in price as compared to sucrose and is widely used in processed foods in Northern America and Europe and is commonly produced in varieties of 42%, 55% and 90% fructose content.

Corn is a readily available crop in Pakistan and can be cultivated twice in a year in both Rabi and Kharif seasons. The availability and low glycaemic index due to fructose make it a viable option.

Honey

As a natural sweetener, honey consists mostly of fructose and glucose and is also rich in nutrients. Due to its limited availability and much higher price, the honey is mostly used for therapeutic purposes and energy supplement rather than a household sweetener.

Molasses

Blackstrap molasses is though less sweet than sucrose, is rich in iron, copper, magnesium, zinc, calcium and potassium. Being rich in minerals, it can be used as a sweetener as well as food supplement. The molasses is already used as sweetener in baking in many countries. In Pakistan, the molasses is readily available, but its use as sweetener is minimal.

Brown Rice Syrup

Rice without removing the bran husk are cooked and converted through enzymes to sugars which can be used as sweetener. The syrup mostly contains maltose and has high glycaemic index. There are few concerns raised worldwide about high Arsenic content which is poisonous to humans; as brown rice in few regions has high Arsenic content which also makes its presence in rice syrup. Easy availability of rice in Pakistan, however, also makes it a viable option.

Maple Syrup

Maple trees produce considerable quantity of starch in winters which is stored in the tree stem. The starch is then converted into sugars by the spring. The sap is collected from tree stem and concentrated through heating and evaporation.

The syrup is rich in sucrose and is commonly used in baking, as well as with pancakes, French toast, waffles and breakfast cereal etc. Canada is the largest producer of maple syrup with yearly production of around 7 million US Gallons and exports of around 130 million US Dollars. In Pakistan, maple trees are available in considerable quantity in Murree and Abbotabad area. The favourable climate can allow for more tree plantations and give us the opportunity to establish a profitable industry.

Agave Syrup

Agave syrup is extracted from leaves of blue agave plant and is used as an alternate sweetener for sugar. It is high in fructose and about 50% sweeter than sucrose; thus have less GI and is required in lesser quantity than regular sugar.

Breakdown of Sugar Content

Breakdown of sugar content for few of the natural sweeteners is shown in the following table.

Sugar Type	Fructose	Glucose	Sucrose (Fructose-Glucose)	Other Sugars
Granulated Sugar	0	0	100	0
HFCS-42	42	53	0	5
HFCS-55	55	41	0	4
HFCS-90	90	5	0	5
Honey	50	44	1	5
Maple Syrup	1	4	95	0
Molasses	23	21	53	3
Corn Syrup	0	35	0	0

Source: www.wikipedia.org

The data show resemblances of maple syrup and molasses to the granulated refined sugar and also hints at the glicaemic index of these sweeteners.

The Way Forward

Keeping in view the present challenges for the sugar industry and the future outlook, it is strongly recommended that the government must start promoting alternate sources of sweeteners. The gradual shift from sucrose as the sole sweetener can significantly reduce the impact of these challenges.

The task is neither easy nor impossible. Few of the steps which can make this conversion easier are as following:-

- ✚ Awareness campaigns may be launched to make general public aware about the healthy aspects of these sweeteners.
- ✚ Incentives may be given to the producers of these sweeteners through subsidies and tax exemptions.
- ✚ Endorsements by the health specialists recommending use of fructose over sucrose.

Conclusion

The sugar industry of Pakistan is presently relying solely on sugarcane as the raw material for sugar production, and refined sugar (Sucrose) is the sole sweetener used in the country. The Industry has an over installed capacity of sugar mills but is generally short of required sugarcane input to run for

complete crushing season. The ownership structure is mostly concentrated and most of the mills are owned by political families which use their political influence to protect their interests. Overall the industry is performing way below its potential in terms of recovery percentage, yield per hectare and other parameters. Major issues identified as barriers at present are:-

- ✚ Direct subsidies.
- ✚ Lack of implementation of policies.
- ✚ Ad-hoc mechanism of price fixing and ineffective monitoring.
- ✚ Low sugarcane yield per hectare.
- ✚ Fluctuation in productivity.
- ✚ High reliance on sugarcane as production input.
- ✚ Improper management of ratoon crop.
- ✚ Under developed infrastructure of roads.
- ✚ Under utilization of by-products.

Despite all these challenges, there seems to be no panic in the tiers, as the industry is generally able to produce enough sugar for local consumption and sometimes even surplus quantity is available for export. Intervention through support price by enlarge has been successful as the prices are still reasonable as compared to the international prices. However, when looked in the bigger perspective, the industry is likely to face a big challenge in next ten years and merits major preparation to mitigate those challenges. To compensate for the population, either the under cultivated area for sugarcane is to be increase by 32%, or yield per hectare is to be increased by the same percentage. However, considering the existing water shortage and previous progress along the experience curve, attainment of both these parameters seems unlikely. Additional steps in parallel would still be required and the viable approach would be a three pronged strategy as following:-

- ✚ Solving the existing issues of sugar industry and adding maximum value to the byproducts.
- ✚ Exploiting sugar beet as alternate of sugarcane.
- ✚ Making solid efforts to motivate people to reduce reliance on sucrose as the only sweetener.

The crisis is not visible at present but will be eminent in few years. Correct policy decision at the government level can avoid the panic that would be created at the beginning of the crises.

Exhibit 1: Area under cultivation, total sugarcane production and yield per hectare, World.

Rank	Country	Area (Million Ha)	Production (Million Tons)	Yield (Tonnes/Ha)
1	Brazil	5.343	386.2	72.3
2	India	4.608	289.6	62.8
3	China	1.328	92.3	65.5
4	Thailand	0.970	64.4	66.4
5	Pakistan	1.086	52.0	47.9
6	Mexico	0.639	45.1	70.6
7	Columbia	0.435	36.6	84.1
8	Australia	0.423	36.0	85.1
9	USA	0.404	31.3	77.5
10	Philippines	0.385	25.8	67.1

*All figures from statistics of 2008-09

Source: <http://agridr.in>

Exhibit 2: Cultivated area, total sugarcane production and yield per hectare, Pakistan

Fiscal Year	Area Under Cultivation (x 1000 Hectares)	Total Sugarcane Production (x 1000 Tons)	Yield (Kg/ha)
1990-91	884	35989	40720
1991-92	896	38865	43371
1992-93	885	38059	43024
1993-94	963	44427	46144
1994-95	1009	47168	46747
1995-96	963	45230	46968
1996-97	965	41998	43521
1997-98	1056	53104	50288
1998-99	1155	55191	47784
1999-00	1010	46333	45874
2000-01	961	43606	45376
2001-02	1000	48042	48042
2002-03	1100	52056	47324
2003-04	1074	53419	49738
2004-05	966	47244	48906
2005-06	907	44666	49246
2006-07	1029	54742	53199
2007-08	1241	63920	51507
2008-09	1029	50045	48634
2009-10	943	49373	52357
2010-11	988	55309	55981
2011-12	1058	58397	55196
2012-13	1129	63750	56466
2013-14	1173	66469	56666

Source: Pakistan Bureau of Statistics

Exhibit 3: Total sugar production and per capita sugar consumption, Pakistan.

Year	Total Sugar Production (x 1000 Tons)	Per Capita Sugar Consumption (Kg/Year)
1990-91	1908	Data not Available
1991-92	2296	Data not Available
1992-93	2357	Data not Available
1993-94	2900	28.11
1994-95	2983	28.51
1995-96	2449	29.17
1996-97	2378	27.75
1997-98	3548	25.78
1998-99	3530	25.35
1999-00	2414	27.10
2000-01	2466	26.39
2001-02	3197	25.19
2002-03	3652	25.29
2003-04	3997	27.09
2004-05	2922	28.56
2005-06	2588	29.24
2006-07	3516	28.58
2007-08	4740	27.53
2008-09	3134	26.90
2009-10	3133	27.72
2010-11	4119	24.08
2011-12	4670	24.08
2012-13	5030	25.44
2013-14	5587	26.00

Source: Pakistan Sugar Mills Association

Exhibit 4: Per Capita sugar consumption of different countries of the world.

Country	Per Capita Consumption Kg/year			
	2008	2009	2010	2011
Albania	7.7	17.7	15.3	15.3
Algeria	25.7	28.2	28.1	24.5
Argentina	7.8	37.5	37.7	38.1
Armenia	30.2	30.3	36.9	33.2
Australia	35.6	34.9	34.3	34.1
Austria	38.9	37.4	37.6	37.9
Azerbaijan	12.7	12.6	13.6	13.9
Belarus	36.2	38.2	32.8	31.8
Belgium	46.5	46.2	46.0	41.4
Bosnia	12.7	11.2	12.3	13.4
Brazil	36.6	36.2	36.5	36.5
Bulgaria	28.3	27.1	22.2	24.0
Canada	35.1	28.5	25.5	31.3
Chile	42.6	42.5	42.2	41.7
China	5.80	5.90	5.90	6.20
Columbia	27.4	27.2	21.3	23.2
Croatia	32.2	32.2	35.0	33.8
Czech Republic	27.9	31.3	32.7	30.6
Denmark	27.9	31.3	32.7	30.6
Egypt	23.8	21.8	25.8	26.4
Estonia	23.8	21.8	25.8	26.4
European Union	31.9	31.8
Finland	23.5	27.5	24.5	25.0
France	30.4	33.9	31.7	31.9
Georgia	41.0	26.1	23.1	27.0
Germany	35.4	34.0	35.4	34.0
Ghana	8.50	10.1	11.7	9.60
Greece	8.50	10.1	11.7	9.60
Hungary	13.0	13.0	13.0	13.1
Iceland	33.0	34.5	34.3	33.9
India	18.3	17.8	17.3	18.3
Indonesia	11.8	11.9	12.2	12.5
Iran	24.7	25.2	26.6	26.1
Ireland	26.5	28.6	25.8	26.3
Israel	20.4	22.3	22.6	29.1
Italy	25.6	25.4	25.1	25.0
Japan	16.4	15.8	13.9	16.0
Kazakhstan	28.5	26.9	24.0	25.8
Kenya	15.6	15.2	14.7	14.3
Kyrgyzstan	20.1	19.8	20.0	20.2
Latvia	26.2	24.4	41.1	38.8

Lithuania	32.7	32.0	35.5	28.7
Luxemburg	9.30	9.50	10.4	10.8
Macedonia	35.8	29.6	34.1	30.7
Malaysia	35.9	39.0	39.2	38.4
Malta	45.6	47.1	46.5	44.1
Mexico	40.3	40.7	35.5	33.3
Moldova	21.7	17.8	20.4	24.0
Mongolia	11.3	10.7	10.3	11.3
Montenegro	17.4	16.7	16.1	18.3
Morocco	37.4	37.6	34.7	36.0
Netherlands	40.9	40.8	40.6	40.6
New Zealand	50.2	49.5	45.9	44.3
Nigeria	8.00	8.70	8.70	8.60
Norway	30.7	30.0	29.0	28.0
Pakistan	25.8	21.3	24.0	23.1
Peru	19.1	19.1	19.2	19.3
Philippines	22.0	19.3	19.1	19.4
Poland	38.0	39.3	39.3	40.6
Portugal	21.9	22.2	22.0	21.7
Romania	21.4	23.7	19.2	18.9
Russia	40.6	38.6	41.2	42.4
Serbia	19.4	25.4	21.7	25.7
Slovakia	35.4	34.3	35.7	32.0
Slovenia	16.2	16.9	17.2	17.0
South Africa	25.9	26.2	30.6	30.3
South Korea	19.3	18.6	19.5	17.4
Spain	22.1	21.9	21.7	21.5
Sweden	34.2	34.0	32.5	33.7
Switzerland	50.9	50.0	49.8	49.2
Tajikistan	15.5	16.4	16.0	16.4
Thailand	33.6	34.3	34.5	35.5
Turkey	27.1	28.4	29.2	27.3
Turkmenistan	7.70	6.70	6.80	7.30
Ukraine	41.9	37.8	37.0	39.6
United Kingdom	32.3	34.9	32.3	35.8
USA	27.3	27.0	26.8	28.1
Uzbekistan	11.1	9.50	9.40	9.30
Venezuela	33.3	33.6	34.9	34.8
Vietnam	10.5	8.80	9.10	9.60
World	18.8	18.3

Source: <http://www.helgilibrary.com>

Exhibit 5: Cane crushed, sugar produced, utilization and recovery percentage of sugar mills of Pakistan

Year	No of Mills	Cane Crushed Tonnes	Sugar Made Tonnes	Utilization % by the Sugar Mills	Recovery (%)
1990-91	51	22,603,696	1,908,838	62.80	8.44
1991-92	53	24,795,815	2,296,698	72.49	9.25
1992-93	61	27,274,806	2,375,289	71.66	8.71
1993-94	63	34,181,899	2,900,523	76.93	8.49
1994-95	66	34,193,290	2,983,101	72.49	8.72
1995-96	66	28,151,434	2,449,598	62.24	8.70
1996-97	68	27,152,918	2,378,751	65.13	8.76
1997-98	71	41,062,268	3,548,953	77.32	8.64
1998-99	71	42,994,911	3,530,931	77.90	8.21
1999-00	69	28,982,711	2,414,746	69.00	8.33
2000-01	65	29,408,879	2,466,788	67.47	8.39
2001-02	69	36,708,638	3,197,745	76.33	8.71
2002-03	71	41,786,689	3,652,745	80.28	8.74
2003-04	71	43,661,378	3,997,010	81.19	9.15
2004-05	71	32,101,739	2,922,126	73.74	9.10
2005-06	74	30,090,632	2,588,177	67.97	8.60
2006-07	77	40,483,977	3,516,218	73.78	8.69
2007-08	78	52,776,922	4,740,913	82.60	8.98
2008-09	82	33,139,418	3,134,145	66.21	9.46
2009-10	83	34,611,003	3,133,494	70.09	9.05
2010-11	84	44,511,571	4,119,421	80.47	9.25
2011-12	86	48,248,535	4,670,380	83.13	9.64
2012-13	86	50,089,483	5,030,129	79.00	10.04
2013-14	88	56,460,524	5,587,568	84.00	9.90

Source: Pakistan Sugar Mills Association

Exhibit 6: Support price of sugarcane and average price per Kg of sugar in Pakistan

Year	Indicative Sugar Price/ 40 Kg			Av Sugar Price/Kg
	Punjab	Sindh	Khyber Pakhtunkhwa	
1994-95	20.50	20.75	20.50	14.36
1995-96	21.50	21.75	21.50	17.86
1996-97	24.25	24.50	24.25	21.46
1997-98	35.00	36.00	35.00	18.75
1998-99	35.00	36.00	35.00	19.63
1999-00	35.00	36.00	35.00	22.85
2000-01	35.00	36.00	35.00	26.73
2001-02	42.00	43.00	42.00	22.00
2002-03	40.00	43.00	40.00	19.83
2003-04	40.00	41.00	40.00	19.26
2004-05	40.00	43.00	40.00	25.31
2005-06	45.00	60.00	45.00	33.07
2006-07	60.00	67.00	65.00	30.60
2007-08	60.00	67.00	65.00	28.62
2008-09	80.00	81.00	80.00	43.39
2009-10	100.00	102.00	100.00	63.41
2010-11	125.00	127.00	125.00	72.82
2011-12	150.00	154.00	150.00	57.16
2012-13	170.00	172.00	170.00	53.16
2013-14*	170.00	172.00	170.00	-

Source: Pakistan Sugar Mills Association

Exhibit 7: Sugar Exports and Imports by Pakistan in last 15 Years

Fiscal Year	Quantity Exported (Tonnes)	Quantity Imported (Tonnes)
1997-98	210632	10990
1998-99	906602	10097
1999-00	-	66627
2000-01	-	930142
2001-02	-	85037
2002-03	45669	85315
2003-04	116175	11398
2004-05	54771	266707
2005-06	61047	1527322
2006-07	12	586543
2007-08	260840	36692
2008-09	23980	125743
2009-10	-	370000
2010-11	-	1031919
2011-12	48672	17221

Source: Pakistan Bureau of Statistics

Exhibit 8: Total yearly Molasses Production in Pakistan

Year	Punjab	Sindh	NWFP	Pakistan
1990-91	1,119,978	611,033	473,432	35,513
1991-92	1,168,158	545,125	581,683	41,350
1992-93	1,330,419	632,055	652,789	45,575
1993-94	1,694,852	972,827	676,790	45,235
1994-95	1,010,890	592,067	47,994	1,650,952
1995-96	821,298	503,692	36,481	1,361,471
1996-97	798,448	482,636	32,661	1,319,860
1997-98	1,237,940	684,823	56,038	1,978,801
1998-99	1,276,391	760,533	76,670	2,113,595
1999-00	800,536	534,003	62,838	1,397,378
2000-01	901,732	550,605	40,480	1,501,501
2001-02	1,224,905	522,939	75,115	1,822,959
2002-03	1,304,284	656,520	87,313	2,048,117
2003-04	1,351,728	667,160	103,211	2,122,099
2004-05	1,039,937	393,287	64,171	1,497,395
2005-06	937,337	458,050	42,568	1,437,954
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

Source: Pakistan Sugar Mills Association (Total molasses production in tonnes)

Exhibit 9: Total yearly Molasses Export by Pakistan

Year	Quantity Tonnes	Value in Rs. "000"	Average Price Rs per Tonne
1990-91	776,071	823,636	1,061.29
1991-92	947,000	1,351,762	1,427.41
1992-93	892,618	1,396,111	1,564.06
1993-94	703,450	993,627	1,412.50
1994-95	769,636	1,213,545	1,576.78
1995-96	806,399	1,852,514	2,297.26
1996-97	1,056,134	2,021,755	1,914.30
1997-98	1,359,328	2,542,504	1,870.41
1998-99	1,688,505	1,802,899	1,067.75
1999-00	1,748,000	2,200,000	1,258.58
2000-01	1,190,012	2,456,573	2,064.32
2001-02	1,607,380	3,898,800	2,425.56
2002-03	1,272,630	2,652,975	2,084.63
2003-04	1,457,283	2,698,964	1,852.05
2004-05	1,151,431	4,297,617	3,732.00
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

Source: Pakistan Sugar Mills Association (Molasses export)

Exhibit 10: Total yearly Ethanol Export by Pakistan

Year	Quantity Ltrs	Values in "000" Rs.	Average Price Rs. per Ltrs
1990-91	8,229,448	61,090	07.42
1991-92	7,636,000	55,332	07.25
1992-93	8,660,900	90,213	10.42
1993-94	13,206,697	125,866	09.54
1994-95	6,050,200	68,137	11.26
1995-96	1,166,000	16,856	14.45
1996-97	1,232,145	18,273	14.83
1997-98	4,107,000	69,646	16.96
1998-99	6,722,000	115,788	17.22
1999-00	7,608,000	136,364	17.92
2000-01	10,061,000	208,082	20.68
2001-02	14,594,000	341,438	23.39
2002-03	16,341,575	342,658	20.96
2003-04	35,921,065	692,840	19.29
2004-05	36,669,688	1,067,445	29.00
2005-06	33,789,535	1,066,048	32.00
2006-07	34,116,438	1,122,000	32.00
2007-08	28,609,832	892,222	31.19
2008-09	27,045,396	1,209,025	45.70
2009-10	101,260,099	4,679,269	46.21
2010-11	168,509,200	9,506,883	56.00
2011-12	215,814,894	14,234,428	65.96
2012-13	142,065,426	8,735,649	61.49

Source: Pakistan Sugar Mills Association (Ethanol export)

Exhibit 11: List of national agricultural universities.

S No	Name of University
1	University of Agriculture, Faisalabad
2	Balochistan Agriculture College, Quetta
3	University College of Agriculture and Environmental sciences, Islamia University, Bahawalpur
4	University of Agriculture, Peshawar
5	Lasbela University of Agriculture, Water and Marine Sciences, Othal, Lasbela District
6	Pir Mehr Ali Shah, Arid Agriculture University, Rawalpindi, Punjab
7	Sindh Agriculture University, Tando Jam
8	University College of Agriculture, Rawalakot
9	Dera Ghazi Khan College of Agriculture,(CADGK) University of Agriculture, Faisalabad
10	Department of Agriculture and Agribusiness Management, University of Karachi, Karachi
11	University of Poonch Rawalakot, Azad Kashmir
12	University College of Agriculture, University of Sargodha
13	Institute of Agricultural Sciences, University of the Punjab, Lahore
14	Zulfikar Ali Bhutto Agriculture College, Dokri
15	Zawar Ameer Bux Jamali Agriculture University

Source: http://en.wikipedia.org/wiki/List_of_agricultural_universities_and_colleges

Exhibit 12: List of R&D facilities related to crop.

S No	Supervising Agency	Name of R&D Agency	Focus of Research Activities
1.	National Agricultural Research Centre (NARC)	Institute of Agricultural Biotechnology and Genetic Resources (IABGR)	Crops
2.		Wheat Research Institute	Crops
3.	Pakistan Agricultural Research Council (PARC)	Arid Zone Research Institute (AZRI), D.I. Khan	Crops, pastures & forages
4.	National Agricultural Research Centre (NARC)	Institute of Plant & Environmental Protection (IPEP)	Crops
5.	Ministry of Planning and Development	Sustainable Development Policy Institute (SDPI)	Crops
6.	Pakistan Agricultural Research Council (PARC)	Arid Zone Research Centre, Quetta	Crops, socioeconomics, livestock
7.	Ministry of Defence	Pakistan Meteorological Department (PMD)	Crops
8.	Pakistan Agricultural Research Council (PARC) - Plant Sciences Division	Mountain Agricultural Research Centre (MARC)	Crops, fisheries, natural resources
9.	Pakistan Agricultural Research Council (PARC)	Neelibar Agricultural Research and Training Station (NARTS)	Crops, natural resources, forestry, socioeconomics
10.	Government of Punjab - Agriculture Department	Ayub Agricultural Research Institute	Crops
11.	Pakistan Atomic Energy Commission (PAEC)	National Institute for Biotechnology and Genetic Engineering (NIBGE)	Crops
12.	Pakistan Agricultural Research Council (PARC)	National Sugar Crops Research Institute (NSCRI)	Crops
13.	Pakistan Agricultural Research Council (PARC)	Technology Transfer Institute (TTI)	Crops, socioeconomics
14.	Government of Punjab - Agriculture Department	Floriculture	Crops
15.	Pakistan Atomic Energy Commission (PAEC)	Nuclear Institute for Agriculture and Biology (NIAB)	Crops, livestock, natural resources, socioeconomic
16.	Pakistan Agricultural Research Council (PARC)	National Tea Research Institute (NTRI)	Crops
17.	Government of Punjab - Agriculture Department	Agricultural Extension & Adaptive Research	Crops, socioeconomics
18.	Pakistan Agricultural Research Council (PARC)	Southern Zone Agricultural Research Centre (SARC)	Crops, off-farm post-harvest, livestock, forestry
19.	National Agricultural Research Centre (NARC)	Crops Sciences Institute (CSI)	Crops
20.		Agricultural Research Institute	Crops
21.	Government of Punjab - Livestock and Dairy Department	Livestock Production Research Institute	Livestock, crops

Source: <http://www.asti.cgiar.org/pakistan/directory>

Exhibit 13: Statistics of Beet Sugar production for Khyber Pakhtunkhwa

Year	No of Mills	Beet Sliced Tonnes	Sugar Made Tonnes	Recoveries (%)	Molasses Made Tonnes
1990-91	03	282,103	23,312	8.26	8,636
1991-92	03	314,758	29,009	9.21	12,840
1992-93	03	214,950	18,916	8.80	8,649
1993-94	04	242,482	21,933	9.05	9,392
1994-95	04	193,595	18,371	9.49	7,412
1995-96	03	211,670	20,435	9.65	7,738
1996-97	03	166,875	14,610	8.76	6,115
1997-98	02	81,794	6,267	7.66	3,127
1998-99	03	126,123	10,831	8.59	5,069
1999-00	03	187,478	14,618	7.80	7,750
2000-01	03	226,252	17,276	7.64	8,684
2001-02	03	316,041	29,127	9.23	13,376
2002-03	03	222,063	22,066	9.94	8,490
2003-04	03	250,171	23,797	9.51	8,684
2004-05	02	120,903	11,373	9.41	4,287
2005-06	03	93,518	8,934	9.55	3,404
2006-07	01	83,580	7,865	9.04	2,973
2007-08	01	64,095	5,532	8.80	2,576
2008-09	01	9,301	947	10.55	419
2009-10	02	53,336	4,641	9.15	2,140
2010-11	02	151,265	13,535	8.95	7,027
2011-12	02	176,709	18,216	10.31	8,392
2012-13	02	306,341	33,028	10.78	12,040
2013-14	01	251,418	27,389	10.89	8,548

Source: Pakistan Sugar Mills Association

Bibliography

- Abdul Raheman, Abdul Qayyum, And Talat Afza. "Efficiency Dynamics of Sugar Industry of Pakistan." *The Pakistan Development Review* (2009).
- Adnan Nazir, Ghulam Ali Jariko, Mumtaz Ali Junejo. "Factors Affecting Sugarcane Production in Pakistan." *Pakistan Journal of Commerce and Social Sciences* (2013, Vol. 7 (1), 128-140).
- Ali Muhammad Khushk, Aslam Memon and Ikram Saeed. "Analysis of sugar industry competitiveness in Pakistan." (2011).
- Amjad Roohani, Arslan Munawar, Hussain Naqvi. "Sugarcane Production in Pakistan." 17 April, 2014. <https://ma4bnu.wordpress.com/tag/production/>.
- David Disch, Kavita Rai, Shachi Maheshwari. "Carbon Finance, A Guide for Sustainable Energy Enterprises and NGOs." 2010.
- <http://agridr.in>. n.d.
- <http://api-islamabad.blogspot.com/2013/10/sugar-beet-cultivation-in-khyber.html> . n.d.
- <http://en.wikipedia.org>. n.d.
- <http://www.belqilibrary.com>. n.d.
- <http://www.pakissan.com>. n.d.
- <http://www.usda.gov>. n.d.
- <https://www.yahoo.com>. n.d.
- Inayatullah Khan, Muhammad Jamil. "Sugar Crops and Sugar Policy of Pakistan." *Quarterly SCIENCE VISION Vol.9 No.1-2 (Jul - Dec, 2003) & 3-4 (Jan - Jun, 2004)* n.d.
- Institute of Cost and Management Accountants of Pakistan. "Capacity Utilization of Sugar Mills in SAARC Countries, ." n.d.
- JCR-VIS Credit Rating Company Limited, Pakistan. "Sugar Industry, Upward pressure ahead with increasing input prices and weakening local currency." 2013.
- Lahore Chamber of Commerce and Industry. "Overview of Sugar Industry in Pakistan." 2013.
- Mian Kausar Hameed, COO - Sugar Operations, Dewan Mushtaq Group. "Overview of Sugar Manufacturing Sector of Pakistan." n.d.
- Ministry of Finance . "Agricultural Economic Survey of Pakistan." Survey of Agriculture Sector. 2013-14. Internet.

Ministry of Finance, Government of Pakistan. "Statistics of Agriculture Sector." Annual Report. 2013-14.

Mohammad F. Hussain, Sofia Anwar, Zakir Hussain. "Economics of Sugarcane Production in Pakistan: A Price Risk." *International Research Journal of Finance and Economics* (2006).

"Moving from cane to sugar beet." *Dawn* (03 March, 2013).

Pakistan Bureau of Statistics. "Monthly Bulletin of Statistics." November, 2014.

Pakistan Sugar Mills Association. "Annual Report." 2013.

—. <http://www.psmacentre.com>. n.d.

Pakistan Bureau of Statistics. <http://www.pbs.gov.pk/content/industry>. n.d.

Presentation on Feasibility of Tropical Sugar Beet cultivation in Tamil Nadu, India. n.d.
<http://www.tnau.ac.in/tech/swc/sugarbeet.pdf>.

Rizvi, Syed Jamil Ahmed. "SUGAR INDUSTRY IN PAKISTAN – Problems, Potentials." n.d.

Shaukat, Muhammad Irfan. "A comprehensive study about Sugarcane in Pakistan." n.d.

Sonia Anwer Rana, Ehsan Ullah Khan, Sheikh Saleem Ellahi, Atta Muhammad Nasar, Rashida Khalil, Adnan Shahid. "Sectoral Analysis of Sugar Industry With Special Reference to Price Hike." n.d.

United States Department of Agriculture (USDA). *The Economic Feasibility of Ethanol Production*. n.d.