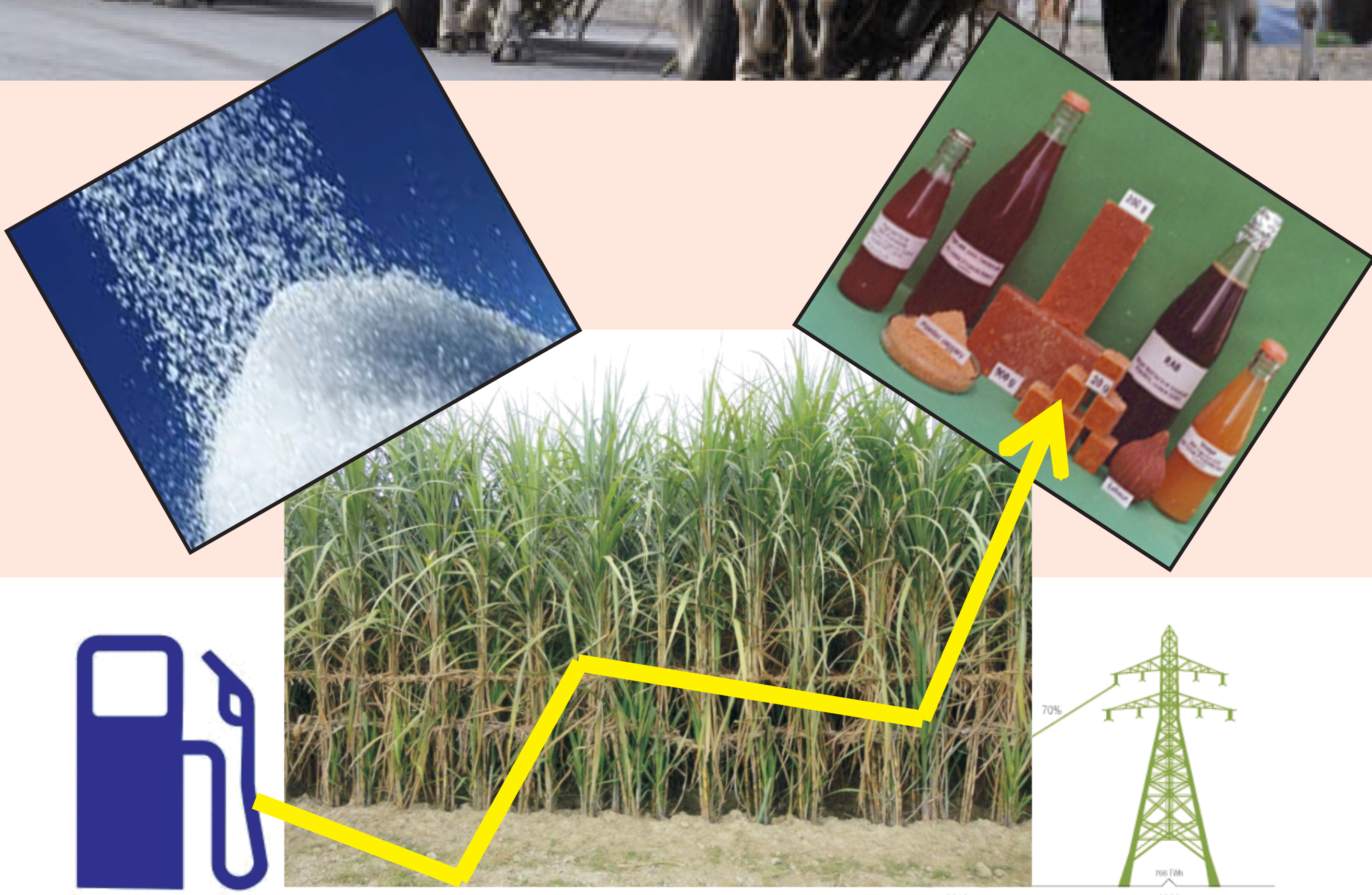
Socio-economic Impact of Sugarcane Production and Diversification in India



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ISO 9001 : 2008

Citation : Gangwar, L.S., Solomon, S.,Singh Pushpa, Hasan, S.S. And Sah A.K.,2014. Socio-economic Impact of Sugarcane Production and Diversification in India. A policy Paper (ICAR-IISR / 2014/ Policy Paper / 01) published by Indian Institute of Sugarcan Research, Lucknow.

Indian Institute of Sugarcane Research (IISR), Lucknow was established in 1952 by the erstwhile Indian Central Sugarcane Committee for conducting basic and applied research on sugarcane production and processing. Government of India took over the Institute from Indian Central Sugarcane Committee on January 1, 1954 and later on transferred it to Indian Council of Agricultural Research (ICAR), on April 1, 1969. This institute devoted for enhancement of sugarcane production, productivity, profitability and sustainability to meet future sugar and energy requirement of India. The mandate of the institute is:

- To conduct basic and applied research on all aspects of production and protection techniques of sugarcane and other sugar crops particularly sugar beet for different agro climatic zones of the country
- To work on the breeding of varieties for sub-tropical region in close collaboration with Sugarcane Breeding Institute, Coimbatore
- To carry out research for diversification and value addition in sugarcane
- To develop linkages with State Agricultural Universities, Research Centres and other organizations for collaborative research, exchange of information and material
- To provide training, and consultancy to end users at regional, national and international levels.

ICAR - IISR / 2014 / Policy Paper / 01

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Published
October 2014

Published by
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FOREWORD

Food and energy security has emerged as an important policy issue all over the world. The reliance of global energy markets on fossil fuels like coal, crude oil and natural gas has led to global destabilizing price shocks, more so in recent years. The extensive worldwide use of fossil fuels has also resulted in serious environmental concerns particularly the climate change. Under such a scenario, the key challenge facing the developing world is how to meet its growing energy needs and sustain economic growth without contributing to climate change, leading to the quest for alternative sources of energy that could reduce dependence on petroleum. Amongst several alternative renewable sources of energy, sugarcane has emerged as the most potent bio-resource for food and energy.

Sugarcane provides means of livelihood to 6.0 million farmer families engaged in its cultivation and allied activities, employment opportunity to 0.50 million skilled and semi-skilled rural workers engated in sugar, bio-ethanol and power cogeneration industry. The diverse challenges and constraints faced by the sugarcane production and Indian sugar sector to fulfill the ever increasing food, fuel and energy demand, climate resilience, natural resource degradation, slow growth of sugarcane farm income, mounting cost of production, labor scarcity and new global trade regulations demand a paradigm shift in formulating and implementation of suitable policies for sustainable development of India's second largest agro based industry. By 2030, India shall require approximately 34 million tonnes sugar and 9 million tonnes Jaggery and *Khandsari*, 10.94 million tonnes bio-ethanol, 14000 MW surplus power supply through cogeneration to national grid and 48 million carbon credits. Therefore, bio-ethanol blending as partial replacement of non-renewable petroleum, fuel, use of bagasse and sugarcane trash for electricity cogeneration has mammoth future potential for improving sugarcane production and sustainable development of Indian sugar sector. The sugarcane production, productivity and sugar recovery has to enhance substantially to fulfill domestic food-energy demand in next decades. As sugarcane acreage is not likely to enhance, the increased sugar-ethanol-power production has to be achieved through vertical growth in productivity and products processing efficiencies. This poses great challenge to sugarcane cultivation and its processing for development of value added products both in terms of demand and sustainability.

The present policy paper has outlined the key issues confronting the future development of the integrated sugar-energy processing complexes and has identified the production potential and constraints. The policy paper presents a number of issues related to the socio-economic impacts of sugarcane cultiavation and the competitiveness of the emerging biofuels supply chain in India along with some approaches, analytical tools, policy reforms and interventions for improving economic viability and sustainability of integrated sugar-energy complexes. I am sure the policy paper will be useful to researchers, policymakers, sugar industrialist and stakeholders in understanding the issues related to socio-economic impacts of sugarcane cultivation, their potential, constraints and the emerging paradigms.

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PREFACE

India is the world's second largest producer of sugar after Brazil with an average annual production of 25.1 million tonnes, with about 5.1 million ha area under cane cultivation and its processing for value added products such as sugar, jaggery, bio-ethanol, paper, bio-fertilizer, power cogeneration etc. has drawn awareness because of its socio-economic impact and environmental concerns. During first decade of 21st century, annual sugar production ranges from 12.7 to 28.4 million tonnes, leading to either deficit or surplus situation in Indian domestic market. This cyclicity in sugar production largely affects the efferts of cane production and sustained supply of cane to sugar mills for economic benefits of both the farmers and milleers. The sugar and co-products requirement expected to improve significantly during coming decades due to population growth, better purchasing power and increase in per capita consumption. Sugarcane cultivation is associated with inherent inconsistencies of area, yield variations due to rainfall, sugarcane and sugar price policy, prices of competing crops, inputs cost and supply, labor wages and its timely availability, cane price arrears, state government policies and sugar mills profitability. Despite of frequent fluctuations in sugar production, changes in government policies and infrastructural development, per capita domestic sweetener consumption has enhanced from 20 to 23 kg during past three decades.

Indian sugar sector facing problem due to high cost of sugarcane production leads to higher expenses on purchase of raw material. The disparity between sugar processing cost and sugar price in domestic market made the sugar mills economically sick. It has led to huge sugarcane arrears of ₹ 12500 crores, which is nearly 21 per cent of total cane dues. The sugarcane price arrears has bound to have create an alarming situation for impending downward cycle in sugar production during next 3-4 crushing seasons. The SAP announced by some State Governments, do not reflect rational linkage with sugarcane cost of production and value of sugar and co-products produced from each unit of cane quantity processed. Sugarcane farmers believe FRP on lower side, while sugar mills think that the SAP on higher side compared to economic value of sugar on market prices. To resolve this problem, state government must follow the sugarcane price policy based on revenue sharing formula. The future challenges of rising population, ever-increasing food, fuel, sugar and energy requirement, natural resource degradation, sluggish cane productivity growth, high wages and production cost require a paradigm shift in cane production planning, policy formulation and implementation.

The policy paper of ICAR-Indian Institute of Sugarcane Research articulates the Institute perceptions of the likely sugarcane production, sugar-ethanol-energy processing scenario in the next 2-3 decades. It is expected that this document will serve as a roadmap for deciding the research agenda of the Institute for achieving the targets envisaged. I am extremely grateful to Dr. S. Ayyappan, Secretary, DARE and Director General, Dr. S.K. Datta, Deputy Director General (Crop Science) and Dr. N. Gopalakrishnan, ADG (CC), ICAR, for their guidance, and constant encouragement.

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ACRONYMS AND ABBREVIATIONS

ABI	-	Agri-Business Incubator
BC	-	Before Christ
BCR	-	Benefit Cost Ratio
BIG-GTCC	-	Biomass Integrated Gassifier- Gas Turbine Combined Cycle
BPL	-	Below Poverty Line
BSC	-	Biofuel Steering Committee
CACP	-	Commission on Agricultural Costs and Prices
CAD	-	Current Account Deficit
CCEA	-	Cabinet Committee on Economic Affairs
CDM	-	Clean Development Mechanism
CERC	-	Central Electricity Regulatory Commission
CGR	-	Compound Growth Rate
CHP	-	Combined Heat and Power
CNG	-	Compressed Natural Gas
CSIR	-	Council of Scientific and Industrial Research
CVC	-	Central Vigilance Commission
CWDP	-	Comprehensive Watershed Development Programme
DAC	-	Department of Agriculture and Cooperation
DES	-	Directorate of Economics and Statistics
EBP	-	Ethanol Blending Policy
EBPP	-	Ethanol Blended Petrol Programme
EGoM	-	Empowered Group of Ministers
FDI	-	Foreign Direct Investment
FFV	-	Flex Fuel Vehicles
FRP	-	Fair Remunerative Prices
FYM	-	Farmyard Manure
FYP	-	Five Year Plan
GDP	-	Gross Domestic Product
GHG	-	Green House Gases
GoI	-	Government of India
HDI	-	Human Development Index
IAMM	-	Indian Agricultural Machine Manufacturers
ICRISAT	-	International Crop Research Institute for Semi-Arid Tropics
ICT	-	Information and Communication Technology
IFPRI	-	International Food Policy Research Institute
IREDA	-	Indian Renewable Energy Development Agency
IRR	-	Internal Rate of Return
ISMA	-	Indian Sugar Millers Association
LPG	-	Liquefied Petroleum Gas
MFRP	-	Minimum Fair Remunerative Prices

MIS	-	Market Information System
MNES	-	Ministry of Non-Conventional Energy Sources
MNRE	-	Ministry of New and Renewable Energy
Mo PNG	-	Ministry of Petroleum and Natural Gas
MPP	-	Minimum Procurement Price
MSA	-	Motor Sprit Act
MSP	-	Minimum Support Price
NBM	-	National Biofuel Mission
NBP	-	National Biofuel Policy
NBCC	-	National Biofuel Coordination Committee
NBDP	-	National Biofuel Development Board
NCA	-	National Commission on Agriculture
NCAP	-	National Centre for Agricultural Economics and Policy Research
NFCSF	-	National Federation of Cooperative Sugar Factories
NFSB	-	National Food Security Bill
NGO	-	Non-Governmental Organization
NPB	-	National Policy on Biofuels
NPV	-	Net Present Value
OECD	-	Organisation for Economic Co-operation and Development
OMC	-	Oil Marketing Company
PDS	-	Public Distribution System
PPP	-	Public Private Partnership
PRS	-	Plant Residue Shredder
RBSP	-	Raised Bed Sugarcane Planter
RFS	-	Renewable Fuel Standards
RPS	-	Renewable Electricity Purchase Standards
SAP	-	State Advisory Price
SAUs	-	State Agricultural Universities
SCAR	-	Sugarcane Agricultural Residues
SDF	-	Sugar Development Fund
SEFASU	-	Scheme for Extending Financial Assistance to Sugar Undertaking
SERC	-	State Electricity Regulatory Commissions
SHG	-	Self-Help Group
SMP	-	Statuary Minimum Prices
SPV	-	Special Purpose Vehicle
SWOT	-	Strengths Weaknesses Opportunities and Threats
TE	-	Triennium Ending
TCD	-	Tonnes of cane Crushed per day
TNAU	-	Tamil Nadu Agricultural University
UPSRTC	-	Uttar Pradesh State Road Transport Corporation
USSR	-	Union of Soviet Socialist Republics
VSI	-	Vasantdada Sugar Institute
WTO	-	World Trade Organization

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Executive Summary

- The sugar industry sustains the livelihood of 6 million agricultural farmers and 0.5 nearly million skilled and semi-skilled industrial worker families as well as generates significant employment in ancillary and allied activities. The area under sugarcane hovering 5.1 million ha which is approximately 2.6 per cent of the gross cropped area (GCA) in the country. In fact, sugar manufacturing is the second largest agro-based processing industry in our country. The turnover of the sugarcane and sugar related economic activities were approximately of ₹ 80-85 thousand crores per annum, out of which, nearly ₹ 55-60 thousand crores is paid to the sugarcane farmers by the sugar mill as prices for its supply.
- Indian share in global sugar production has risen from 5 per cent to 15 per cent during last five decades. India's share in global sugar consumption has gone up from 5 per cent to 13 per cent. Globally, India is the second largest sugar producer. In spite of huge domestic consumption, India is self-sufficient and is also able to generate exportable sugar surpluses. India has produced sugar in the range of 24 -26 million tonnes during past three production seasons. Therefore, it has met the estimated domestic sugar consumption requirement of 23 million tonnes during 2012-13 season and also had exportable surplus sugar production.
- The estimated Compounded Annual Growth Rate (CAGR) for domestic sugar consumption was 3.5 per cent, which was more than the global average. It is attributable not only to the lower initial base but also to the ever increasing disposable incomes (2.1 per cent contribution on this account is comparable to world standards of per capita sugar consumption growth) as well as population growth (1.4 per cent contribution). As per estimates, the share of bulk consumers in the sugar consumption basket ranges from 60 per cent to 65 per cent and remaining sugar consumption is by the individual households. The per capita estimated sugar consumption and availability in India was 18 kg / annum for 2012-13 sugar season Economic Survey (2013-14). The per capita consumption of traditional sweetener in India was 5 kg / annum in form of jaggery and *Khandsari* products. The lower per capita sugar consumption base in our country is indicative of huge opportunities for the domestic industry and as the nation grows, the domestic sugar consumption may match the world standards (world sugar annual per capita consumption was nearly 24 kg / annum and per capita sugar consumption in Europe and American sub-continents was 35-40 kg / annum).
- Sugarcane will go a long way as the major contributor for the energy security of the nation and slowly minimize dependence on petroleum sector imports through ethanol production. India could start preparing grounds for necessary amendments in the national automobile policies to promote the development of flexi fuel engines and delivery pumps, an area which would need full-fledged adoption, once the ethanol blending targets of 20-25 per cent with petrol would be implemented in years to come. This option could be further explored in the form of tax/excise duty based incentives to various stakeholders.
- India has to reap the natural advantages of specialty sugars and traditional sweetener ethnic food products. The fair trade sugar, jaggery based value added products, jaggery and *Khandsari* are well established and consumed in India. The efforts should be made for

maintaining quality standards, proper packaging, advertisement, certification / branding / aggressive marketing strategies. These activities should be the part of better market management and has to be taken up by the sugar industry. There is urgent need and sound case for kick off policy interventions that would promote production and branding of organic sugar, jaggery and *Khandsari*.

- Special purpose vehicles (SPVs) should be floated to strengthen the state level sugarcane research institutes, which were lagging due to lack of trained manpower, financial resources crunch. This should be encouraged by state government / research organization and the sugar mills and sugarcane farmers become contributor as well as partners.
- The appropriate changes should be made in the import policy/tariffs for promotion of sugar beet as a complementary sugar crop. The input-output supply chain must be ensured through availability of the quality raw materials i.e. seeds, pesticides, etc. and processing industries for sugar beet as worry in the beginning stages of expansion of the crop.
- The FRP and SAP system of sugarcane payment set by the Central and States Governments is the minimum price payable to the farmers by the sugar mills. The FRP is based on sugar recovery and SAP is based on sugarcane cost of production. The sugarcane growers plants different varieties having different characters such as early, mid, late maturity and sugar recovery level. There is no discrimination in price for high, medium, low sugar varieties as sugarcane prices paid to the farmers on weight basis. Therefore, it would be useful to develop and implement the sugarcane price system based on juice quality. It would encourage sugarcane farmers to plant high sugar varieties and also help in improving the sugarcane productivity for higher economic return and remuneration. The voluntary adoption of sugarcane samplers and sucrose testing machines could be effective for this innovative sugarcane price policy.
- Slowly, sugar - power cogeneration - ethanol distillery would emerge as a key source to fulfill ever increasing sugar-energy requirement of India. The power cogeneration and bio-ethanol production, as the renewable green energy sources have huge potential of converting economic sick sugar mills into sugar-energy complexes to achieve the future targets. The contribution of these by-products based utilization activities has led to industry turnover of ₹ 10-12 thousand crores. However, in long term, the sugar industry has the future potential to meet 20-25 per cent of total motor-fuel requirements of India. It could therefore become a substantial collaborator in reducing the petroleum import bills and save foreign exchange.
- The sugar processing in India is largely spread in ten states. The five states are in sub-tropical belt (Punjab, Haryana, Uttarakhand, Uttar Pradesh, and Bihar) and the remaining five states belong to tropical region (Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu). The states of central India such as Chhattisgarh and Madhya Pradesh, Odisha and West Bengal from eastern India and the Union Territory of Puducherry (tropical belt) also contribute to the domestic sugar production. Most of the old established sugar mills have sugarcane crushing capacity of 2500 to 5000 TCD. However, the modern sugar-energy processing complexes has expanded the crushing capacity even beyond 10000 TCD. Based on the existing level of sugarcane availability and sugar recovery, the tropical and sub-tropical belts have the potential to produce 16 million tonnes and 12 million tonnes sugar per

crop season respectively.

- Two stand-alone sugar refineries has been established in coastal belt, Gujarat and West Bengal for production of refined sugar from imported or domestically produced raw sugar. Though, these refineries are export oriented, the sugar produced by these refineries supplement white / refined sugar supply in domestic market during low production seasons. It could improve sugar supply and reduce seasonal price fluctuation to maintain sugar supply at affordable price to the consumers. The sugar production capacity of the refineries was 5000 tonnes / day, to enhance sugar production capacity up to 1.5 million tonnes per annum.
- The liberalization of the sugar sector and growing linkages with the global sugar markets had brought transformational changes. The sugar processing efficiencies has been achieved by the small inefficient sugar mills. There were 526 operational sugar mills in India during 2012-13 sugarcane crushing season. However, 136 integrated new sugar-energy complexes were in various establishment stages and are expected to start production in next two to three years. Most of the new sugar-energy complexes have integrated with in-built mechanism for sugar production, cogeneration and ethanol distillation facilities.
- Indian sugar industry has traveled a lot on development front during past six decades. The sugar processing has replaced the old 11Kg boiler to 100 Kg boilers, 65 per cent steam consumption to 30 per cent steam consumption, from operating sugar mills totally manual to complete automation. The molasses fermentation efficiencies has also improved from 82 to 90 per cent. The sugar industry has enhanced its profitability from single unit sugar to integrated sugar-energy processing complexes for production of bio-ethanol, power cogeneration, bio-fertilizer etc along with superior quality sugar.
- The cyclic nature of sugarcane production has been the curse for the Indian sugar industry. India had achieved the highest sugar production of 28.4 million tonnes in 2006-07. After achievement of this production level, the growth was not unidirectional and steady as there have been wide swings in sugar production in recent years. This trend was mainly due to fluctuation in sugarcane production and raw material shortage to sugar mills. In sub-tropical belt, sugar mills has the short crushing duration of 100-130 days / season. The sugarcane crushing duration in tropical states has 140-180 days / season. In Tamil Nadu, sugar industries are able to get raw material supply for 200-210 working days.
- Sugar cane area for crushing season 2014-15 would be 5.2 million ha, down three per cent as compared to 2013-14. Based on estimated cane production, sugar recovery and drawal of sugarcane for sugar processing, sugar production may be 25.3million tonnes. It would be 4 per cent higher then be sugar production during season 2013-14.
- Sugar industry has been working below its installed sugar production capacity. It is the main limiting factor responsible for sugar processing inefficiencies and also adds to the per unit sugar processing costs, apart from raw material costs. Therefore, sugar manufactured by India had lost its comparative advantages as compare to major exporting nations and unable to create impact as a reliable sugar exporter in the world market. During surplus sugar production years, gluts led to price decline in domestic market and high investment cost make Indian export non-competitive. Hence, India faces difficult situation in selling surplus sugar in global markets. During low sugarcane production seasons and the raw material shortages to sugar mills lead to sugar production decline. It adds to overhead

expenses and per unit operational costs of sugar production. It adversely affects the economic viability, profitability of the sugar mills and other allied processing industries.

- India is far off-the-mark in realizing the full potential of human and capital resources invested in sugar-energy processing sector. Brazil has become the largest sugar and ethanol producer. It produces 30 to 35 million tonnes sugar, and 28 billion litre ethanol from sugarcane. Brazilian sugar and ethanol production is environmental and eco-friendly as compared to other energy options for present and future requirements. However, Indian sugar and ethanol having cushion of huge domestic market, has not been able to create a stable niche in the international sugar trade.
- The delayed price payment to the farmers for sugarcane supplied by them to sugar mills, de-motivates them for enhancing sugarcane acreage in subsequent years. It leads to consistently fluctuating cycles of sugarcane planting and ultimately notorious sugar cycle of India. Accentuating the poor economic returns of sugar production has lead to stagnant sugar recovery levels. The percentage sugar recovery has been far below standards achieved by major sugarcane growing countries with similar agro-climatic conditions, like as Brazil and Australia. The sugar recovery has been hovering 9.5 per cent to 11.5 per cent, with overall sugar recovery of 10 per cent in India. However, sugar recovery target potential should be 11 per cent for sub-tropical and 13 per cent for tropical region of India.
- India has not been able to exploit the huge potential of sugar industry to fulfill the partial requirement of the energy demand. In Brazil, 40-50 per cent of the motor fuel is met by ethanol produced from sugarcane based distilleries. Brazilian flex fuel vehicles (FFVs) run on any proportion of flexi-fuels such as 20-25 per cent ethanol (E20-E25), 100 per cent ethanol (E100) or gasoline. All gasoline / petrol sold in Brazil since 1975 contains 20-25 per cent ethanol (E25). Brazilian consumers have choice at the pump as the type of fuel they use is based on the price and environment benefits. In 2012, FFVs accounted for 57 per cent of the light vehicle and 92 per cent of new cars sold in Brazil. The PROALCOOL programme had saved the valuable foreign exchange spend on import of petroleum products. However, India is still struggling with the situation to meet the 5 per cent ethanol blending target, set a decade ago to achieve (E5) level of ethanol blending programme goals.
- Bio-ethanol has emerged as renewable and eco-friendly energy source. It could help in enhancing energy self-sufficiency and minimize dependence of India on imported fossil fuels. In this endeavour, Government of India has initiated several programmes to expand ethanol production and its use as biofuels during the past decade. National biofuel mission (NBM) is the leader of such initiatives, with Ethanol blended petrol programme (EBPP) as its integral components. The EBPP had specified time bound ethanol blending targets of 5 per cent, 10 per cent and 20 per cent with petrol in a phased manner to catalyze the shift from the purely fossil fuel based transport system to the partially bio-fuel driven transport system. In India, sole feedstock identified for the ethanol production is molasses as GoI, has not permitted bio-ethanol production directly from sugarcane juice.
- National policy on biofuels (2009) has forecasted biofuels as the potential means for encouraging rural development and additional employment opportunities. It also aims to reap environmental and economic benefits taking place from their large-scale exploitation. NBP has to be carried out solely on the non-edible food-feed stocks, crop residues and sugar mills by-products to avoid conflicting situations for fulfilling the food and energy security.

- The study examines the ethanol blended petroleum pricing mechanism in India in comparison with the global price mechanism. The cost of ethanol production varies with molasses prices. Hence, cyclical variations of sugarcane production mainly determine the ethanol production cost. The estimated ethanol production costs under different expenditure heads to explain the price fixation at ₹ 27 per litre by the government. The ethanol price for a stand-alone distillery varies close to the price fixed by the government. The cyclical sugarcane production and periodic review of ethanol prices has becomes critical. The ethanol prices has also complicated because of decontrol petrol prices and the FRP / SAP for sugarcane.
- Notwithstanding, the progress through different measures has been taken to support biofuels production, progress of the biofuels has been very slow in India. The key issue is that India's ethanol programme depends on economic viability of molasses-ethanol conversion. The reviewed studies reveal that the economics of molasses based ethanol production did not favour ethanol blending with petrol on commercial level. This study also supports this concept and highlighted that the existing production cost and ethanol prices favours its diversion towards potable purpose rather for petrol blending. Hence, the oil marketing companies (OMCs) have not able to achieve mandatory ethanol blending targets fixed by the government.
- Another apprehension has related with long-term sustainability of molasses based ethanol blending programme. The study reveals that if the government has to achieve the EBPP target of 10 percent blending by year 2016-17, planned in NBP, sugarcane production has to reach 735 million tonnes from 10.5 million ha area at existing productivity. It means that the sugarcane production and acreage should be more than double in next five years for attaining 10 per cent ethanol blending target. The growth (CGR) trends for sugarcane area and productivity, fulfilling 20 per cent ethanol blending target still appears highly unrealistic without huge ethanol imports. Moreover, it would be highly unsustainable to expand the sugarcane area beyond a certain limit, keeping in view the fact that sugarcane is a water intensive crop with the requirement of 20,000–30,000 m^3/ ha / crop. The only alternative is to improve the efficiency of ethanol recovery from molasses and ethanol production conversion from sugarcane juice. However, this alternative could affect the sugar production and food security, and an impracticable. Therefore, it is the time to think of diversification of alternative sources for sugar and ethanol production such as sweet sorghum, sugar beet, cassava, and palms etc. These alternative short duration sugar crops can prove to be more sustainable.
- In order to harness the full potential of Indian sugar sector, Government of India has also implemented the Dr. Rangarajan Committee recommendations for sugar sector. It has dispensed away with the key regulations for regulated sugar release and levy imposition on domestic production. These policy reforms expected to boost the performance of Indian sugar mills in long run. Similarly, the trade related barriers have also been removed to give full freedom to the sugar industry. The opening sugar stock of 7.5 million tonnes from season 2014-15 would be sufficient to regulate domestic sugar supply of 24 million tonnes. Hence , GoI, has restored sugar export subsidy @ ₹ 3300 per tonne. It has also offered other incentives to sugar sector for improving economic viability of industry for clearing sugarcane price arrears.

- Biotechnological innovations are crucial to transform bio-ethanol and energy sector into an economical viable options. Technology policy may be vital to bring efficiency in ethanol production and cost- effective so that the second largest agro-based industry should survive without financial subsidy. Therefore, future research had to discover the feasibility of eco-friendly and economical alternative sugar feedstock's crops. The improved technological intervention, mechanization and agronomic practices for sugarcane cultivation, along with R&D support for suitable alternatives feedstock crops may facilitate Indian sugar sector with required thrust. Therefore, efforts should be made to develop second generation technologies for commercial ethanol production from ligno-cellulosic biomass. It is also ensured that the national policy on biofuels must be comprehensive and should be based on the sound pillars such as techno-economic viability, environmental sustainability and demand driven market factors. These policy reforms and implementation should ensure energy security without compromising the food security.
- Indian sugar industry and sugarcane cultivation is passing through a critical phase of restructuring. Hence, sugar industry should also harness the potential of sugarcane production and diversification for power, bio-ethanol , other co-product, jaggery and *Khandsari* for sustainable development of industry and economic prosperity of sugarcane farmer.

1

Introduction

Sugarcane originated in New Guinea, where it has been known since 6000 BC. In 1000 BC, its cultivation slowly spread along with human migration routes to Southern Asia and India. Some literature reveals that it hybridised with wild sugarcane origin of India and China, to produce the thin canes. Sugarcane has incredibly long history of cultivation in the Indian sub-continent. The earliest reference to it is in the Atharva Veda (1500-800 BC), where sugarcane was called *Ikshu* and has mention as an offer during sacrificial rites. The Atharva Veda also mentioned it as the source and symbol of sweet pleasant appearance. The word 'sugar' is derived from the ancient Sanskrit word "*sharkara*". By 6th century BC, sharkara was frequently referred in Sanskrit texts which even distinguished superior and inferior varieties of sugarcane. A Persian description from 6th century BC gives the first account of solid sugar and describes it as coming from the Indus Valley. This early sugar would have resembled as raw sugar, traditional dark brown sugar / Indian jaggery / gur.

Some ancient literature emphasized that sugarcane cultivation originated from tropical south and south east Asia. In India, the process of crystallized sugar, extracted from the sucrose stored in sugarcane, was known 5000 years ago. In 7th century, the knowledge of sugarcane cultivation and sugar production was transferred to China. Approximately in 8th century, sugarcane crop was introduced by the Arabs to Mesopotamia, Egypt, North Africa and Spain, from where it was moved to central and south America. Christopher Columbus brought sugarcane to the Caribbean islands, today's Haiti and Dominican Republic. Driven by the interests of major European colonial powers, sugarcane production had a great influence on many tropical islands and colonies in the Caribbean, south America and the Pacific. In the 20th century, Cuba played a special role as main supplier of sugar to the countries of the former USSR. In the last 30 years, Brazil wrote a new chapter in the history of sugarcane production, the first time not driven by colonial powers and the consumption of sugar, but substantially driven by domestic policies fostering bio-ethanol production to increase energy self-reliance and to reduce the import bill for petroleum.

Global sugarcane production was nearly 260 million tonnes from 6.3 million ha area, with average productivity of nearly 41 tonnes per ha during 1950's. In 1980's, the world annual sugarcane production had reached up to 770 million tonnes, cultivated on 13.6 million ha area with the average yield of 57 tonnes per ha. In next three decades time, world sugarcane production achieved the new height by more than two fold increase in production to 1800 million tonnes from the area of 25.4 million ha. In nutshell, global sugarcane production had enhanced nearly seven times during past six decades. The sugarcane area and productivity also improved 4.0 and 1.75 time respectively with average sustained CGR of nearly 1 per cent per annum during 1950-2011, FAOSTAT (2013).

1.1 Socio-economic impact of sugarcane production and processing in India

Sugarcane cultivation had changed drastically during last six decades. The rationality of cane as the green source of renewable energy entails emphasis in its future planning as the ever increasing population and desires of the people for better quality of life has resulted enormous demand for safe and green energy. Sugarcane crop has extra advantage in terms of biomass production potential because of multiple ratooning that helps in minimizing cultivation cost and produce biomass for several years. Therefore, it offers itself as the natural green carbon resource which could be utilized as a substitute for fossil fuels as biomass for bio-green energy efficient production. It had played crucial role in socio-economic development of rural areas through mobilization of production resources. It has generated enormous avenues for the income and employment generation to the rural work force. It is the main source of raw material for the production of white sugar, green bio-fuel (ethanol), electricity, jaggery and *Khandsari*. However, annual fluctuations in sugarcane acreage, production and productivity have continuously the matter of great concern. These fluctuations in sugarcane area, production and yield had serious implication on cane supply to sugar mills affecting crushing duration, sugar production and ultimately have impact on farmer's income and livelihood security. These fluctuations depend on farm input supply, comparative cost advantage and its relative crops profitability, government price policies, infrastructural facilities, weather and climatic conditions.

In India, there are two distinct zones for sugarcane cultivation, tropical and subtropical. The subtropical comprised of 61 per cent of total sugarcane area contributes only 43 per cent of total sugarcane and 34 per cent of total sugar production. Sugarcane cultivation, especially in sub-tropics had faced serious challenges of sustainability, due to factors such as climate change, escalating cost of cane production, deteriorating soil health, emergence of new diseases and pests, acute labour scarcity, improper cane marketing etc. severely impede sugarcane productivity and sugar recovery. Therefore, high cost of sugarcane production, less productivity and low sugar recovery in sub-tropical north zone are the foremost causes of overall difference between the two zones. The average sugarcane productivity in sub-tropical zone was 58.4 tonnes / ha as compare to 87.9 tonnes / ha in tropical zone during Triennium ending (T.E) 2011-12 respectively.

There were more than 525 sugar factories which utilized nearly 73 per cent of the sugarcane produced and manufactured 25.1 million tonnes of sugar, with an average crushing duration 126 days in 2012-13. The Indian sugar industry also supports the rural economy through income and employment avenues. It also has phenomenal future growth potential, if it could fully exploit the power co-generation and green biofuels / ethanol production. Keeping in view, the potential of sugar industry, Govt of India, has set up an expert committee to review that how best to de-regulate sugar sector to realize and reap benefits. Indian sugar industry is considered worth of ₹ 80,000 crores with huge employment. The sugar industry paid nearly ₹ 50-60,000 crores annually to farmers / growers for the supply of sugarcane and also contributes ₹ 3,400 crores to the Central Exchequer, besides contributing over ₹ 2,200 crores to the state Governments. About 6 million farmers, their dependents and a large number of agricultural labourers are involved in sugarcane cultivation, harvesting and ancillary activities. Besides it, more than 5 lakh skilled and semi skilled workers, primarily from rural villages were engaged in sugar industry, probably the second largest agro-based processing industry after textiles industry / cotton processing in India.

Sugarcane as the renewable energy crop for ethanol production could supplement to fossil fuel. It had provided avenues for further boosting sugarcane production. Because of its renewable energy potential, sugarcane has became the preferred choice, since the Brazilian venture in early

1980's for ethanol production and its utilization as fuel blend with petrol for running automobiles. In India, molasses, a by-product of sugar processing industries, will remain the main raw material for ethanol production. Similarly, bagasse, another by-product of sugar mill and sugarcane agricultural residues (SCAR) should remain raw material for power generation. By year 2030, each and every Indian sugar mill would be modernized as sugar - energy integrated complexes for sugar, ethanol production along with the power co-generation to supplement the electricity demand of rural areas. This would boost the growth of Indian economy and socio-economic transformation of rural India.

1.2 Significance of sugarcane cultivation for sugar-energy production

Sugarcane is a C_4 photosynthetic large standing perennial grass, harvests maximum solar radiation. It has efficient photosynthetic mechanisms amongst the commercial crops. It produces the world's maximum crop tonnage, FAOSTAT (2013) and fixes 2-3 per cent radiant solar energy and transforms it into chemical energy. It has enormous exploitable potential as the stable food

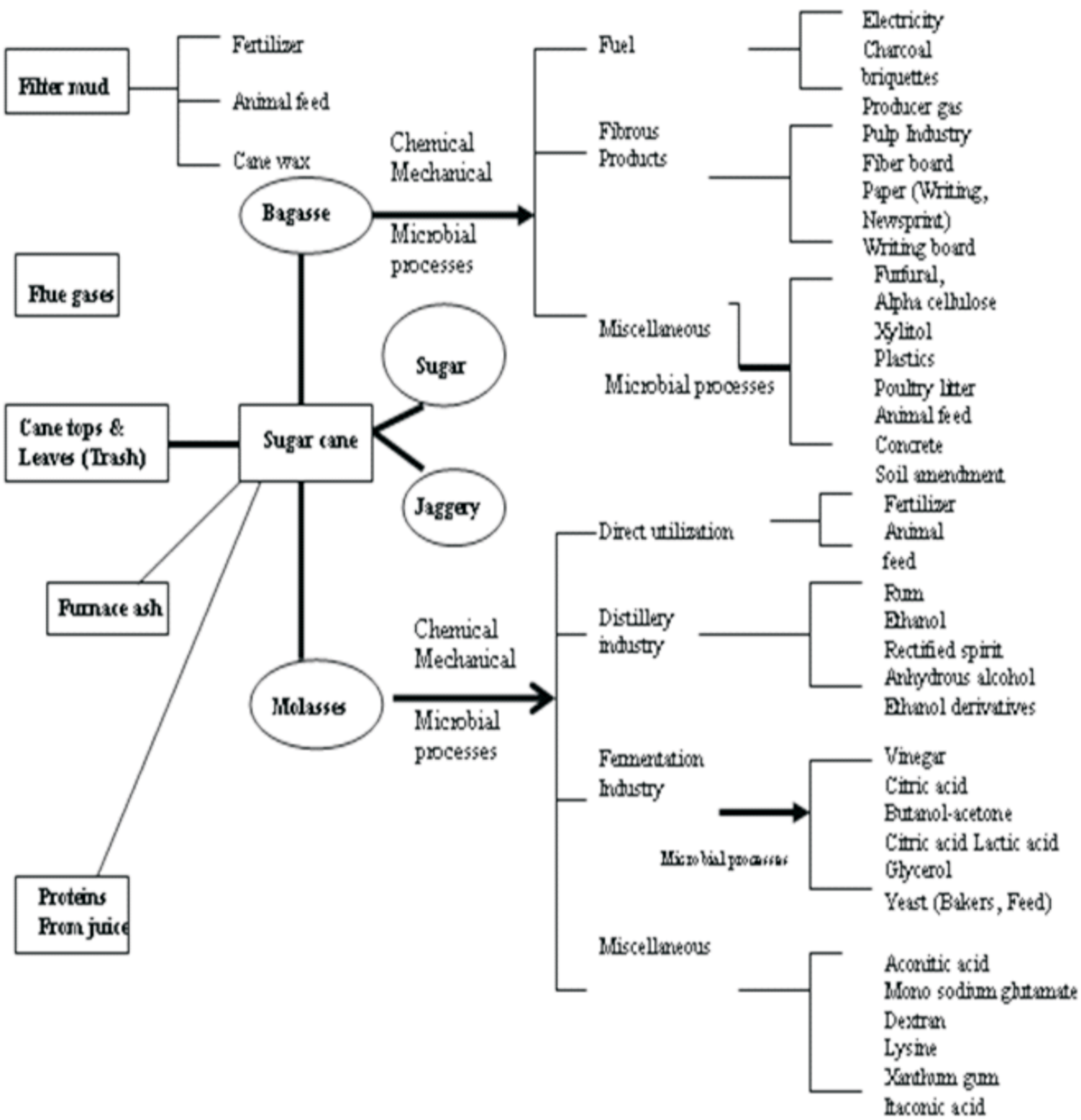


Figure 1: Sugarcane processing and potential value added products development
Source : Paturau, (1982), Singh, (2011)

and fuel source as compared to other alternative sugar bio-green crops. It fixes solar energy into chemical bonds of organic compounds such as carbohydrates composed of sugars and ligno-celluloses have energy content of (~ 15.9 MJ/kg). The high photosynthetic capability allows it to high CO_2 fixation, comparable to the moderate climate zone woods. Hence, it contributes to decreasing the greenhouse gas effect. Sugarcane is an efficient assimilator as it produces nearly 200 tonnes biomass per ha (on fresh weight) in farmers field conditions.

In India, sugarcane crop produces more than 100 tonnes green biomass per ha. every year, which is more than twice the yield of any other commercial crops. Sugarcane yield of 100 tonnes contributes 60-65 tonnes of dry biomass and 8-10 tonnes trash in field. This dry matter when burned has the potential of producing 4000 Kcal per kg (7200 Btu / lb). Therefore, the entire dry biomass has the fuel equivalent of 10- 20 tonnes oil. The efficient utilization of such huge energy potential of sugarcane may supplement nearly 1.0 tonnes of oil equivalents from a unit tonnes sugar production. The energy production capacity of sugarcane is equivalent to five times that used by the alternative sugar crops. Hence, energy produced from sugarcane makes it a key renewable energy bio-resource crop. Besides, sugar processing from sugarcane, it is possible to manufacture 6-7 other value added products and by-products **(Figure 1)**. These products could be used as potential raw materials for the pharmaceuticals, chemical and fuel industries leads for production of more than fifty commercial products. The sugar by-products obtained from sugarcane has potential to serve as substrates for liquid or solid state fermentation processes, second and third generation technologies, a large number of production processes and products may be developed.

1.3 Ethanol production and its blending with petrol for automobile sector

Prior to introduction of fossil fuels as the energy source in the twentieth century, energy generated from agricultural biomass holds the key position. The post Independence period witnessed the reversal scenario as agricultural production became gradually more reliant on fossil fuel based inputs, viz. chemical fertilizers, plant protection chemicals and power operated farm machinery used non-renewable fossil fuels. Similarly, the growing dependence of surface transportation system has made it more reliant on fossil fuel energy. Therefore, a small shock in the petroleum products supply, because of its production decline or prices increase has straight blow on the agricultural production and allied agro-processing sector. Like agriculture, many other sectors also depend on fossil fuels, which is a non-renewable source of energy.

Therefore, energy security has become an important global policy issue during later half of 20th century and will also continue in 21st century. Transport fuels like bio-ethanol have been receiving increased attention in recent years as an alternative solution for solitary dependence on imported petroleum fuels. It has destabilizing price effects on the developing economy and caused serious environmental problems such as degradation of forest, natural resources and ultimately leads to climate change. Indian national fuel and energy policy has proposed an ambitious target of 20 per cent ethanol blending with petrol by end of XIIth five year plan in March 2017. This policy paper attempts to work out the economic feasibility of sugarcane processing industry by-products especially molasses for bio-ethanol production in India without compromising the objectives of food security as a competing policy priority. The review study indicated that the 20 per cent blending of bio-ethanol with petrol could not be achieved without affecting sugar production for food security in India at the existing level of raw material productivity and its processing efficiencies. In addition to this, the cost of sugarcane based bio-ethanol production also exceeds the social benefits. Hence, the use of sugarcane bio-ethanol may not rationalize on economic concern. The molasses, a by-product of sugar mills, could support only up to 5 per cent blending of bio-ethanol without compromising sugar production for food security. It also improve socio-economic welfare of sugarcane farmers. The first generation bio-ethanol production has limited scope to fulfill the ever increasing energy demand in the country. Therefore, India's ambitions to enhance energy security should rely only on second generation bio-ethanol production technologies which require the R&D efforts to make them economically viable.

Bio-energy is the energy generated from renewable biomass of plants origin. The biofuels have environmental, social and economic advantages, apart from the renewable alternative to fossil fuels. They may be useful in controlling the vehicle pollution and green house gases production through the emission of sulphur dioxide, lead and carbon monoxide are comparatively less from biofuels, Subramanian ***et al.*,** (2005**).** These biofuels are classified as first and second generation biofuels. The first generation biofuels are produced from the agricultural biomass consist of sugars, starch, vegetable oils, animal starch and other biodegradable by-products of processing industry, forestry and households wastes, by applying conventional technologies. The cereal crops such as maize, sweet sorghum and sugar crops like sugarcane, sugar beet etc. could be simply fermented for the ethanol production. The green bio-ethanol could be used as automobile fuel in either pure form or blended with the petrol/gasoline. However, the production of first generation biofuels had some limitations. They could not be produced beyond a threshold level without affecting food security. To overcome such problems, there is prime need to explore the possibility of second generation biofuels which are affordable, available in sustainable manner and eco-friendly. They comprise of ligno-cellulosic materials such as grasses, trees, agricultural crops residues, poultry manure and processing waste, animal waste and municipal solid wastes. Therefore, the possibilities for conversion of such agro-industrial waste material into bio-ethanol should be explored. The review of literature reported that the technologies to convert algae into ethanol had been developed. However, these processes are relatively complex as compared to sugars and food grains processing for bio-ethanol production. Keeping in view, bio-ethanol future demand, the R&D should be initiated to develop cost effective processes and technologies to convert cellulosic rich crop and animal wastes into green bio-ethanol energy.

The developed countries had adopted the aggressive policies to encourage ethanol production, new dimensions of adverse impact of expansion of biofuels have also emerged. The studies had shown concerns about the environmental sustainability of production, green house gas emissions and its impact on land use pattern, food security and prices of food commodities IEA, (2008); FAO, (2008). There are apprehensions that with more and more land allocation for biofuels crops, food prices could increase substantially, adversely affecting consumers belonging to the low-income net food importing countries. The deliberations on the food fuel energy trade-off is gaining momentum with most of the major biofuels-producing countries resorting to using staple food crops for bio-energy production. It is estimated that out of the total fuel, ethanol, being produced globally at present, around 60 per cent, is from the cereals and the rest from sugarcane, both of which are important food crops. As per the estimate of National corn growers association of the United States, it was reported that the US diverted 81million tonnes corn for ethanol production during 2007-08. This corn quantity was not small when compared with the total world trade corn, which was 89 million tonnes in 2007- 08. Similarly, Canada and China also met most of their ethanol requirements from corn and wheat. However, the primary feedstock used for ethanol in Brazil is sugarcane. In addition to cereals and sugarcane, oilseeds such as rapeseed, soybean and sunflower may be diverted for biofuels production.

The diversion of food crops for energy production is believed to be one of the major contributing factors towards a drastic rise in food prices in global market in recent years Von Braun, (2008), and especially maize for bio-ethanol production in USA, Rosegrant, (2008), Runge and Senauer (2007). The world may witness unprecedented levels of food riots due to high price for the food grains. The wheat price in the US increased up to $ 326 per tonnes and the corn price went up to $ 223/ tonnes during production year 2008. The impact of price rise in these food commodities also reflected in Indian domestic markets. Keeping in view, the concerns of future impact on food prices, China changed its biofuels policy to restrain the use of food grains as feedstock and immediately slowed down its ethanol production Qiu *et al.,* (2010). The analysis based on global bio-fuel expansion plans by applying International Food Policy Research Institute (IFPRI) IMPACT model cautioned that the oilseeds and corn prices may further rise by 18 and 26 per cent respectively by the year 2020.

India has also initiated the bio-ethanol production programme for exploring the cleaner energy source and partially to counterbalance, the ever growing imports bill for crude petroleum products. It is mainly relying on the fossil fuels for energy requirement, which has imported from various nations. The demand of petroleum products as source of energy has gone up drastically, leading to abnormal increase in the prices of these products. In this backdrop, Government of India has initiated an ambitious programme for exploring the possibility of ethanol blending with petrol to meet the future energy demand. The Government actually intends to achieve the multiple objectives of energy security and environment protection, higher income and employment opportunities for the rural population. The efforts made to meet these objectives were started during first decade of 21st century with introduction of National Biofuel Mission (NBM) in 2003 and National Policy on Biofuels (NPB) released in 2009. These initiatives have set the indicative for bio-ethanol blending target up to 20 per cent with petrol by year 2017, GOI, (2009). In concurrence with the NPB, India allowed to produce bio-ethanol only from non-edible feedstock's such as molasses, a by- product of sugar industry. However, bio-ethanol could also be produced directly from sugarcane juice and other sugar crop sources such as sweet sorghum, sugar beet, cassava, etc. without compromising food and fodder security.

Prior to initiation of NBM, Govt. of India had undertaken an *ex-ante* assessment by the Planning Commission. It was followed by the establishment of institutional and policy framework for implementation of various R&D activities. However, non-existence of favourable environment for production, processing, marketing and distribution of ethanol, programme has witnessed very slow progress. Therefore, Government of India is unable to meet its ethanol blending targets with petrol. Hence, questions arise about the future of bio-ethanol production in India. The essential are what is the current status of bio-ethanol production in India? Whether existing choice of feed stocks and technologies are suitable to meet the ethanol future demand of the nation? What are the constraints inhibit the progress of bio-ethanol production and power cogeneration in India? What are the pre-requisites for economically viable and self-sustainable bio-ethanol industry? What would be socio-economic implications of large-scale bio-ethanol production? What would be the impact on food, fodder, fuel security and exiting farming systems? Keeping in view, above facts, the present study has been formulated with the following objectives

(i) To examine changes in sugarcane area, production, productivity in India and other major production countries during past decades.

(ii) To identify the socio-economic constraints faced by the sugarcane growers and sugar producers in production and marketing of sugarcane, sugar, co-product and suggest suitable means for efficient sugarcane and sugar - energy supply chain in India.

(iii) To analyse the status of bio-ethanol production and power cogeneration in context of institutional mechanisms infrastructural facilities and national policies.

(iv) To examine the pricing and taxation aspects of bio-ethanol blending and power supply policy in India

(v) To examine techno-economic potential of the major feedstock's for bio-ethanol production and power generation in India.

(vi) To identify the socio economic constraints that hold back the development of bio-ethanol production, suggest interventions and suitable policy reforms.

(vii) To estimate the future requirement and challenges for sugar, jaggery and *Khandrasi*, power cogeneration and bio-ethanol production and also suggest appropriate measures.

1.4 Scope of the Policy Paper

This policy paper addresses the socio-economic aspects of farmers involved in sugarcane production and sugar processing industries in India. The problems faced by the farmers in sugarcane cultivation involve marketing problems of sugar industry dealing with procurement of raw material, price policies, sugar production and distribution pattern. The paper also assesses alternative feedstocks crops such as sugar beet, sweet sorghum, cassava etc. for production of green energy in the form of bio-ethanol and power cogeneration. The ethanol requirement for blending with petrol to fulfill the future need of energy sector in India is an alternative to non-renewable transportation fuels. The importance of development of sugar and bio-energy sector to achieve the twin targets of food and energy security within the framework of the complex policy matrix in India has also been highlighted. It also explains the fundamental issues with conflicting objectives of potential development of Indian sugar and bio-energy sector. It also analyzes the consequences of large scale development of bio-ethanol production in India, keeping in view, the future challenges of food security bill 2013 recently passed by the GoI. Therefore, it is essential to cover the other probable feedstocks to be considered for ethanol production. The policy paper also illustrates and discusses the existing production potential, as well as agronomic and techno-economic constraints which could restrict their potential growth. Besides, addressing the issues of competitiveness of the emerging bio-ethanol supply chain, the policy reforms and technological interventions essential for efficient production and sustained economic viability of Indian sugar industry, electricity co-generation and ethanol based energy sector have been highlighted.

2

Present Status of Sugar and Bio-ethanol Production: An Overview

2.1 Global sugarcane and sugar production scenario

Brazil has landmark development in the history of sugarcane production. Its sugarcane production not driven by colonial powers and sugar consumption, but significantly pushed by domestic policies for nurturing ethanol production for energy self-reliance and to reduce the import bill for petroleum products especially gasoline used as motor fuel. World crop production database FAO (2013) reveals that the global sugarcane production was 448 million tonnes produced from 8.91 million ha., with the average productivity of just over 50 tonnes per ha. during 1960's *(http://www.fao.org)*. After, three decades, in 1990's, the global annual sugarcane production had touched the level of 1053 million tonnes from 17.08 million ha acreage with the average yield of 61 tonnes per ha. During next two decades, the sugarcane production for 2011 indicates more than 1.75 time increase in output. The global sugarcane production touches the level of 1800 million tonnes from approximately 25.4 million ha with average productivity 71 tonnes per ha. In nut shell, the global sugarcane production had a nearly four times increase and sugarcane area increase by 2.8 times during last five decades (1961 to 2012). During this period, the average global sugarcane productivity has also improved from 50 to 71 tonnes per ha with the sustained CGR of nearly 0.72 per cent in sugarcane yield per annum.

Figure 2 View of sugarcane cultivation in India

The sugarcane has been widely cultivated in more than 100 countries across the world. Based on the FAO production database, 12 major sugarcane producing countries were selected for the study purpose **(Table 1)**. It indicates that the main sugarcane producing countries and ranked them on their production during year 2012. It is evident that the global sugarcane production ranks vary at the decade interval period. India ranks first as the leading sugarcane producer prior to 1980's. Brazil ranks first in sugarcane production since 1981, followed by India. During 1960's, India, Brazil and Cuba were the three largest sugarcane producers in the world. India dominated in global sugarcane production up to 1980, when Brazil took over the first rank in sugarcane area and production. Cuba maintained third rank amongst the major sugarcane producers till 1991's. However, after that the disintegration and collapse of the USSR, Cuba's assured sugar export market and its sugar industry also crumpled rapidly during economic trade liberalization WTO regime. The latest sugarcane production in Cuba reveals that its production had declined drastically since 1990's. Cuba is the major sugarcane producing nation which lost its rank from 3^{rd} to 12^{th} during trade and economic liberalization since implementation of WTO regulation. In China, sugarcane cultivation has been revolutionized during last two decades. Since, 1990's sugarcane production and productivity in China has improved drastically. Therefore, China has now becomes the 3^{rd} largest sugarcane producer after Brazil and India during a short span of hardly two decades. The other asian countries such as Pakistan and Thailand also improved their global ranks as sugarcane growing nations during five decades.

Table 1 : Ranks of major sugarcane producing countries (1961-2012)

Sl.	Country/Years	1961	1971	1981	1991	2001	2012
1	Brazil	2	2	1	1	1	1
2	India	1	1	2	2	2	2
3	China	9	8	7	4	3	3
4	Cuba	3	3	3	3	7	12
5	Australia	7	7	8	10	8	9
6	Guatemala	11	11	11	11	11	10
7	Indonesia	6	9	9	8	10	8
8	Mexico	4	4	5	6	5	6
9	Pakistan	9	6	6	7	6	5
10	Philippines	5	5	7	9	9	7
11	Thailand	10	10	10	5	4	4
12	Vietnam	12	12	12	12	12	11

Data source: FAOSTAT, online database at http://www.fao.org, accessed July 2014

FAO database reveals that the sugarcane is primarily used as raw material for sugar and ethanol production in the more than 100 countries across the world having tropical climatic conditions. However, global sugarcane production is largely concentrated in only the few countries as evident from **Table 2**. These 12 countries accounted for nearly 85 percent of the total world sugarcane production during 2011. The countries rank 1 to 5 namely Brazil, India, China, Thailand and Pakistan produced approximately 75 percent of the total sugarcane production. Brazil alone contributed 40 percent of total global sugarcane production during first decade of 21^{st} century. India and China accounted for nearly 20 and 6 percent of total world sugarcane production respectively during year 2012. The sugarcane production growth has been phenomenal in Brazil, Thailand and China.

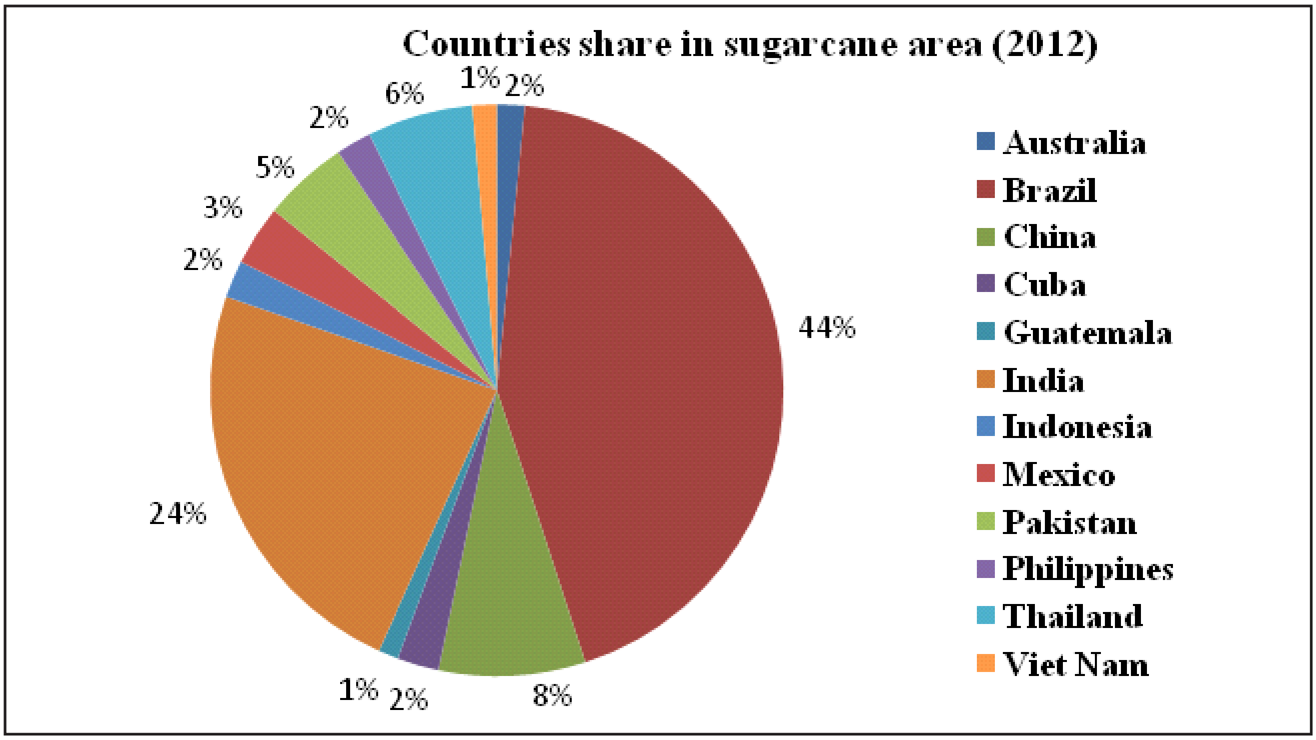
Table 2 : Global Sugarcane production in selected countries during 1961-2013

(In million tonnes)

Sl.	Country/Year	1961	1971	1981	1991	2001	2011	2013
1	Australia	9.7	19.4	25.1	21.4	28.1	25.2	27.1
2	Brazil	59.4	80.4	155.9	260.9	345.9	734.0	739.3
3	China	4.3	13.1	29.7	67.9	75.7	114.4	126.1
4	Cuba	55.9	54.7	66.7	79.7	32.1	15.8	14.4
5	Guatemala	1.5	2.8	6.3	10.8	16.9	20.6	26.3
6	India	110.0	126.4	154.2	241.0	296.0	342.4	341.2
7	Indonesia	10.9	11.2	22.3	28.1	25.2	24.0	33.7
8	Mexico	19.2	32.7	33.2	38.4	47.3	49.7	61.2
9	Pakistan	11.6	23.2	32.4	36.0	43.6	55.3	63.8
10	Philippines	17.5	27.6	31.6	24.8	27.0	30.0	32.0
11	Thailand	2.0	6.6	19.9	40.7	49.6	96.0	100.1
12	Viet Nam	1.4	1.1	4.0	6.2	14.7	17.5	20.0
	Sum of above	303.4	399.2	581.2	855.9	1002.0	1524.9	1586.1
	World (Total)	448.0	582.1	799.6	1089.3	1266.5	1800.4	2165.2
	per cent of World	67.7	68.6	72.7	78.6	79.1	84.7	73.3

Source: FAOSTAT, online database at http://www.fao.org, accessed July 2014

Figure 3 : Sugarcane production share of major producing countries



The world sugarcane acreage is also concentrated in the few countries as evident from **Table 3**. The identified 12 countries account for 74 percent of the world sugarcane area in 1961. It is evident from **Table 3** that the sugarcane area further intensified in these countries during past five decade's period. The total sugarcane acreage of listed nations now accounts for 84 percent of world area under sugarcane. The top three rank countries Brazil, India and China had nearly 65 per cent of the global sugarcane acreage during year 2011. Brazil alone had a lion's share of approximately 38 per cent in global sugarcane area. India and China accounted for 19 and 7 per cent of the world's sugarcane area respectively during 2011. The area under sugarcane also improved in other selected countries of asian and other sub-continents during past five decades highlighted the significance of sugar, electricity and ethanol for food and energy security. The higher compound growth rate (CGR) in sugarcane production was attributed by the acreage extension and productivity improvement in most of the sugarcane producing countries of the world. It was found that the three time sugarcane acreage expansion during past five decades since 1960's was in asian sub-continent. It was mainly attributed by the ever increasing population, human living standard index and higher income growth that had boosted up the domestic demand of sugar, jaggery and other sweeteners in China and India. Amongst the listed countries, only Cuba has found the declining trend in sugarcane acreage during reported years. It indicates that the Cuba sugarcane production has becomes uneconomical to the farmers due to collapse of sugar industry during last two decades. The energy demand in the form of bio-ethanol and co-generation of power from sugarcane bagasse has played a minor role in this dynamics in the countries of Asian continent. Brazil is the exception, where the PROALCOHAL programme well supported by the sugarcane processing infrastructural facility, capital investment and other suitable government policies to create environment for foreign investors for creation of additional sugar and ethanol processing facilities to utilize sugarcane production more efficiently.

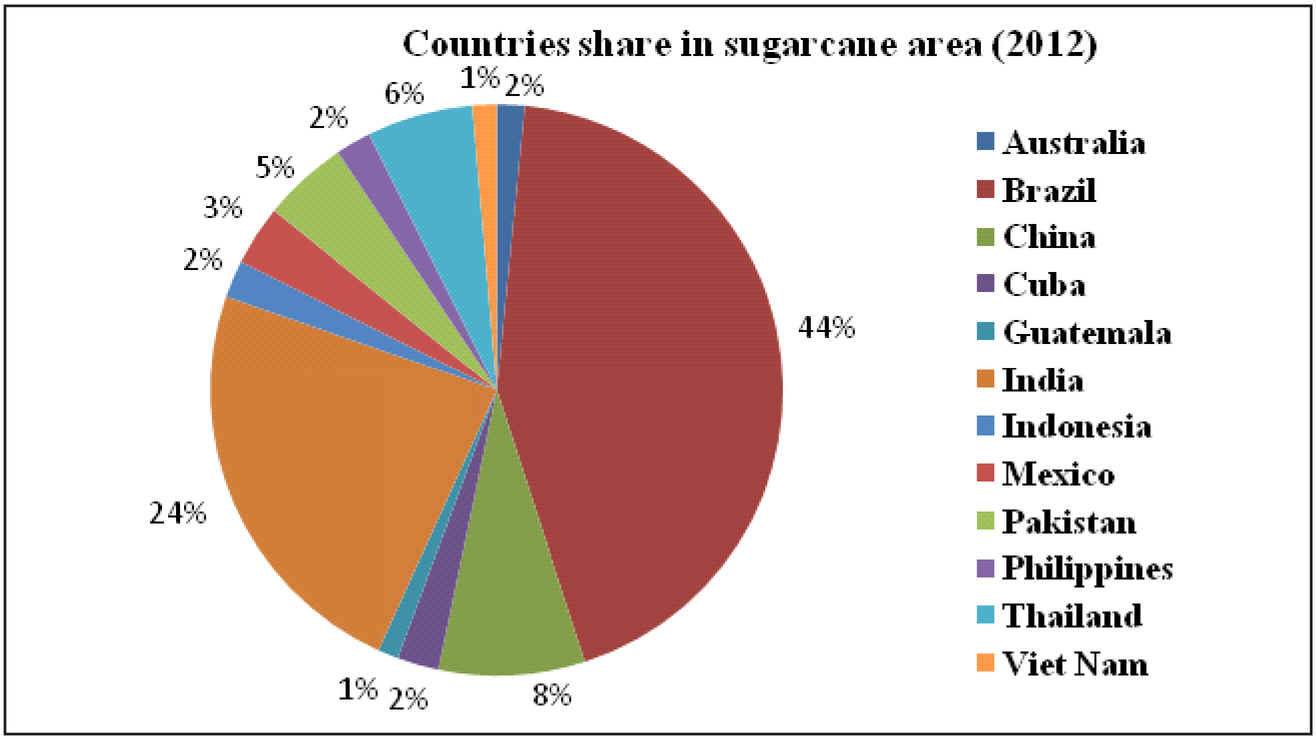
Table 3 : Sugarcane area in major producing countries during 1961-2013

(In lakh ha.)

Sl.	Country/Years	1961	1971	1981	1991	2001	2011	2013
1	Australia	1.57	2.34	3.16	3.41	4.03	3.08	3.29
2	Brazil	13.67	17.28	28.26	42.11	49.58	96.01	98.35
3	China	1.89	4.26	5.51	11.64	12.48	17.21	18.27
4	Cuba	12.61	13.54	12.09	14.52	10.07	5.06	3.61
5	Guatemala	0.30	0.41	0.80	1.23	1.82	2.39	2.61
6	India	24.13	26.15	26.67	36.86	43.16	49.44	5.06
7	Indonesia	0.80	0.71	1.93	3.65	3.86	4.35	4.50
8	Mexico	3.48	4.81	5.30	5.47	6.24	7.14	7.82
9	Pakistan	3.88	6.36	8.25	8.84	9.61	9.88	11.29
10	Philippines	2.32	4.42	4.00	3.60	3.87	4.40	4.35
11	Thailand	0.63	1.38	4.57	7.83	8.38	12.59	13.2
12	Viet Nam	0.44	0.28	1.10	1.45	2.91	2.82	3.09
	Sum of Above	65.70	81.93	101.62	140.60	155.99	214.38	220.9
	World (total)	89.12	110.55	136.87	177.83	195.90	253.94	265.2
	% of World	73.72	74.11	74.25	79.06	79.63	84.42	83.33

Source: FAOSTAT, online database at http://www.fao.org, accessed July 2014

Figure 4: Share of sugarcane area of major producing countries



These favourable policies development in Brazil were responsible for socio-economic transformation of farmers, mechanization of sugarcane cultivation and harvesting operations, development of integrated sugar-energy-power generation complexes and huge expansion of sugar industry and bio-ethanol production. The Brazilian experiences and capability for responding successfully to international demand for transport motor fuels, which was recently triggered by the suitable measures to diminish greenhouse gas emissions from rampant growing transport sector, concerns in developed countries to enhance energy security and minimize dependence on non-renewable petroleum products. There is urgent need for many developing countries such as India to reduce petroleum import bills and partially fulfill the ever increasing future energy demand of automobile sector through ethanol blending with petrol.

Amongst the selected 12 major sugarcane producing countries of the world, three nations namely Cuba, Indonesia and Philippines had observed declining trend in sugarcane productivity. The sugarcane productivity in Indonesia was very high during 1980's. It has declined from 158 tonnes/ha to 55 tonnes/ha during last three decades. Similarly, the sugarcane yield in Cuba also decreased from 55 tonnes/ha during 1990's to just 31 tonnes/ha in 2011, **Table 4**. It is evident from**Table 4** that the sugarcane productivity has improved further in the other selected countries of different sub-continents during past five decade's period. The average productivity of major sugarcane producing nations has enhanced from 46 to 71 tonnes/ha during 1961-2011. It has contributed significantly for improvement of global sugarcane productivity. It was due investment on research and development of suitable sugarcane high yielding varieties, mechanization and modernization of sugar processing technologies. Australia, Brazil, Thailand and Guatemala have sugarcane productivity of more than 75 tonnes/ha. The top three ranks countries Brazil, India and China have average productivity of nearly 73 tonnes/ha during year 2011. The sugarcane productivity in China has increased by three times during the study period. The global sugarcane productivity has also improved from 50 to 70 tonnes/ha during 1961-2011.

It may be concluded that the sugarcane production performance, sugar and other value added products processing technological advancement, suitable policies in different countries was quite impressive and helps a lot in socio-economic transformation of sugarcane farmers. It is observed that the some countries registered diminishing trends in sugarcane productivity during post liberalization WTO reform period. However, the global sugarcane production has showed that the sugarcane acreage and yield was stable in majority of countries in post reform period as compare to pre-reform regime. The bio-ethanol production has played the key role in the sugarcane production dynamism in Brazil. The Brazilian dominance in global sugar market, ethanol trade and energy production was responsible for the huge expansion of sugarcane based agro-industrialization during first decade of 21st century.

Table 4 : Sugarcane productivity in major producing countries during 1961-2013

(In tonnes/ ha)

Sl.	Country/Years	1961	1971	1981	1991	2001	2011	2013
1	Australia	62.17	82.96	79.42	62.66	69.77	81.73	82.4
2	Brazil	43.45	46.52	55.18	61.95	69.78	76.45	75.2
3	China	22.64	30.84	53.86	58.34	60.63	66.49	69.03
4	Cuba	44.33	40.40	55.14	54.88	31.87	31.22	39.8
5	Guatemala	51.79	68.40	79.09	88.15	93.05	86.04	100.7
6	India	45.59	48.32	57.84	65.39	68.58	69.25	67.4
7	Indonesia	136.64	158.13	115.49	77.08	65.23	55.17	74.9
8	Mexico	55.14	68.02	62.68	70.26	75.75	69.67	78.2
9	Pakistan	29.99	36.43	39.24	40.72	45.39	56.00	56.5
10	Philippines	75.19	62.59	79.01	68.91	69.76	68.23	73.5
11	Thailand	31.75	47.75	43.49	51.96	59.17	76.20	75.7
12	Viet Nam	32.18	39.71	35.97	42.62	50.42	62.14	64.7
	Sum of Above	46.18	48.73	57.19	60.88	64.23	71.13	71.8
	World (total)	50.27	52.65	58.42	61.26	64.65	70.90	81.6
	% of World	91.87	92.54	97.89	99.38	99.35	100.33	87.9

Source: FAOSTAT, online database at http://www.fao.org, accessed July 2014

2.2 Indian sugar production and consumption scenario

The sugar industry sustained the livelihood of 6 million agricultural farm families and 0.5 million skilled and semi-skilled industrial workers families as it generated significant employment in ancillary and allied activities. The area under sugarcane hovers around 5 million ha which is around 2.6 per cent of the gross cropped area (GCA) in India. In fact, sugar manufacturing, power cogeneration and alcohol distillery processing is the second largest agro based industry after textiles in India. The turnover of the sugarcane and sugar related economic activities were ₹ 80 to 85 thousand crores per annum, out of which approximately ₹ 55 to 60 thousand crores paid to the farmers for supply of sugarcane to the sugar mills, jaggery and *Khandsari* production units all over the country. India's share in global sugar production has improved from 5 percent to 16 percent during last 50 years period. Similarly, India's share in global sugar consumption has also increased from 5 to 13 percent during study period.

In nutshell, globally, India is one of the largest producer as well as consumer of sugar and sweeteners. India is now the second highest sugar producer after Brazil in the world. In spite of the largest sugar consumption base in the world, India is not only self-sufficient in sugar production required to satisfy the domestic demand but also generate exportable sugar surpluses. The annual sugar production in India varies from 24–26 million tonnes during past three sugarcane crushing seasons. Hence, India had met its huge domestic annual sugar consumption requirements of 23 million tonnes for the current sugar season 2012-13. It also had enough surplus sugar to maintain buffer stock for maintaining domestic supply at reasonable price to fulfill future demand.

The compound annual growth rate (CAGR) for domestic sugar consumption was 3.5 percent during past three decades. This CAGR was more than the global average and is attributable not only to the lower initial base but also to the ever increasing disposable income (2.1 per cent contribution on this account is equivalent to world standards of per capita sugar consumption growth) as well as high population growth (1.4 per cent contribution). The share of bulk consumers in the aggregate sugar consumption basket ranges from 60 to 65 percent. The share of the individual household consumers in total sugar consumption was 35-40 percent of the aggregate consumption at national level. The estimated per capita sugar availability and consumption was 18 kg / year for sugar season 2011-12 in India, Economic survey (2012-13). The jaggery and *Khandsari* also produced from sugarcane and other sugar based crops is the another source of sweetener with the average per capita consumption of 5 kg /annum. Therefore, the aggregate per capita annual sweetener consumption in India was 23 kg / annum which was still lower as compared to the world aggregate sugar consumption of 24 kg /annum. Hence, the present level of sugar consumption illustrates enormous opportunities for the domestic sugar industry as well as traditional gur and *Khandsari* production units. As the country's population and income grows in future, the domestic sugar consumption could match the world standards of per capita consumption 24 kg annually and subsequently the per capita consumption of developed economies of Europe and American sub-continents 35-40 kg /annum.

2.3 Socio-economic transformation through sugarcane production and processing

Sugarcane cultivation and sugar industry sector have seen profound changes during last four decades. It had plays the vital role in socio-economic development of rural economy through mobilization of production resources and provided better avenues for income and employment through development of Indian sugar processing industries. It is the main source of raw material for the production of white sugar, green biofuels, jaggery and *Khandsari*. The annual fluctuations in sugarcane production continued as the matter of concern and discussion to solve the problem of raw material supply to the sugar mills. The fluctuations in sugarcane area and production had serious implication of processing raw material supply management chain to sugar mills affecting crushing duration and sugar-energy production. These fluctuations in sugarcane production and productivity depends on farm input supply, comparative production cost advantage and relative profitability, government price policies, timely cane price payment to the farmers, infrastructural facilities and climatic conditions. The Indian economy was opened to world market with several economic liberalization reforms in 1990's. These reforms would have impact on international trade of agricultural crops and commodities.

The compound growth rates (CSRs) and instability in sugarcane acreage, production and productivity were worked out for six major producing states as well as at country level. Sugarcane and sugar production in India has been well known for the wide yield gaps, sugar recovery in tropical and sub-tropical states. There were variations in crop duration, crop production and market management practices, climatic conditions, availability of natural resources, government policies, institutions, infrastructure etc. amongst these states. Because of these variations, pattern of growth in sugarcane area, production and yield respond to various incentives, motivational and inducements vary across the tropical and sub-tropical states. Similarly, instability in sugarcane illustrates the agro-based industrial development patterns in different states during the pre and post economic reform regimes. The estimated CGRs and instability index in sugarcane area, production and yield are presented in **Table 5**. It is evident that the area under sugarcane has increased from 2.49 million ha to 5.0 million ha during past four decades, with the CGR of 1.63 per cent and instability index 0.08. In spite of pressure of high acreage allocation to food grain crop to feed ever growing population, the CGR in sugarcane area was quite impressive. Similarly, sugarcane production has also increased substantially with CGR 2.52 per cent which was significant at 1 per cent level during study period. However, the productivity CGR was marginal and the instability index of 0.104 does not indicates wide fluctuations in sugarcane production at national level.

The sugarcane production performance as indicated by the CGRs in Karnataka, A.P. Maharashtra and Tamil Nadu which was significant at 1 per cent was comparatively better than the states of sub-tropical region. The sugarcane yield in India has registered the annual CGR of 0.88 per cent with instability index 0.05. Therefore, it is concluded that the sugarcane production growth was more due to increase in area as compare to yield. The analysis also reflected that there was wide difference in sugarcane yield in tropical and sub-tropical states.

Table 5 : CGRs and instability in sugarcane area, production, yield (1970-71 to 2012-13)

(Area in million ha, production in million tonnes, yield tonne/ha)

States	Av. T.E 1973	Av. T.E 2013	CGRs	T- value	Instability index
U.P. (Area)	1.35(54.4)	2.17(43.4)	1.208**	15.706	0.068
Production (P)	55.62(45.7)	126.62(36.6)	2.266**	15.388	0.097
Yield (Y)	41.1(84.1)	58.4(84.4)	1.046**	10.456	0.072
Maharashtra (A)	0.18(7.3)	0.98(19.5)	4.066**	16.574	0.199
Production (P)	12.73(10.5)	76.37(22.1)	3.753**	11.664	0.236
Yield (Y)	70.9(145.0)	78.1(112.7)	-0.300*	-2.174	0.094
A. P. (A)	0.12(5.0)	0.20(4.0)	1.335**	7.563	0.136
Production (P)	9.87 (8.1)	15.75(4.6)	1.549**	7.624	0.158
Yield (Y)	79.6(162.7)	79.7(115.1)	0.211*	2.251	0.093
Tamil Nadu (A)	0.13(5.3)	0.35(7.1)	2.417**	13.348	0.148
Production (P)	10.73(8.8)	38.35(11.1)	2.818**	11.952	0.185
Yield (Y)	81.3(166.1)	108.9(157.2)	0.391**	4.438	0.066
Karnataka (A)	0.10(4.1)	0.42(8.4)	3.150**	11.932	0.148
Production (P)	8.61(7.1)	36.90(10.7)	3.501**	10.603	0.200
Yield (Y)	83.9(171.5)	87.9(126.9)	0.340**	2.815	0.105
Haryana (A)	0.14(5.4)	0.10 (1.9)	-0.719**	-3.157	0.163
Production (P)	6.04(5.0)	6.83(2.0)	0.746**	2.997	0.194
Yield (Y)	44.7(91.5)	71.4(103.1)	1.475**	11.184	0.126
India (A)	2.49(100.0)	5.01(100.0)	1.629**	17.827	0.083
Production (P)	121.60(100.0)	345.99(100.0)	2.521**	18.475	0.104
Yield (Y)	48.9(100.0)	69.3(100.0)	0.878**	11.187	0.051

Figures in parentheses are percentage to national level

Source: www.iisr.nic.in

** Significant at 5 per cent and ** Significant at 1 per cent probability*

2.3.1 Performance of sugarcane production and sugar sector during pre-reform regime

The estimated CGRs and instability index for sugarcane area, production and yield during pre economic liberalization WTO regime are presented in **Table 6**. It is evident that the sugarcane area in U.P. has increased from 1.35 to 1.77 million ha during 1970-1990, with the annual CGR of 1.50 per cent and instability index was 0.083. Though the Uttar Pradesh had maximum sugarcane acreage, its share at national level has declined marginally. Similarly, sugarcane production in U.P. increased substantially with CGR 3.09 per cent which was significant at 1 per cent level during pre-reform period. Though the CGR of sugarcane production for Uttar Pradesh was slightly higher than CGR at national level, the instability index of 0.12 indicates wide annual fluctuations. Maharashtra, another leading sugarcane production and sugar processing state, registered the higher CGR's in area and production. In Haryana, the sugarcane production and sugar processing growth was poor with high instability as compare to other states of India. However, sugarcane production was comparatively stable in India with instability index of 0.09 during pre-liberalization regime.

Table 6 : CGRs and instability in sugarcane area, production and yield in pre-reform period

(Area in million ha, Production in million tonnes, Yield tonne/ha)

States	Aver. TE 1973	Aver. TE 1990	CGRs	T- value	Instability index
U.P. (Area)	1.35(54.4)	1.77(53.0)	1.502**	5.899	0.083
Production (P)	55.62(45.7)	92.99(44.6)	3.088**	8.292	0.119
Yield (Y)	41.1(84.1)	52.4(84.3)	1.562**	6.473	0.083
Maharashtra (A)	0.18(7.3)	0.33(9.8)	3.940**	8.271	0.116
Production (P)	12.73(10.5)	32.641(15.7)	4.708**	7.644	0.138
Yield (Y)	70.9(145.0)	85.5(137.5)	0.739	2.068	0.082
A. P. (A)	0.12(5.0)	0.15(4.5)	0.688	1.366	0.154
Production (P)	9.87 (8.1)	10.46(5.0)	0.217	0.413	0.169
Yield (Y)	79.6(162.7)	68.9(110.8)	-0.467	-1.510	0.114
Tamil Nadu (A)	0.13(5.3)	0.22(6.4)	2.564**	6.491	0.136
Production (P)	10.73(8.8)	22.63(10.9)	3.719**	6.719	0.180
Yield (Y)	81.3(166.1)	105.0(168.9)	1.126**	4.152	0.079
Karnataka (A)	0.10(4.1)	0.24(7.0)	4.565**	12.719	0.086
Production (P)	8.61(7.1)	19.17(9.2)	4.689**	12.860	0.104
Yield (Y)	83.9(171.5)	81.6(131.1)	0.119	0.431	0.082
Haryana (A)	0.14(5.4)	0.13(4.0)	-0.844	-1.519	0.162
Production (P)	6.04(5.0)	6.19(3.0)	0.016	0.0241	0.212
Yield (Y)	44.7(91.5)	46.9(75.4)	0.868	1.754	0.160
India (A)	2.49(100.0)	3.35(100.0)	1.486**	5.786	0.078
Production (P)	121.60(100.0)	208.45(100.0)	2.972**	9.242	0.099
Yield (Y)	48.9(100.0)	62.2(100.0)	1.464**	9.792	0.054

Figures in parentheses are percentage to national level
Source: www.iisr.nic.in
** Significant at 5 percent and ** Significant at 1 per cent probability*

The sugarcane production performance as indicated by the CGRs in Karnataka, Maharashtra and Tamil Nadu was ranges from 3.7 to 4.7 per cent and significant at 1 per cent. It was much better than the states of sub-tropical region where the CGR in production was only 0.016 per cent in Haryana. The sugarcane yield also registered the annual CGR of 1.46 per cent with instability index 0.054. The study concluded that the area and productivity growth contributed regularly in sugarcane production in India during pre liberalization reform regime. The analysis also reveals that there were wide gaps in sugarcane yield in tropical and sub-tropical states.

2.3.2 Performance of sugarcane production and sugar sector during post-reform regime

The estimated CGRs and instability index for sugarcane area, production and yield during post liberalization regime are presented in **Table 7**.The study shows that the sugarcane area and production in Haryana has declined substantially during 1993-2013, with CGR of -1.92 and -0.55 percent and highly volatile as indicated by instability indices 0.168 and 0.179 respectively.

Though, Uttar Pradesh still had maximum acreage under sugarcane, its share at national level has declined from 51.5 to 43 per cent during post reform period. Similarly, the CGRs for production and productivity in U.P. declined substantially as compared to the pre-reform period. The production and yield, instability index of 0.069 and 0.059 respectively in U.P. indicates sugarcane production was comparatively stable during post liberalization regime at national level with instability index 0.11. In majority of sugarcane growing states, there were slight variations in yield during the post-reform regime, as evident from the values of instability indices. The fluctuations were relatively higher in Karnataka and Maharashtra. The CGRs values indicated that during the post-reform regime 1993-2013, the growth in sugarcane area, production and yield was sluggish as compare to the pre-reform regime. The sugarcane production performance in Maharashtra was quite impressive as the CGR in area and production were 4.10 and 3.7 per annum. However, concerns were raised due to decline in yield CGR which put a question mark on sustainability of sugarcane production particularly in Maharashtra and states of tropical region due to severe water scarcity during deficiency rainfall years.

Table 7 : CGRs and instability in sugarcane area, production and yield in post reform period

(Area in million ha, Production in million tonnes, Yield tonne/ha)

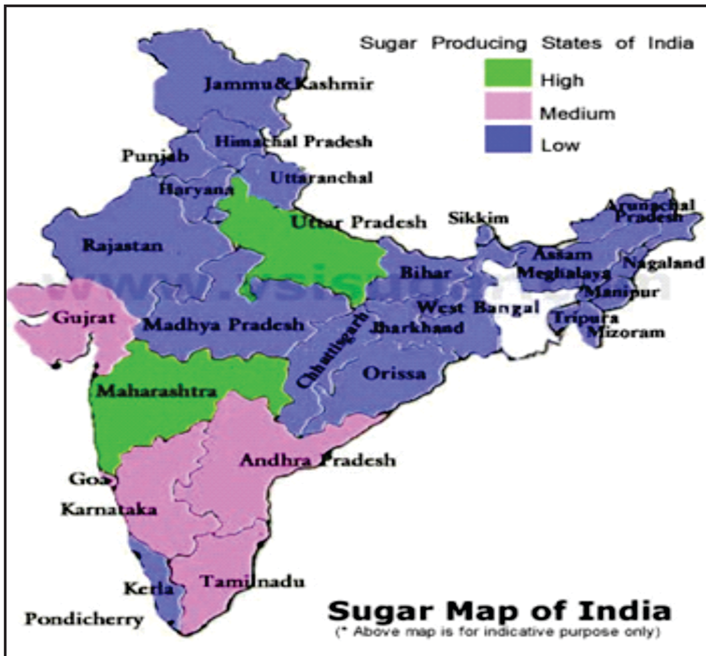
States	Av. T.E 1993	Av. T.E 2013	CGRs	T- value	Instability index
U.P. (Area)	1.88(51.5)	2.17(43.4)	0.728**	4.953	0.052
Production (P)	105.87(44.5)	126.62(36.6)	0.620**	2.854	0.069
Yield (Y)	56.2(86.2)	58.4(84.4)	-0.106	-0.704	0.059
Maharashtra (A)	0.43(11.9)	0.98(19.5)	4.099**	4.782	0.260
Production (P)	35.15(14.8)	76.37(22.1)	3.697**	3.329	0.308
Yield (Y)	80.9(124.1)	78.1(112.7)	-0.385	-1.048	0.106
A. P. (A)	0.19(5.1)	0.20(4.0)	0.236	0.587	0.118
Production (P)	133.58(5.6)	15.75(4.6)	0.563	1.164	0.149
Yield (Y)	72.1(110.6)	79.7(115.1)	0.326	1.798	0.069
Tamil Nadu (A)	0.23(6.4)	0.35(7.1)	1.345*	2.434	0.162
Production (P)	23.80(10.0)	38.35(11.1)	1.463*	2.139	0.193
Yield (Y)	101.7(156.0)	108.9(157.2)	0.116	0.666	0.051
Karnataka (A)	0.27(7.4)	0.42(8.4)	0.822	1.073	0.191
Production (P)	22.23(9.3)	36.90(10.7)	0.610	0.601	0.265
Yield (Y)	82.6(126.6)	87.9(126.9)	-0.210	-0.565	0.127
Haryana (A)	0.15(4.0)	0.1 (1.9)	-1.934**	-2.912	0.168
Production (P)	7.78(3.3)	6.83(2.0)	-0.552	-0.865	0.179
Yield (Y)	52.5(80.5)	71.4(103.1)	1.409**	6.726	0.083
India (A)	3.65(100.0)	5.01(100.0)	1.365**	5.248	0.089
Production (P)	237.85(100.0)	345.99(100.0)	1.404**	3.982	0.110
Yield (Y)	65.2(100.0)	69.3(100.0)	0.039	0.247	0.048

Figures in parentheses are percentage to national level

Source: www.iisr.nic.in.

** Significant at 5 per cent and ** Significant at 1per cent probability*

Amongst six major sugarcane producing states in the country, three states, U.P., Maharashtra, and Karnataka had showed declining trend in yield during post reform period. The comparative CGRs for sugarcane area, production and yield during pre and post-liberalization reform period indicated that the number of states registered poor and negative growth trend were more during post liberalization reform period. However the instability index at India level showed that the sugarcane production was more stable in post reform period as compare to pre-reform regime.



2.4. Indian sugar industry : Current scenario, problems and constraints

Indian sugar industry is passing through a difficult phase due to lower sugarcane and sugar productivity, huge cane price arrears, unremunerative sugar prices that fail to support high input costs of sugarcane farmers and sugar mills, Mohan (2014). The sugar manufacturing in India is spread out amongst ten states, out of which five states are in sub-tropical region (Punjab, Haryana, Uttarakhand, Uttar Pradesh, Bihar) and the remaining five states are in tropical zone of the country (Gujarat, Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu). Some other states like Chhattisgarh and Madhya Pradesh, in central India as well as Odisha from eastern India and the Union Territory of Puducherry formally Pondicherry also contribute to the domestic sugar production up to some extent. There are sugar production units of various sizes, mainly in 2500 -5000 TCD capacity. There are sugar mills of higher capacity, some of them gradually expanding even beyond 10000 TCD. It is estimated that based on the existing levels of sugarcane availability and sugar recovery, the tropical and sub-tropical regions have the potential to produce approximately 16 million tonnes and 12 million tonnes white sugar per production season respectively. Besides it, two sugar refineries had been established in the coastal belt of Gujarat and West Bengal to produce refined sugar from imported raw sugar and also from domestically produced raw sugar. Though, these sugar refineries are export oriented, the sugar produced by them has the possibility of augmenting the white sugar stocks in the domestic market mainly during the years of low production and can drastically improve the sugar security in India. The sugar production capacity of these two refineries is 5000 tonnes /day, which is capable of producing 1.5 million tonnes annually. In future, raw sugar refining capacity could be further improved as some new refineries also coming up within the sugar mills campus, GOI (2013).

The gradual liberalization and better linkages with the global sugar markets are bringing transformational changes in the sugar sector. The production efficiencies and integrated sugar-energy cogeneration complexes have to replace the old and inefficient single product sugar mills. In India, there were 690 registered sugar mills, amongst them, nearly 93 sugar mills were on the verge of closure. These mills have not produced any sugar during last five sugarcane crushing seasons, leaving 597 operational sugar mills. Moreover, out of these working mills, all the sugar mills were not functional during past five sugarcane crushing seasons. The number of operational sugar mills was 526 during 2012-13 sugar production seasons. In coming years, it is expected that 136 new sugar mills are in different stages of establishment and could start sugar production in next 2-5 years. Most of the new sugar mills are integrated with integral arrangement for cogeneration and bio-ethanol distillation facilities. These upcoming new integrated sugar-energy-cogeneration plants are predominantly in Maharashtra and Karnataka in the tropical zone.

The sugar industrial processing capacity is primarily under the ownership of private sector followed by the cooperative sector mills. There are some public sector sugar mills owned and operated by the state governments. The establishment of Indian sugar industry has been the vanguard of co-operative movement in Maharashtra and Gujarat. The number of functional sugar mills belongs to cooperative sector was 286. However, the number of operational sugar mills run by the private sector was 282. The crushing capacity and the size of sugar mills owned by the private entrepreneurs in general bigger than the cooperative sector mills. In India, the total per day sugarcane crushing capacity was 22.24 lakhs TCD. The private sector sugar mill had the highest crushing capacity of 13.74 lakhs TCD followed by the cooperative sector mills 7.77 lakhs TCD and 0.73 lakhs TCD by the public sector mills. The majority of new and upcoming integrated sugar-energy-cogeneration plants have to be established by the private sector. The number of non-profitable, economically unsustainable and financially sick sugar mills was highest from the cooperative and public sector.

The cyclic nature of sugarcane production has been the curse for the Indian sugar sector. The highest level of sugar production achieved by the country was 28.4 million tonnes during crushing season 2006-07. After that the sugarcane production has not been uni-directional and stable as there were wide gaps in annual sugar production. Due to shortage of raw material, sugar mills in sub-tropical states normally worked for 100-130 days per crushing season. The number of effective working days in tropical zone ranged from 140-180 days. However, in the tropical state Tamil Nadu sugar mills are able to get raw material for working up to 200-210 days per production year. Therefore, sugar mills in sub-tropical zone had shorter crushing duration and were under-utilized against their operational capacity, which adds to their overhead and working expense for sugar production costs, apart from problems in sugarcane price fixation and payment issues. In the years of good sugarcane crop and surplus sugar production, the supply gluts led to domestic prices collapse. The higher comparative per unit cost of sugar production makes Indian sugar exports non-competitive due to high logistic cost and other trade barriers. Hence, it is difficult to sell overseas the surplus sugar in international market at the prevailing global market price. However, during low sugarcane production years and short supply of raw material, higher fixed costs affect the profit and economic viability of the sugar mills adversely. The delayed price payment to the farmers for sugarcane supplied to the mills, discourage them to increase sugarcane acreage in subsequent seasons which led to low availability of raw material for processing. In nut shell, it is responsible for burst and boom situation in sugarcane production and ultimately the infamous sugar production cycle in India. The studies on economics of sugar production reveal the thin profit margins, technical inefficiencies in sugar processing, wide fluctuation in market prices, raw material availability and huge capital investment in India, Murthy (2010). The long stagnation in sugar recovery at far below level than standards sugar recovery achieved by the major sugarcane based sugar producing countries with comparable agro-climatic conditions such as Brazil and Australia. The sugar recovery in major producing Indian states varies from 9.0 to 11.5 percent, with national average of 10.25 percent. However, India has expected sugar recovery potential up to 11.0 percent in sub-tropical and 13.0 percent in the tropical states.

The unorganized sector utilized 14-16 per cent sugarcane production for jaggery and *Khandsari* manufacturing, which is a traditional source of sweetener to Indian consumers. The estimated annual jaggery and *Khandsari* production in India was 5.2 million tonne. It accounted for 40-50 percent of total world jaggery and *Khandsari* production of 10-11 million tonnes year 2012-13. In India, 60 per cent of total operational jaggery and *Khandsari* production units have been established in Uttar Pradesh and Maharashtra. The reviewed studies reported the inverse relationship between Indian jaggery and *Khandsari*, sugar production on the basis sugarcane production, price payment policy and time taken by sugar mills for making payment to the farmers. It is well documented that the diversion of sugarcane for alternate uses was more at the times of anticipated downswings in the sugar production. Besides it, there was tendency of the farmers to shift to other alternate crops due to non-payment of sugarcane price to the farmers by the sugar mills, late decision on sugarcane price, state advise price (SAP) fixation and domestic market sugar supply prices. These sectarian imbalances primarily caused by sugar glut situations leads to downfall of sugar prices in domestic markets. In subsequent years, again due to less sugar production, its prices increases, farmers attracted back to the sugarcane crop. The regional variations in sugarcane productivity were largely due to climatic conditions, sugar mills developmental activities, non adoption of scientific management practices and timely supply of cane seed and other inputs.

India is well behind in realizing the full potential of the human and capital invested in the sugar processing sector. Brazil had become the largest sugar and ethanol producer from sugarcane during past three decades. It produces 35 to 38 million tonnes of sugar annually, apart from massive quantities of bio-ethanol used as alternative motor fuel . The Brazilian sugar and ethanol production is export oriented. In spite of massive domestic and global demand, Indian sugar production has been unable to create a stable position in international sugar trade. The neighbouring sugar importers such as Indonesia / Sri Lanka / middle east Gulf countries import the Brazilian / Thailand sugar. Indian sugar export share was meagre during last decade against the Brazilian and Thailand export share of 70 per cent.

Besides it, India has been unable to exploit the potential of sugar industry for achieving at least part of the energy sector requirements. In Brazil, 50 percent of the motor fuel requirements are met from bio-ethanol produced by sugar processing industry. The vehicles run on flexi-fuels such as E 20, E 25 or 100 per cent anhydrous alcohol to conserve petrol and save the valuable foreign exchange on petroleum products import bill. However, in India, we have been struggling with the position of even 5 per cent ethanol blending is yet to gain momentum. To exploit the huge untapped bio-ethanol production potential of Indian sugarcane processing sector, Government of India has implemented the major recommendations of the Rangarajan Committee for sugarcane and sugar sector. It has dispensed away with the regulations for regulating sugar release and levy imposition on domestic sugar production. These policy developments are expected to resolve the problems of sugarcane farmers and make drastic change to enhance sugar-ethanol-energy production and economic viability of sugar processing agro-industrial complexes in long run. Similarly, the imposed duty, taxes and other trade barriers on sugar and other value added co-products would be removed to give complete freedom to the sugar industry for importing advance sugar-energy-power cogeneration processing technology for establishment of modern integrated sugar-energy complexes. Therefore, reforms in sugar sector should be taken up to its logical conclusion, from de-licensing to de-control, so that these could be developed as the energy hub producing sugar, ethanol from molasses and power from bagasse, creating jobs and enhance income of millions of cane farmers. These policy changes would lead for overall development of sugarcane production. The sugar supply will further improve which in turn would have a positive effect on production efficiency, regulating market prices and would also make Indian sugar export more competitive.

SWOT analysis of the Indian sugar processing sector

Strengths

- **Huge domestic consumption demand for sugar, bio-ethanol, electricity and others sugar industry co-products imparting relative insularity from global markets:** The annual sugar consumption is growing @ 3.5 per cent and the estimated domestic sugar requirement was 23 million tonnes during production season 2012-13. The gap between global sugar consumption standards and developing country consumption standards may be further reduce in future. The improvement in consumers purchasing power due to high growth of Indian economy and the high projected population for year 2030, means that the country need not import sugar to fulfill the domestic requirement. The domestic demand of sugar, ethanol, industrial alcohol, liquor, electricity cogeneration or any other value added products are expected to increase further and remain favourable in future.
- **Sugar and distillery production capacity stretch out in two distinct agro-climatic zones :** It provides cushion against climate vagaries, especially in future climate change scenario. Sugarcane cultivation further spread across two different agro-climatic conditions provides natural buffer against emergence of new diseases and pests.
- **Indigenous technical expertise in industrial processes :** The huge industrial capacity for sugar machinery manufacture and sustainable technologies to make inroads in global markets as supplier of sugar / distillery machinery.
- **Suitable and established network of scientific support institutions** : India has the accessibility of gene pool from world and suitable sugarcane varieties for various agro-climatic zones.
- **Strong sugarcane management, research and development system :** The cane management system initiate from land survey of sugarcane area at the commencement of crop, production estimates, sugarcane harvesting schedule, establishment of cane purchase centres, cane transportation to the sugar mills and prices payment for sugarcane supplied to mills by the farmers. This cane supply system is well tested and evolved over the period of time. It is practically matured for cane supply to sugar mills. However, there are some constraints and issues to be addressed with regional variations. The sugar industry has gradually advanced and expanding application of Information and Communication Technology (ICT) to assist continuous update information about cane planting, supply schedules, cane prices payment position to the farmers, to improve efficiencies in the sugarcane supply chain management as well as to develop sugar Market Information System (MIS). In spite of, ICT interventions efforts has been made for mechanization of sugarcane planting, intercultural, harvesting operations, with machines accustomed to location specific and need based.

Weaknesses

- **Stagnant levels of sugar recovery and sugarcane yield :** The sugar recovery at national levels is stuck around 10 per cent in 1950-51 to 10.25 per cent in 2012-13. The compound growth rate (CGR) in sugarcane productivity was only 0.68 per cent during 2000 -01 to 2012-13.

There are wide variations in sugarcane yield in tropical and sub-tropical regions. The situation of sugarcane less productivity further aggravated by the low ratoon crop productivity which further leads downwards trends in overall cane yields. Hence, it is essential to utilize the huge scientific and technical expertise in the country, with a need to reframe policy and relook on proper implementation of replacement of old varieties with suitable new cane varieties through quality seed production, seed multiplication and its supply to the farmers for varietal planning.

❖ **Wide gaps in planning and policy implementation :** The sound scientific knowledge as well as the feasible administrative adjustments, takes undue more time in planning and its implementation. These are the problems linked with lack of government supportive extension mechanisms and coordination amongst the various agencies.

❖ **Small and scattered land holdings :** The preponderance of small and marginal size of land holdings varies from 0.25 to 5.0 hectare, which covers more than 70 per cent of sugarcane area. This had tremendous challenge to the extension staffs for convincing farmers to discourage sowing of rejected varieties, adopt suitable technologies for mechanization of cane planting, intercultural and sugarcane harvesting.

❖ **Paucity of labour and high production costs :** The sluggish yields because of poor adoption of improved cane varieties and agronomic practices, high wages and labour scarcity, poor mechanization, timely non-payment of sugarcane prices to the farmers by the mills are the major production side constraints. Majority of the sugar mills are also not technologically up to date and do not have integrated sugar-energy-cogeneration complex. It leads to sugar as single processed product and lack diversity of possible value added products as the major industrial side limitation. This makes sugar production in India costly *vis-à-vis* other major sugarcane based sugar producing countries such as Brazil. Therefore, India does not have comparative cost advantages in sugar production in comparison to its global competitors. Hence, India is unable to become major sugar exporting country in spite of its rank as second largest sugar producing nation. The non-existence of association between sugarcane prices paid to the farmers and sugar / by-product recoveries further aggravated the condition of sugarcane production sustainability, net profit and long term economic viability of Indian sugar mills. The raw material and sugar mill cost in India was ₹ 29000-30000 / tonne in the most efficient state Maharashtra. The sugar production cost in Brazil was nearly ₹ 24000-25000 / tonne. In other major exporting countries such as Thailand and Australia the sugar production cost was also in the range of ₹ 25000-26000 / tonne, GOI (2013).

❖ **Technical inefficiencies in the sugar mills :** Out of total 526 operational sugar mills, 318 sugar mills were of less than 2500 TCD. These mills are stand-alone sugar production plants without cogeneration and distillation facilities. This is immensely upsetting situation and happens to be the root cause of techno-economic inefficiencies and overall profitability of the Indian sugar sector. The majority of sugar mills having the installed capacity of less than 2500 TCD belong to cooperative sector. These sugar mills have conventional double sulphitation process instead of flexi-process to facilitate sugar production as per domestic demand or international standards concurrently.

❖ **Mammoth unused sugar production capacities and shorter crushing duration:** The regular shortage and irregular supply of sugarcane as raw material to sugar mills has utilized only 60-80 per cent of installed crushing capacity. In sub-tropical zone, the sugar mills have crushing season of 80-125 working days in different years. It leads to the situation of vast unused idle sugar processing capacity in India.

Opportunities

- **Huge possibility for sugar sector diversification into value added products :** Besides, sugar processing, bio-ethanol, power cogeneration, industrial and potable alcohol, animal feeds are the some other products could be derived from sugarcane milling operations. The integrated production of such co-products may gradually transform sugar mills into profit oriented and economically vibrant sugar-energy complexes. The unexploited cogeneration potential for sugar industry is at least 50 per cent, while the bio-ethanol, sky is the limit since the ethanol blending programme is yet to be established in India and further intensified in future. The forthcoming applications also provide possibilities of CNG production from press mud, spent wash, effluents, etc on industrial scale.
- **Enormous untapped potential of natural resources :** Brazil produces around 680-730 million tonnes sugarcane from 9.0-9.5 million ha area with the productivity of 75-80 tonnes/ha. India produces only 340-360 million tonnes sugarcane from 4.9-5.1 million ha area with average productivity 70 tonnes/ha. Indian sugar recovery is just 10 per cent, while Brazilian sugar recovery is nearly 13 per cent. Without any additional capital investment in the industrial capacities, the single step of making available sufficient sugarcane by adopting twin strategy of productivity and sugar recovery enhancement, the country may become the world leader in sugar production. Indian Institute of Sugarcane Research, Vision document (2030), indicates possibilities of achieving the average productivity of 100-110 tonnes/ha and sugar recovery of 10.75 per cent to meet the expected 33 million tonnes of domestic sugar requirements by (2030), without any further horizontal crop acreage expansion, the target could be achieved.
- **Massive sugar mills operational capacities and upcoming new sugar-energy complexes :** The analysis of operational installed capacities and new capacities reveals that the 526 sugar mills had the sugarcane crushing capacity of two million TCD. There are more than 120 new sugar-energy-cogeneration complexes in the process of establishment, likely to add 0.5 million tonnes sugarcane crushing capacity per day by end of 12th plan. If the raw material supply to the sugar mills and sugar recovery improves the annual sugar production could reach up to 30 million tonnes. If the domestic sugar demands, market price and state policy provides favourable situation, sugar production taking into account the operational capacities may be enhance up to 37 million tonnes per crushing season. These estimates are calculated with the assumption of the minimum crushing duration of 150 days in India, except for Karnataka and Tamil Nadu where it could be 180 days with sugar recovery over 10 per cent in the country except Maharashtra and Karnataka where 12 per cent recovery is achievable. In best scenario, sugar production could touch 46 million tonnes taking into account only existing operational mills capacities. The sugar production may achieve the target of 58 million tonnes by taking into account the new upcoming capacities expected to be operational by crushing season 2017-18. These estimates are calculated with the assumption of the minimum crushing duration of 180 days in sub-tropical zone, 210 days in A.P, Gujarat, and Maharashtra and crushing duration up to 240 days in Karnataka, T.N. and Puducherry. The sugar recovery percentage could be technical achievable 11 per cent in sub-tropical belt, 13 per cent in Maharashtra, Karnataka and Gujarat with average capacity utilization at 90 per cent.
- **Vast unexploited domestic bio-ethanol market :** India has huge domestic consumption of not only sugar, but also for alcohol based co-products of sugar industry that paradoxically faces

complex situation of sugar glut and idling crushing capacities, many a times in a cycle of 3-5 years. However, Brazil with very minimal domestic consumption has nurtured huge sugar economies centred on the international sugar trade achieved lowest sugar production costs amongst the major exporting countries and utilized ethanol on large scale to meet domestic motor fuel requirements. Hence, India could also have opportunity of promoting the adoption of ethanol blended petrol to keep pace with ever increasing demand of motor fuel and supplement domestic petroleum fuel needs. The decisions taken by the Government of India for reducing regulation in sugar sector and to give free hand to oil marketing companies (OMCs) for achieving mandatory target of 5 per cent ethanol blending programme requirements through tender process by market driven prices, signify bright future. This policy support gives further boost for the number of upcoming new integrated sugar-energy-cogeneration complexes with process flexibilities of shift between sugar and ethanol production.

- **Enormous unexplored potential for power cogeneration :** The economic feasibility studies of available technology for the electricity cogeneration along with sugarcane milling have been well established in many leading sugar processing nations. However, in India this pioneering technology has yet to be exploited as the progress was very slow. The present installed capacity for cogeneration of surplus electricity by the sugar mills for grids is nearly 3800 MW against its estimated potential of 8800 MW based on passive estimates and 10500 MW in superlative scenario. This unexploited situation obviously illustrated the huge opportunities as the technology and its market is now well developed.
- **Possibilities of new emerging co-products :** The developed countries have started the commercial possibilities in the realm of bio-plastics, ligno-cellulosic ethanol, butanol, cellulosic gases (Syngas), bio-gases (CNG from press mud as well as other effluents) as secondary activities in the integrated sugar-energy complexes. The industry needs to reap the economic benefits of these new products emerging opportunities and formulate suitable strategies to harness economic advantage.
- **Niche sugar products :** The Indian sugar industry also have capability for developing niche sugar and ethnic value added jaggery products. The sugarcane farmers are intrinsic part of sugar production chain, makes one wonder why the fair trade sugar niche has not been explored by the industry in order to get premium prices in the export market. The labour intensive structure of sugarcane cultivation makes it the breeding ground for developing sugar value chains as organic sugar another niche product as the organic cane cultivation is the human resource intensive realm. There is plenty scope for proper packaging, branding and marketing of traditional Indian jaggery based value added processed products and *Khandsari* as healthy sweeter alternative. These niche products have not fully explored by any country in the world markets. These niches products could render help to Indian sugar sector in getting foothold in the world sugar products trade and minimises the production inefficiencies.

Threats

- **Delicately poised domestic sugar demand and supply scenario :** The production of sugarcane and sugar has shown wide fluctuations. These fluctuations are due to fluctuations in sugarcane acreage, climate change in adequate and timely supply of seed, water, fertilizer, remunerative and timely payment of cane prices to the farmers. The raw material supply to the sugar mills also depends on rainfall, incidence of diseases and pests, road connectivity and government policy on sugarcane and sugar pricing. Hence, any breakdown to sugarcane supply chain with the huge sugar processing industrial capacities have been setup in the country could lead to attrition and bleed the industry. This ultimately could lead to sugar production stagnation. The burgeoning population and huge domestic sugar requirements, failure to fulfill domestic sugar requirements may create challenge to issues of food and nutritional security.

- **Huge cane price arrears and poor moral of sugar sector :** The sugarcane cultivators are generally worried due to timely non payment of money lead to enormous cane price arrears, which happen uninterrupted regularity every year. The problem of non payment of cane prices is very serious in U.P. as the sugar mill has to pay nearly ₹ 6200 crores for sugarcane supplied by the farmers in crushing season 2013-14.The sugar mill managements are worried due to losses in some years and inadequate compensation on the capital and resources invested in other years. Therefore, huge industrial capacity of milling or distillation was lying idle because of raw material supply constraints. If the situation, not improved in future it may boomerang and lead an unnecessary production crisis.
- **Competition from other remunerative crops :** The regular accumulation of cane price arrears on sugar mills and the steadily growing support to food grains crops for food security may lead to condition whereby the competing crops permanently take over the area currently under sugarcane. The manifestation of this trend is the increasing replacement of sugarcane by high value crops and popular based agro-forestry models in western U.P. and Uttarakhand, whereby the sugar industry is in continuous scarcity of sugarcane.
- **Climate change :** The unpredictability of climate might be unleash by the more risk and uncertainty threats. It would have tendency of adversely affecting the long durational crops like sugarcane. The small and marginal sugarcane farmers have the tendency to shift to the high value short duration crops during climate change and environmental uncertainties.

2.5 Sugarcane cost of production, marketing pattern and price policy mechanism

2.5.1 Factors contributed for sugarcane cost of cultivation

The economics of sugarcane crop is assessed based on the cost of production and net return obtained per unit area. The CACP under its cost of cultivation scheme collected primary data for various crops to declare the minimum support prices (MSP) for crops or statuary minimum price (SMP) / fair revenue prices (FRP) for sugarcane. This information on various physical inputs and economic return per unit area could be useful to the farmers in decision making for acreage allocation under the alternative crops, as well as for policy makers to boost the production and productivity of sugarcane based farming systems.

The costs and returns of sugarcane cultivation in tropical region (Maharashtra) for past one decade were compiled from the publication of CACP and presented in **Table 8**. It is evident from the **Table 8** that the sugarcane production cost had doubled during the past decade. The factors contributed to operational cost were labour wages, cost of seed, irrigation charges, chemical fertilizers etc. However, the rental value of own land has lion's share in fixed cost. The BC ratio indicates that the sugarcane crop was remunerative to the farmers in some years in Maharashtra. However, the sugarcane was uneconomic during year 2002-03 and 2006-07 in Maharashtra as indicated by B. C. ratio 0.88 and 1.04 respectively.

Table 8 : Sugarcane cost of cultivation and returns in tropical region Maharashtra :

(In ₹ / ha)

Cost/returns Parameters/Year		1998-99	2002-03	2006-07	2009-10	2010-11
Cost per hectare basis	A	25582	46983	48967	64371	75586
	B	36796	63991	60961	90603	97828
	C	40640	71245	76694	128182	129421
Cost per quintal.	A	31.15	48.07	52.38	61.46	73.21
	B	43.81	64.99	58.7	76.86	83.45
	C	52.75	77.68	90.04	134.28	137.40
Breakup of cost						
Operational cost		28461	52745	53938	72976	85901
Human labour		10431	19904	19782	29483	35242
Animal labour		1164	2684	4070	3483	3858
Machine labour		2794	6833	5801	6217	11271
Material (S+F+M+PP+IC)		12604	20618	17475	24176	31154
Interest on working capital		1470	2705	2818	3713	4375
Fixed costs		11813	17999	21164	54329	43096
Rental value of own land		9009	11054	14141	36701	31169
Land revenue		198	253	200	193	224
Depreciation on implements and building		401	737	853	1053	995
Interest on fixed capital		2205	5954	5971	16382	10713
Total cost (OC+FC)		40274	70744	75102	127305	127997
Value of main product		50594	62193	78294	212443	177939
Value of by-product		3448	4120	6533	7721	9038
Total value		54042	66313	84827	220163	186977
B-C ratio		1.26	0.88	1.04	1.67	1.46

Source : Agricultural Statistics at a glance. http//www.eands.dacnet.nic.in/costof cultivation.

The Uttar Pradesh is the leading sugarcane producing state in sub-tropical region. The costs and returns of sugarcane cultivation in sub-tropical region (Uttar Pradesh) were compiled from the publication of CACP and presented in **Table 9**. It is evident from the **Table 9** that the sugarcane cost of production (Cost C) in sub-tropical region had increased from ₹ 26336 to ₹ 66,800 during 1998 to 2010. The human labour wages had increased almost twice during last decade. The other major factors contributed to operational cost were seed cost, machine labour, irrigation charges, fertilizers and plant protection chemicals. However, the rental value of own land has lion's share in fixed cost. The BC ratio indicates that the sugarcane crop was remunerative to the U.P. farmers in sub-tropical region .

Table 9 : Sugarcane cost of cultivation &returns in sub-tropical region U.P

(In ₹ / ha)

Cost/returns Parameters	1998-99	2002-03	2006-07	2009-10	2010-11
Cost per hectare basis A	10368	14327	16667	19465	28479
B	21995	27054	35423	47351	56951
C	26336	32650	41193	57699	66799
Cost per quintal. A	19.93	27.02	27.69	35.17	57.40
B	42.28	50.85	58.58	90.21	105.50
C	55.67	67.72	75.34	119.04	136.75
Breakup of cost					
Operational cost	14175	19109	21870	27571	37220
Human labour	7363	9275	10488	14705	17306
Animal labour	368	596	623	1034	2199
Machine labour	596	729	1183	1059	1428
Material(S,FM,PP,IC)	5258	7712	8630	9677	14677
Interest on working capital	590	797	947	1096	1610
Fixed costs	11973	13501	19323	28712	29580
Rental value of own land	10060	10083	16079	24165	24283
Depreciation on implements and building	311	643	542	801	1107
Interest on fixed capital	1602	2775	2678	3721	4189
Total cost (OC+FC)	26148	32610	41193	56284	66799
Value of main Product	38459	39220	67123	128162	100727
Value of by-products	2320	2827	4086	5247	5631
Total value	40779	42047	71209	133408	106358
BC Ratio	1.47	1.20	1.63	2.28	1.59

Source : Agricultural Statistics at a glance. http//www.eands.dacnet.nic.in/cost of cultivation.

2.5.2 Functions of cultivation cost for deciding FRP

Sugarcane cost of production is one of the key considerations to determine fair and remunerative price. It is a supply side consideration from farmer's view point. However, the price policy of sugarcane, also require demand side considerations. This came from the sugar, and by-products market demand. It has grown primarily for sugar production. The demand side embodied the domestic and international prices of sugar in global sugar markets were relatively free as compared to other agricultural commodities. Therefore, FRP determined by cost of sugarcane production, demand for sugar and it's by products. The CACP is a statutory body which advises the government on the price policy for major crops/commodities of farm produce. The fair and remunerative price (FRP) system has followed by most of the sugarcane growing states, excluding some state such as Uttar Pradesh. Keeping in view, cost of sugarcane cultivation in major states, the CACP recommend statutory minimum price (SMP) of sugarcane payable by sugar factories to the farmers for sugar production season. The recovery per cent is the quantity of sugar produced from the unit quantity of sugarcane crushed. It includes a margin of 45 per cent on account of profit and risk to the farmers on all India adjusted average cost of production of sugarcane, including the cost of harvesting and its transportation cost to the sugar mills. The commission recommends SMP for the basic sugar recovery percentage of 9 per cent and additional premium prices for each 0.1 per cent increase in the sugar recovery above minimum level. From the 2009-10 onwards, the GOI had decided to fix the FRP as the base price must be paid by the sugar mills instead of the SMP earlier. The FRP is linked to the basic recovery of 9.5 per cent, subject to the premium of ₹ 1.46 for an incremental sugar recovery of 0.1 per cent above 9.5 per cent. In view of steep rise in prices of inputs such as labour wage, diesel, fertilizer prices that led to quantum rise in total cane production costs, the CACP had proposed more than 17 per cent increase in sugarcane FRP over 2012-13 season to ₹ 210 and ₹ 220 per quintal for the sugarcane crushing season 2013-14 and 2014-15 respectively.

The latest cost estimates for sugarcane cultivation released by Directorate of Economics and Statistics (DES) for year 2010-11. These estimates were for the major sugarcane growing states of A.P., Haryana, Karnataka, Maharashtra, Tamil Nadu, U.P and Uttarakhand. Based on these estimates, the CACP has projected the sugarcane production cost for year 2013-14 and did the FRP exercise. In this exercise, commission used the actual costs for the past three years, 2008-09, 2009-10 and 2010-11and adjusted the inputs price increase (labour wage, fertilizers, farm machinery, diesel etc) till 2013-14. These projections have been then modified by applying a correction factor (CF), which is the percentage difference in the actual costs and projected costs for 2008-09 to 2010-11. Initially, these estimates had to be generated at state level and then aggregated at all India level by applying the relevant state level sugarcane production weights.

Based on average of three years actual cost of cultivation in major sugarcane producing states, the gross and net returns were estimated and presented in **Table 10**. The net returns over **C2** costs as well as gross rate of return on (A2+FL) cost and C2 cost were also worked out. It is evident from **Table 10** that the net rate of return over C2 cost, during TE 2010-11 was 66 per cent at national level. It varies from 30 per cent in Andhra Pradesh to 96 per cent in Karnataka. It should

be noted that these returns were estimated on actual costs and prevailing sugarcane prices received by the farmers in different states (not recommended by CACP as SMP / FRP). In most of states it was observed that the actual prices received by farmers were more than recommended by the CACP. The sugarcane price received by the farmers ranges from ₹ 200 to ₹ 250 per quintal during 2009-10 and 2010-11. However, the FRP declared by the CACP were far below than the price paid by the sugar mills to the sugarcane farmers.

Table 10 : Gross and net returns from sugarcane based on actual cost estimate T.E 2010-11

(In ₹ /ha)

State	Cost A_2+ FL	Cost C_2	Gross return	GR on A_2+ FL level	GRR as % of A_2+ FL	Net returns over C_2	NRR as % of C_2
A.P.	64866	107306	139877	75011	116	32570	30
Haryana	32361	73025	132199	99838	309	59174	81
Karnataka	51241	88407	172915	121674	237	84508	96
MH	73003	114034	167976	94972	130	53941	47
T.N	76115	99807	161022	84906	112	61215	61
U.P	30421	56107	101227	70805	233	45119	80
U.K	34734	70757	129993	95260	274	59236	84
IndiaWt. Ave.	46853	78104	129645	82791	177	51541	66

Source: Price policy for sugarcane season 2013-14 pp 35

Note: A_2 + FL Cost includes all expenses in cash and kind on account of hired labour, seed, manure, fertizer, irrigation charges, etc. including imputed value of family labour.

Cost C_2 includes cost A_2 + FL, imputed rental value of own land, interest on fixed capital etc.

2.5.3 Future projection for Sugarcane cost of production

The sugarcane cost of production data published by the CACP during past years could be useful for future forecast and projection of cost of production and deciding the FRP in forthcoming sugarcane crushing season. The national average at actual paid out cost plus imputed value of family labour i.e. Cost (A2+FL) was worked out to be ₹ 46853/ha. The national weighted average of Cost C2, adjusted at 9.5 per cent recovery, including transportation cost and crop insurance premium was worked out to be ₹ 197 per quintal for year 2013-14. This was 22 per cent higher than the last year cost of sugarcane cultivation ₹ 162 per quintal. The break up of projected cost of production for the year 2013-14, advocate that the ₹ 179/ quintal could be the share for cost of production, ₹ 15 / quintal as transportation cost and ₹ 3 / quintal for the crop insurance premium. This projected cost of ₹ 197 / quintal (with sugar recovery at 9.5 per cent) have been derived from the unadjusted cost of ₹ 185 / quintal based on the actual cost estimates for 2008-09, 2009-10 and 2010-11. The cost of sugarcane production had accelerated primarily because of rise in labour wages and prices of other purchase material inputs such as fertilizers, diesel etc. The analysis concluded that the nominal costs in sugarcane production have increased at the compound annual growth rate of 10 per cent during 2006-07 to 2008-09. However, it is expected that cost of sugarcane production during 2010-11 to 2013-14 has increased at the annual compound growth rate of more than 15 per cent.

Table 11 : Extent of men, women and child labour share in sugarcane farming operations

(In per cent)

Sl. No.	Farm operations/ Activities	Tropical zone (Maharashtra)			Sub-tropical (U.P. /Bihar)		
		Men	Women	Child	Men	Women	Child
1.	Field preparation						
	Ploughing	100	-	-	80	-	20
	FYM application	15.0	65.0	20.0	25.0	40.0	35.0
	Ridges / furrows opening	100	-	-	100	-	-
2.	Sugarcane planting						
	Cane sett cutting and treatment	10	75	15	40	30	30
	Sett transport and spreading	30	60	10	40	40	20
	Sett planting and covering	30	60	10	60	20	20
3.	Weed management / intercultural operations						
	Spray of weedicide	80	20	-	80	-	20
	Manual weeding or hoeing	20	70	10	60	30	10
4.	Fertilizer application						
	Fertilizer application on sowing	30	70	-	80	10	10
	Top dressing	40	40	20	60	20	20
5.	Irrigation						
	Applying irrigation water	40	40	20	50	20	30
	Cleaning of water channel	30	70	-	70	30	-
6.	Earthing up	70	-	30	80	10	10
7.	De-trashing	25	65	10	50	30	20
8.	Plant protection chemicals						
	Water supply & mixing chemicals	20	80	-	70	20	10
	Spray of chemicals in crop	80	20	-	80	-	20
9.	Sugarcane harvesting						
	Cutting, de-topping, cleaning and bundling	30	50	20	60	10	30
	Loading and transportation	40	20	40	70	-	30
10.	Ratoon management						
	Trash collection and disposal	40	50	10	60	20	20
	Off barring	60	40	-	80	10	10

Source: Gangwar et al., (2013)

2.6 Sugarcane based farming system and socio-economic status of farmers

Rural women as unseen farmers form the backbone of agricultural work force in India. They perform the most tedious and laborious works in crop production, animal husbandry, poultry, fisheries, or any allied activities. In sugarcane agriculture, women are also active partners associated to almost all unit operations from land preparation, planting till harvesting; shares work between 10-70 per cent in case of majority of sugarcane intercultural operations and almost 100 per cent especially in those involves laborious repetitive work such as children care, cooking and kitchen management. The women empowerment and gender issues have prime importance in diversified Indian agricultural scenario. Keeping in view, socio-economic, income disparity and cultural diversity; the rural women status influenced mainly by social, religious taboos and agricultural production systems. The rural women contribute nearly 30-70 per cent of the total labour requirement for some sugarcane production operations. The involvement of women in sugarcane production and processing operations is besides their customary household and animal husbandry rearing activities.

The remarkable contribution made by the women to sugarcane cultivation also goes unaccounted as sometime they are not directly paid or paid lower wages for same job. The study determined the participation level for men, women and child (workers below 18 years) in time percentage as labour (family + hired) involved in various sugarcane crop production operations presented in **Table 11.** It is evident from the **Table 11 t**hat in tropical and sub-tropical zones, sugarcane farm operations are being done by the men, women and child labourers. However, the extent of their participation varies from crop production operations to operations. In sugarcane cultivation operations such as ploughing, furrow opening, spray of weedicide, cleaning of irrigation channels, earthing up, spray of plant protection chemicals and off barring were done by the men. These crop production operations were cumbersome and required hard labour, hence performed by the men. However, the cane production activities such as FYM application, seed setts cutting, transport, planting and setts covering, manual hoeing / weeding, de-trashing and trash collection were done either by women or child workers. These operations were also tedious and labour intensive, but did not demand that much physical energy as required by the operations done by the men. However, in some operations, there exists wide variation between the tropical and subtropical states.

The other operations in which women workers participated remarkably were FYM application, seed cane sett cutting, bundling, transport, fertilizer top dressing, de-topping of harvested cane, cleaning and bundling, collection of trash, stables and their disposal. The majority of the sugarcane production operations performed by the women could also be performed by the men as well. However, the decision for employing more women and child labour was the prevailing differential labour wages paid to the men, women and child. The average market labour wages was ₹ 200 -250 per day whereas the women and child labour wages was ₹ 150-200 per day for the same work. The significant variation in prevailing wage disparity for hired human labour is the matter of concerns and did not compensate for the energy demand for sugarcane agriculture in India.

Time utilization pattern of rural farm women **Table 12** reveals that on an average, household farm woman spends eight hours for doing work on sugarcane farm in the case of daily paid labour with 30 minutes to one hour break for lunch. However, the women member of the sugarcane farmers and most of the labourer farm families involved in rearing of animals such as cow, goat, poultry birds etc. and in most of the cases the animals rearing was the women's responsibility **Table 12**. They spend 3.30 hours / day on an average caring for the animals and poultry. However, women also spend the considerable time of nearly 4.60 hours at home in doing cooking and other household work. The farm women also spend nearly two hour for child and personal care. With the availability of drinking water facility near the house in the villages, they feel that the time spent in water collection has been reduced drastically. The results concluded that the dairy / poultry rearing and kitchen household activity takes much time of rural women besides the other farm operations. Some studies indicates that the women contribution in economics of dairy and poultry enterprises was nearly 76 per cent and 84 per cent of total family labour income from dairy and backyard poultry rearing respectively.

Table 12 : Time utilization of farm women in sugarcane and allied agriculture activities

Sl.	Agriculture/household activities	Rural women labour employment	
		Time spent (hrs/day)	Per annum (hrs)
1	Sugarcane agriculture farm work,	0.8 (6.89)	292.0
2	Dairying/poultry rearing work	3.3 (28.45)	1204.5
3	Food cooking /Kitchen work	2.7 (23.28)	985.5
4	Household work	1.9 (16.38)	693.5
5	Child care work	1.2 (10.34)	438.0
6	Personal care	0.5 (4.31)	182.5
7	Other crops related works	1.2 (10.34)	438.0
	Total	11.6 (100.0)	4238.0

Source: Gangwar et al., (2013)

Note: Figures in parentheses show the percentage of total time devoted to each activity

Table 13 : Decision making pattern in sugarcane farming operation

(On percent basis)

Sl.	Particulars/operation	Men	Women	Collectively
1	Acreage allocation and crops shown	78.00	12.00	10.00
2	FYM application and cane planting	86.00	5.00	9.00
3	Procurement of seed and fertilizer	88.00	7.00	5.00
4	Hiring of labourers and type of labour	73.00	8.00	19.00
5	Marketing of crop produce	54.00	35.00	11.00
6	Supply of sugarcane to sugar mill	70.00	12.00	18.00
7	Financial management	60.00	25.00	15.00
8	Borrowing of loans	70.00	20.00	10.00
9	Disposal of farm by-products	60.00	30.00	10.00
10	Money keeping and spending	68.00	22.00	10.00

Source: Authors own calculation based on primary data.

Role of sugarcane farm women in decision making pattern

The role played by the rural women in decision making on sugarcane farming operations has complied and presented in **Table 13**. It reveals that amongst the decisions related to sugarcane farming operations, such as decision on acreage allocation, planting time, purchase of inputs, type of labour to be engaged, marketing and sugarcane supply to sugar mill etc., were taken solely either by the family head especially, men themselves or jointly in consultation with their female family members. The women have limited role in farm decision making process. The women have some role in other activities like marketing of crop produce, farm financial management, disposal of by-products and money keeping and spending for household operations. The men dominate in terms of loans borrowing, as this could be attributed to their high social interaction and thereby better exposure. In most of the cases, it was seen that the women were not considered as the forefront in decision making process. Sometime, women deliberately did not take part in decision process because men put blame on them if anything goes wrong. The results concluded that in majority of cases the men played dominant role in decision making process and the women had to play a supportive role as sometimes major decisions were jointly taken by men, women and other family members.

2.7 Global ethanol production scenario

Bio-ethanol is being produced by many countries around the world. The world ethanol utilization as fuel in 2007 was nearly 42 billion litres. The major quantity of bio-ethanol was produced by the USA (49.6 per cent) and Brazil (38.3 percent). The contribution of other countries was only 12 percent, European Union (EU) 4 per cent, followed by China and India shared 0.4 per cent each respectively Pohit, *et al.,* (2009). Globally, sugarcane, sweet sorghum and sugar beet are used for the production of bio-ethanol as sugar containing feedstock. Corn, wheat and other cereals containing starch which could be easily converted into sugar. In India, bio-ethanol is mainly produced by using sugar industries by-product the molasses. This is an example of first generation biofuels that uses biomass containing large amounts of sugar. The other feed stocks materials which could be converted into sugar such as starch, for the generation of ethanol. First generation biofuels are made from sugars, grains or seeds, by using specific regularly edible portion of the biomass produced by the plant and relatively simple processing of the biomass is required to produce the bio-ethanol, Ruane *et al.,* (2010). The bio-ethanol forecast 2012 indicates that the world bio-ethanol production may touched 85.25 billion litres during year 2012-13. This bio-ethanol contributed roughly, 82 per cent of total global production of biofuels. Brazil and USA, accounts for nearly 87 per cent of total ethanol production worldwide. The China and India are the major ethanol producers as well consumers in asia- pacific region. The maximum ethanol production of 5476 litres / ha, sugarcane has been realized by the Brazil which has set up an economically competitive bio-ethanol sector. Brazil has also developed the cost-effective technology for converting sugarcane juice directly into ethanol, in contrast to other countries such as India where bio-ethanol is produced primarily from the molasses a by product of sugar mills. However, the comparative yield of bio-ethanol production from the maize in USA and China was much lower than per unit ethanol produced from sugarcane juice or molasses in Brazil and other countries. It was approximately 3,751 litres / ha and 1,995 litres / ha in USA and China respectively Naylor *et al.,* (2007). In China, besides, corn other food grains and crops such as wheat, cassava and sweet sorghum were also commercially utilized for ethanol production. In EU, countries, utilized cereals such as wheat, maize, barley and sugar beet for bio-ethanol production. The ethanol blending rates with petrol differ significantly across the countries of different regions. In USA, it was compulsory to blend at least 3 per cent bio-ethanol with petrol. The prevailing ethanol blending rate of 25 per cent in Brazil was highest amongst all the nations. India, China and Indonesia has set the target of 10 per cent ethanol blending with petrol. However, EU countries followed the ethanol blending rates at 5.75 per cent with petrol during 2003-12 as illustrated in **Table 14**.

Table 14 : Bio-ethanol feed stocks and blending targets of selected countries

Nation	Primary feedstock's	Production forecast 2012(billion litres)	Blending rate and target (%)	
			2003-2012	2013-2020
USA	corn, sorghum	52.62	3-5	5-15
Brazil	sugarcane	21.25	18-20	25
EU	wheat, corn, barley, sugar beet	4.9	5.75- 10	>10
Canada	corn, wheat	1.75	5	10
China	corn, wheat, cassava, sweet sorghum	2.09	10	10-15
India	sugarcane molasses, sweet sorghum	2.17	5-10	10-20
Indonesia	sugarcane, cassava	0.47	5	10
Total	-	**85.25**	-	

Source: F.O. Licht (2012); Global Renewable Fuels Alliance (GRFA) forecast 2012

The ethanol production policies has a crucial role in enhancing the global demand and prices of food grains. The ethanol industry has become a major consumer of food grains in Canada and has created stimulant to food grains demand led to steep prices increase. Due to subsidies, ethanol industry had edge over animal feed industry. Canadian government mandated use of ethanol at 5 per cent of gasoline, had created the extravagant demand for ethanol. The future expanded ethanol use up to 10 per cent of gasoline would have serious reduction in food grains availability to the animal feed and had negative consequences on livestock sector, Grier *et.al.,* (2012). In OECD nations, production as well as consumption of bio-ethanol was highly subsidized, mainly because of the energy security and climate change mitigation. It was estimated that the ethanol subsidy support varies from US $ 0.20 and US $ 1.00 per litre. Amongst, major producers' countries, Brazil sugarcane ethanol production was competitive without subsidies FAO, (2008). The US maize production has impact of the US ethanol subsidies and ethanol expansion. The maize prices increases substantially by US $ 2.88 per bushel during 2005-10. The factors responsible for maize prices increase were ethanol subsidies, ethanol market expansion, and factors outside the ethanol such as strong domestic and global maize demand for animal feed. If the size of the ethanol production maintained at 2004 level, the US maize price in global market would be 17 per cent lesser during year 2010, Fabiosa (2012). Hence, the future global expansion of maize based bio-ethanol production would have to face many challenges and not very encouraged. Therefore, it is suggested to explore potential feedstocks as green sources of bio-ethanol energy rapidly, as most of the major bio-ethanol producing countries resort better alternatives to staple food grains crops for production of bio-ethanol. The quantity of food grains utilized for bio-ethanol production by the developed nations during recent years has complied and presented in **Table 15**. During production year 2012, 172 million tonnes maize was utilized for bio-ethanol production, which was nearly 17 per cent of the global maize production. Out of this, the USA alone utilized 80 per cent which had adverse impact on maize availability for other sectors. It led to upward maize price movement in global market. Similarly, Canada and China also produced almost entire ethanol production from maize and wheat. Therefore, it would be exciting to analyses that the cereals use for bio-ethanol production likely to increase @ 10 per cent per annum during

2nd decade of 21st century. However, the projected cereals production could grow only @ 1.4 per cent, indicates further squeeze in availability of food grains that widen the gaps in global demand for and supply of cereals for human consumption, Chand (2009).

Table 15 : Diversion of food grains for ethanol production: 2005-06 to 2011-12

(In million tonnes)

Country/Year	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
USA	41.3	54.5	76.8	101.7	119.6	131.6	151.4
EU -27	3.2	3.4	2.9	5.2	4.9	6.3	7.9
Canada	0.7	1.5	1.8	2.5	2.8	3.4	4.1
China	9.5	11.0	11.5	12.0	14.2	16.6	20.4
Others	1.1	1.4	1.9	2.4	2.8	3.5	5.3
Total	**55.8**	**71.8**	**94.9**	**123.8**	**144.3**	**161.4**	**189.1**

Source : Von Braun (2008), estimates/projections

2.8 Global bio-ethanol production and future demand and supply scenario

Based on the mandatory blending requirements stipulated by different nations, OECD-FAO (2010) has projected the future demand for biofuels in several countries. The ethanol production of China would be 2090 million litres in 2012. If Japan had to fulfill, Kyoto Protocol obligation, its ethanol demand would have to enhance from 719 to 897 million litres during 2007-2012. Therefore, to cater the ethanol demand, Japan has to meet its supplementary requirement from ethanol imports. In EU nations, about 6.75 billion litres bio-ethanol has to be required during 2012-13 to fulfill the mandatory ethanol blending target 5.75 per cent with gasoline. In USA, implementation of efficient renewable fuel standard (RFS_2) expected to significantly increase the quantity of bio-ethanol to be blended with gasoline from existing three per cent level of petrol automobile fuel. India, China, Indonesia and other developing nations have mandated 5 to 20 per cent ethanol blending with petrol in the phased manner in the forth coming decades. The global bio-ethanol industry has bright future in world economy and it would continue to grow in next decades of 21st century. It could support 1.4 million workers and contribute US $ 277.3 billion to the global economy, GRFA (2012). It is reported that the global trade in bio-ethanol though limited at present and suppose to grow up significantly in future. Presently, global ethanol trade was 20 per cent of total ethanol demand, but its share has steadily risen during past few years, Licht, (2012). Brazilian export of bio-ethanol, including the volume re-exported from the Caribbean basin, accounts for 45 per cent of total international ethanol trade. The Brazil is the leading bio-ethanol exporter and the USA is the biggest importer. Amongst the EU nations, Netherlands, Germany and the U.K. were the largest bio-ethanol importers. However, protectionist trade policies adopted by many countries to safeguard the economic interest of their promising bio-ethanol industry act as trade barrier. The US also discouraged the Brazilian ethanol import by imposing high tariffs and custom duties. Similarly, other countries also make arrangement in the form of non-tariff barriers to avoid glut in their domestic markets. In recent year, the USA reduced tax credit on farm subsidy to its domestic bio-ethanol industry, due to political pressure towards fiscal austerity and domestic livestock and poultry producers as they perceived the subsidized ethanol production leads to shortage of feed raw material and higher poultry feed prices. Some research studies argued that the rapid growth of US bio-ethanol industry during first decade of 21st century had less impact on tax credit, subsidies and more concerns to high profitability due to sharp increase in crude / petroleum oil prices, Babcock (2011). In nutshell, it is concluded that the global future bio-ethanol production would depend on large number of interrelated factors, economic trade matrix, factors of production including the future crude oil prices, availability of low-cost feedstock, technological advancement for utilization of second generation ligno-cellulosic raw material and continuous government commitment for supportive policies, which reduce per unit bio-ethanol production cost from second generation raw materials and their competition with unconventional fossil fuel alternatives.

2.9 Indian bio-ethanol production, demand and supply scenario

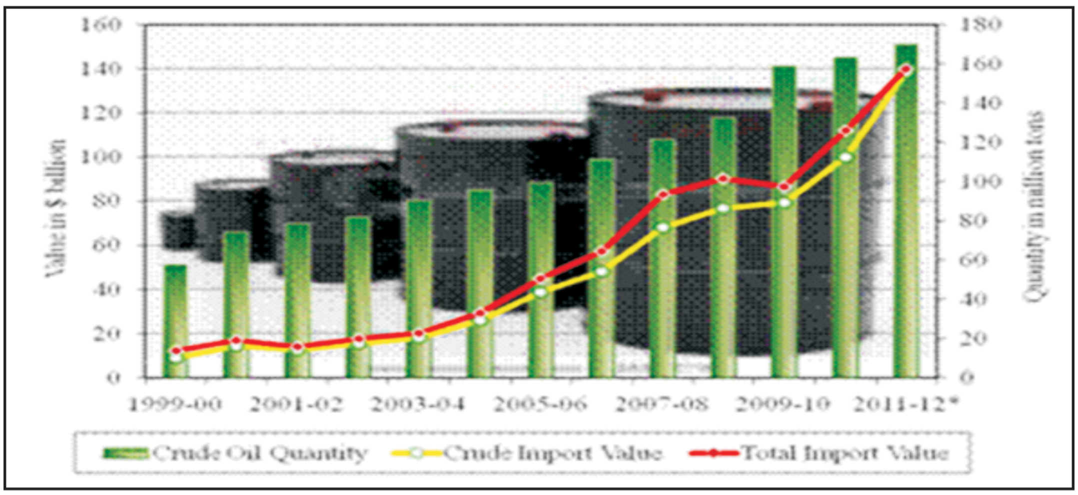
Globally, India is the fourth largest petroleum consumer after USA, China, and Japan. By 2035, India and China will have maximum share in Asian energy demand growth. Indian economy was the 10th largest economy of the world in 2011, grew at the rate of 7 per cent per year during first decade of 21st century. The associated risks for Indian economic growth include high debt intensity, lack of infra structural facilities, non-supportive government policies to fulfill the requirement of future energy needs of growing Indian economy. The primary energy consumption in India had more than doubled during 1990-2011. However, the per capita energy consumption remains lower as compared to developed economies. Therefore, for the transitional Indian economy some energy subsidies are realistic and necessary for achieving social goals. However, the ever rising energy prices and environmental concerns, conflicts emerge between energy subsidies, energy demand / supply and climate change. It has implications on sustainable energy development through their effects on energy use, efficiency and fuel choice. The subsidies on petroleum products are the biggest, followed by subsidies for electricity and coal. The reduction in energy subsidies would result a significant fall in energy demand and gas emissions, but also have negative impacts on growth of Indian economy.

Ethanol blending policy (EBP) has been implemented for quite a long time since 2003. The sugar industry supplies most of ethanol required for blending with petrol because of its merits. Recently, the MoPNG, GOI has decided to make 5 per cent ethanol blending with petrol mandatory cross the nation. The cabinet committee on economic affairs (CCEA) failed to suggest the effective ethanol price policy. However, it approved the ethanol procuring policy for OMCs and gave liberty to procure ethanol either from domestic or international suppliers. The CCEA left on OMCs and ethanol suppliers to decide the ethanol procurement price based on the market demand and supply situation. The OMCs to meet the requirement of ethanol blending programme has floated tenders for procurement of 1.4 billion litre ethanol from the Indian sugar mills during year 2012-13. Ethanol as fuel has extensively used in Brazil and USA. These two countries together produced nearly 87 per cent of total global ethanol production during 2012. Many countries have reap the benefits of ethanol mixed petrol as an automobile fuel. India has also made some efforts in this direction through partial implementation of EBP, with very enthusiastic and stiff future ethanol blending targets of 20 per cent by year 2017. Certainly, it would reduce the country's dependence on petroleum oil import and slash import bill. The sugar mills which faced the problems in timely payment of sugarcane price to the farmers, the EBP can provide opportunities to earn more profit and ensure timely and regular payment to the farmers.

The domestic crude oil production from fossil fuels has been stagnant over the years and sufficient to meet barely 25-30 per cent of the national requirement. Therefore, India has to meet 70-75 per cent of its total requirement through imports of 160 million tonnes of crude petroleum products that cost the exchequer nearly $144 billion during year 2012-13, which was approximately

22 per cent higher than financial year 2011-12, **Figure 5**, GAIN Report (2013). High reliance on import of crude oil affect country's foreign exchange reserves in a big way. It is reported that the road traffic is growing @ 7 -10 per cent. The growth of vehicle number is @ 8 -10 per cent per annum during past few years. Hence, the number of registered motor vehicles in India has increased from 90 to 140 million during 2005-2012. The higher economic growth, easy car loan bank policy, urbanization, increase in consumer purchasing power and improvement in road infrastructure had encouraged new vehicle especially cars on Indian roads. It is expected that the petroleum demand for transport sector would further grow in tandem. The petrol demand expected to grow @ 6 to 8 percent in present decade. It is reported that the consumption of petrol has increased @ 6.90 per cent from 7.0 to 16.59 million tonnes during 2001- 2011 MoPNG (2013). It is further forecasted that the petrol consumption growth would continue during current decade of 21st century. It is projected that the motor car population in India during 2011-2020 may grow @ 10-12 per cent may further add to petroleum products demand. Because of ever increasing future petroleum products demand, the contribution/share of crude oil import likely to grow up to 92 per cent by the 2030 *(IEA, 2009)*. The ever growing dependence on fossil fuels for the transport sector will be the key reason for India to enhance the domestic bio-ethanol production. Therefore, strengthening of domestic bio-ethanol production would address the issues of poverty alleviation, agro-based industrial development, socio-economic transformation and environmental pollution. The increase in import bill of crude oil was primarily due to increase in crude oil price and petroleum products in the international market, depreciation of rupee and increase in domestic consumption of petroleum products. The Govt. of India suggested measures to mitigate the oil import bill through ethanol blended petrol as non-conventional source of energy substitute for petrol.

Figure 5 : Indian import of crude oil in quantity and value term



Source: Petroleum Planning and Analysis Cell, (GoI) 2013

2.10 Bio-ethanol production and consumption pattern in India

Globally, India is the second largest producers of sugarcane after Brazil and produce bio-ethanol from sugarcane molasses, a by-product of sugar mills. For producing ethanol, India has 140 distilleries with the annual production capacity of over 4.0 billion litres **Table 16**. In year 2013, India produced nearly 2.06 billion litres bio-ethanol, out of which 650 million litres ethanol was blended with petrol. Ethanol production is highly volatile in India due to the cyclical nature of sugarcane production and therefore, the blending of ethanol with petrol is also volatile. For instance, India produced around 2.15 billion litres bio-ethanol in 2008, out of which 280 million litres was utilized for blending with petrol **Table 16**. In 2009, ethanol production went down to 1.07 billion litres and blending to 100 million litres. Ethanol is primarily produced by the fermentation of molasses. It is estimated that from one tonne sugarcane, 85-120 kg sugar (8.5–12 per cent) and 40 kg (4 per cent) of molasses could be obtained. The ethanol recovery from molasses is 22-25 per cent as per Indian standards. Presently, about 70-75 percent of total sugarcane produced in India has utilized for the sugar production and remaining 25-30 percent utilized for alternative sweeteners jaggery and *Khandsari* production, seed and chewing. Thus, the molasses a by-product of sugar processing is available as sole source of raw material for ethanol production. Due to cyclical nature of sugarcane and sugar production in India, sugarcane farmers and the processing industry experience periodic market gluts/deficit in sugarcane production, sugar and molasses, impacting their prices and farmers income. The bio-ethnol produced in India used for various purposes. There are three main uses of bio-ethanol in India. It includes potable liquor manufacturing, industrial use as alcohol-based chemical solvent, blending with petrol as automobile fuels and other purposes. In India, approximately, 25 per cent of the total ethanol production used for industrial purposes, 30-35 per cent for potable purposes (beverages production) and the 30-40 per cent utilized as automobile fuel blended with petrol and other uses.

Table 16 : Bio-ethanol production and consumption in India during 2006-2013

(In million litres)

Sl.	Particulars	2006	2007	2008	2009	2010	2011	2012	2013
A.	Bio-ethanol production	1898	2398	2150	1073	1522	1681	2170	2064
B.	Bio-ethanol consumption								
i.	Industrial use	619	650	700	700	720	700	720	740
ii.	Potable liquor	745	800	850	880	900	850	880	910
iii.	Blended with petrol	200	200	280	100	50	365	305	650
iv.	Misc.	75	100	110	100	110	80	85	85
	Total	1639	1750	1940	1780	1780	1995	2085	2135
C.	Existing infrastructural facility for bio-ethanol production								
i.	No. of distilleries/ ethanol	115	115	115	115	115	115	140	140
ii.	Production capacity	1500	1500	1500	1500	1500	1500	2000	2000
iii.	Fuel bio-ethanol	200	200	280	100	50	365	305	650
iv.	Petrol/ gasoline Cons.	13056	14527	15829	18022	19954	21080	22132	22510
v.	Ethanol blending (per cent)	1.5	1.4	1.8	0.6	0.3	1.7	1.4	2.9
D.	Quantity of feedstock molasses used								
i.	Molasses (million tonnes)	7.91	9.99	8.96	4.47	6.34	7.01	8.98	8.60
ii.	Ethanol yield (liter/tonnes)	240	240	240	240	240	240	240	240

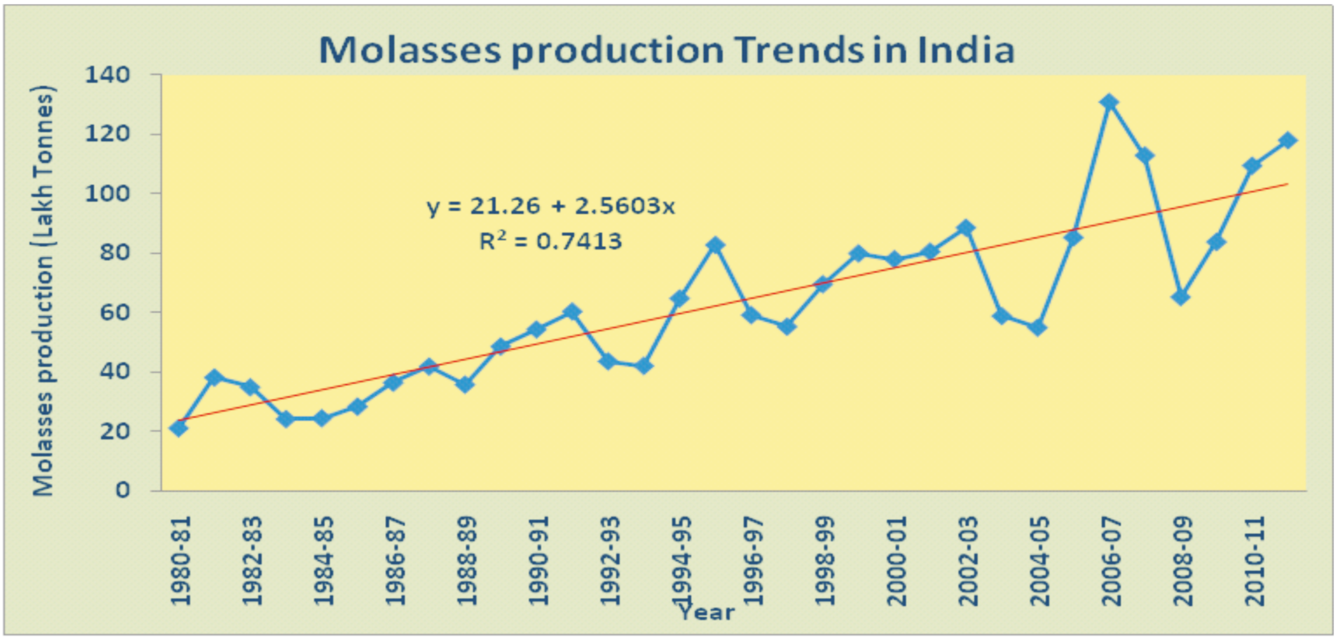
Source: GAIN report 2012-13

The bio-ethanol supply for EBP program for the year 2012-13 was just sufficient to meet only three per cent blending target. This was in contrast to the NBP which encourages use of renewable energy as alternate fuel to supplement fossil automobile fuels with the aims to substitute

20 per cent petrol fuel consumption with bio-ethanol by terminal year of 12th FYP 2016-17. Keeping in view, the better sugarcane and sugar production during recent years, the government may implement five per cent ethanol blending with petrol, provided that a consensus among the OMC's, sugar mills / bio-ethanol suppliers and other stakeholders on purchase price of bio-ethanol for the EBP. The five per cent ethanol blending with petrol has been achieved successful during surplus sugar production and realization below set target when sugar production decline. India is the fourth largest global contributor to carbon emissions. Hence, GoI, transport policy had adopted vehicle emission norms as Bharat-III and BS IV for all motor vehicle. Therefore, it would be mandatory requirement to implement clean and green fuel policy. In future, government has serious concerns for economic growth, environmental, food and energy security at the same time as search for alternate fuels to meet ever increasing energy demand through safe, clean and convenient forms of energy at least cost in techno-professional, eco-friendly, financially viable and environmentally sustainable manner.

With the rising per capita income, urbanization, infrastructural development and the ultimate increase in vehicular density, the demand for petrol in India is galloping ahead. The CGR for petrol demand was 8.5 per cent during the XIth Five Year Plan (2007-12). This growth of petrol demand is expected to continue uninterrupted over the subsequent next two-three decades. Taking cognizance of the government plan to implement 20 per cent blending of petrol with bio-ethanol by 2017, the ethanol demand as fuel for EBP, portable, industrial and other alternative uses has projected using the growth rate for the period 2004-05 to 2011-12 in **Table 17**. It is evident from the **Table 17** that the ethanol demand for the year 2012-13 at 5, 10 and 20 per cent blending could be 0.78 million tonnes, 1.56 million tonnes and 3.12 million tonnes, (988 million litres, 1976 million litres and 3953 million litres), respectively. It is reported that one tonne of ethanol is equivalent to 1267 litres with the bulk density 0.789 g /mL, Shinoj *et al.* (2012). India's total ethanol requirement after inclusion of its demand for potable, industrial and other uses would be 2.21 million tonnes, 2.99 million tonnes and 4.55 million tonnes, respectively during 2012-13. The projected ethanol demand for 2016-17, with petrol @ 20 per cent that has to be implemented, the total ethanol requirement for different purposes would be 6.11 million tonnes, equivalent to 7741 million litres. The projected petrol demand for India would be 36.82 million tonnes and 44.34 million tonnes by the year 2025 and 2030 respectively. With the annual growth rates of real petrol price at 4 per cent, the petrol price expected to increase from ₹ 66 to ₹ 120 per litre by 2025. The annual CGR for petrol demand would be 7.2 per cent and the expected GDP growth rate could also be virtually seven per cent, Agrawal (2012). It is clear from the analysis that the demand of petrol and ethanol will have to increase substantially during 2015-2030. Therefore, India should adopt the different improved ethanol processing, energy efficient automobile technologies and petrol demand management policies to fulfill the growing future ethanol demand. This should include policy of market linked prices for petroleum products. The subsidies on petroleum products, Diesel, CNG, LPG etc. should be minimised and offered only to the targeted groups such as BPL families and farmers.

Figure 6 : Molasses production trends in India during 1980- 2012



Data source : Cooperative Sugar 45 (1) : 2013.

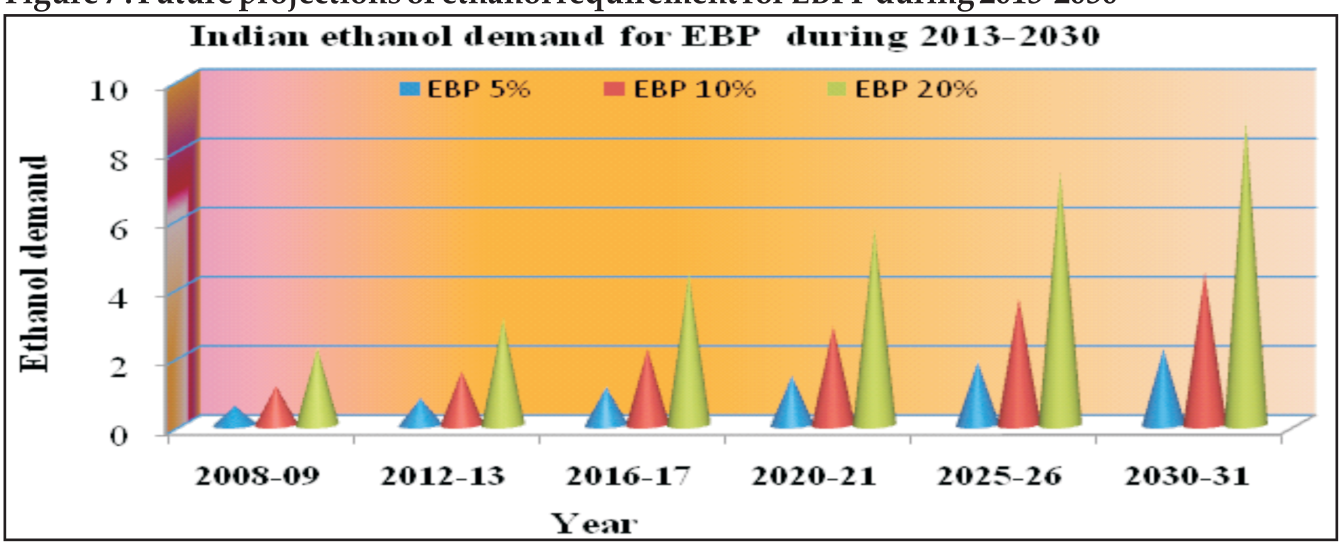
Table 17 : Projections for India's petrol and ethanol demand for 2013-2030

(*In million tonnes*)

Year	Petrol demand	Ethanol demand for fuel			Portable	Industrial & other uses	Total ethanol demand		
		5 %	10 %	20 %			5 %	10 %	20 %
2008-09	11.25	0.56	1.13	2.25	0.65	0.60	1.82	2.39	3.51
2012-13	15.60	0.78	1.56	3.12	0.74	0.69	2.21	2.99	4.55
2016-17	22.14	1.11	2.21	4.42	0.87	0.82	2.8	3.9	6.11
2020-21	28.64	1.43	2.86	5.73	0.97	0.89	3.29	4.72	7.59
2025-26	36.82	1.84	3.68	7.36	1.03	0.93	3.8	5.64	9.32
2030-31	44.34	2.22	4.43	8.87	1.09	0.98	4.29	6.5	10.94

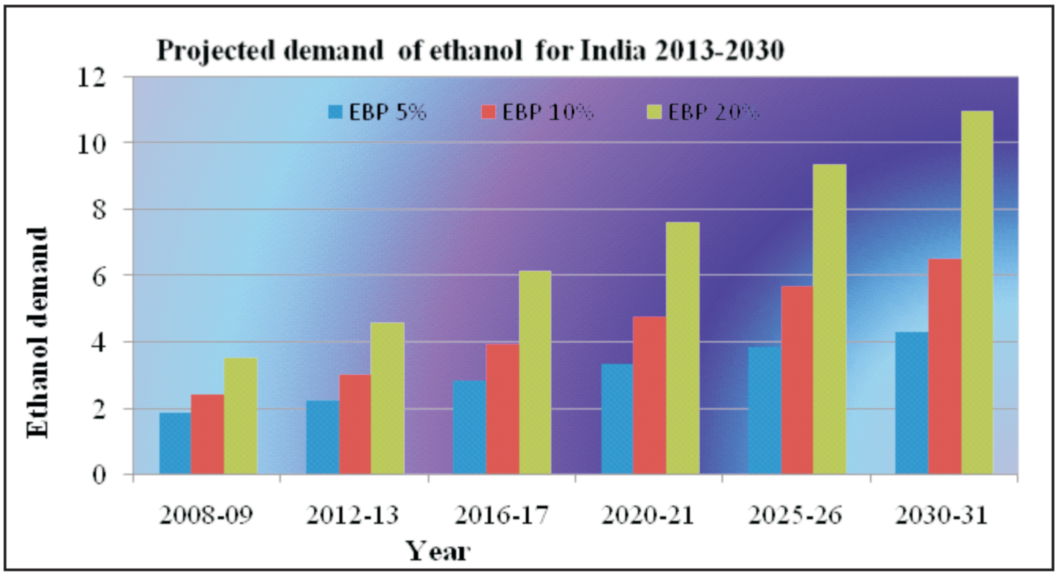
Source: Author's computations

Figure 7 : Future projections of ethanol requirement for EBPP during 2013-2030



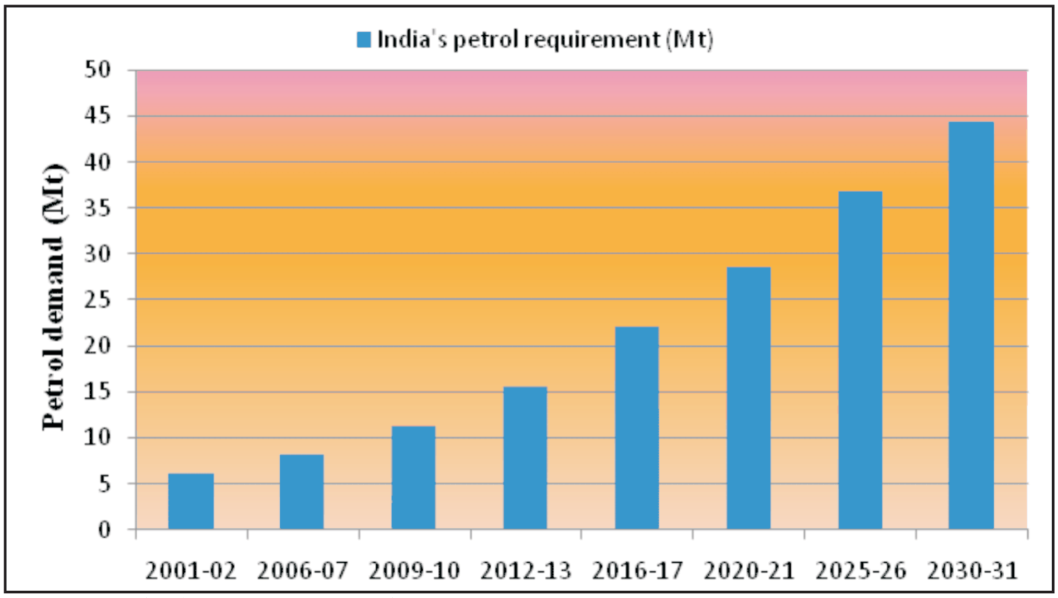
Source : Author's computations

Figure 8 : Projections of total ethanol requirement for various uses 2013-2030



Source : Author's computations

Figure 9 : Future projections for petrol requirement during 2013-2030



Source : Author's computations and projections

The projection indicates that the petrol as well as bio-ethanol demand to meet the future targets of EBP should increase rapidly in next two decades. Among the demand of petroleum products, petrol consumption would enhance more rapidly as compared to the other products such as naphtha, kerosene and low sulphur heavy stock. It would be because of increase in number of automobile vehicles (cars and motorcycles) for public and personal transport. The combined demand for bio-ethanol in India for industrial uses and 20 per cent blending with petrol across the nation may be 10.9 million tonnes by 2030. The regulatory environment will need to facilitate the transition to higher blending programme through necessary changes that would be made to sugarcane control order. Higher levels of blending also need that the sugar mills have flexibility to shift from sugar to ethanol, based on market dynamics. The expected future demand could further swell due to higher purchasing power of Indian population, improvement in per capita income and high GDP growth rate of Indian economy.

2.11 India's projections for sweeteners production and consumption demand

The sweetener production and consumption has been rising fast in developing countries such as India, Brazil and China. The share of developing nations in global sugar consumption has increase from 58 per cent in early 1980's to 74 per cent equivalent of sugar crops used for non food industrial utilization, primarily sugarcane used for bio-ethanol production in Brazil. The sugar demand of developing countries has been improving significantly since 1980's, whereas the sugar consumption in developed countries has been declining or remains unchanged. The estimated sweetener consumption trends indicate that the sugar consumption in India and other developing countries may further increases in next three decades **Table 18**. The key factor in sugar consumption stagnation of developed nations could be rapid expansion of corn based sweeteners in U.S.A. The sliding sugar consumption trend in developed countries has counterbalance by the higher consumption in developing countries. However, the world average per capita sugar consumption would be more or less constant during next several decades.

Table 18 : Global sugar and sweetener consumption trends

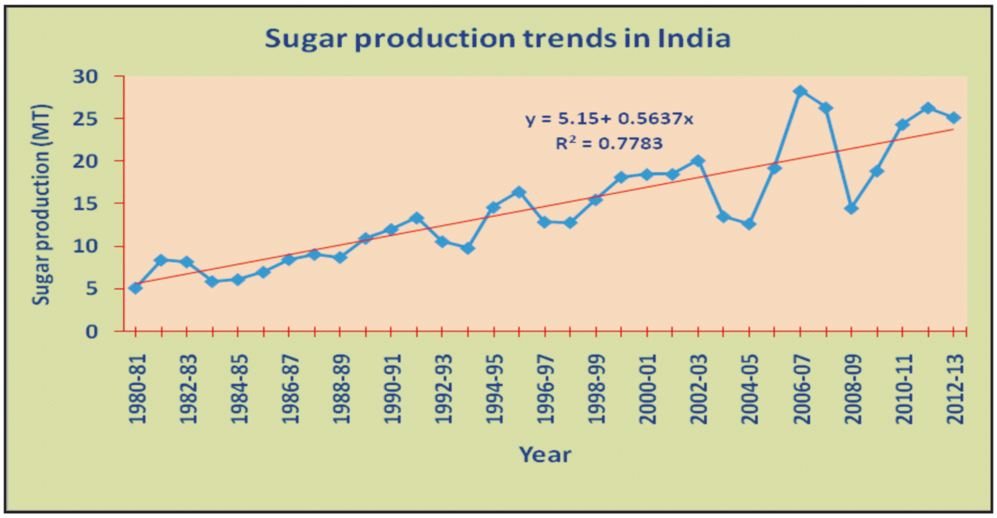
Total sweetener consumption demand , (In Kg/person/year)	1980	2010	2020	2030	2050
India	20	23	25	26	31
Developing nations	17	18	19	22	24
Developed nations	40	36	34	33	33
World	23	22	22	24	25

Source : Vision document 2050 draft SBI, Coimbatore

The first decade of 21st century has witness the paradigm priorities shift for sugarcane as raw material for sugar and energy production. Sugarcane, sugar beet and alternative sugar crops were used as feedstocks for bio-ethanol production. Brazil is the largest ethanol producer from sugarcane as it utilizes 40-50 per cent sugarcane production for bio-ethanol. In spite of it, Brazil still dominates global sugar market as it remains the largest sugar producer and exporter.

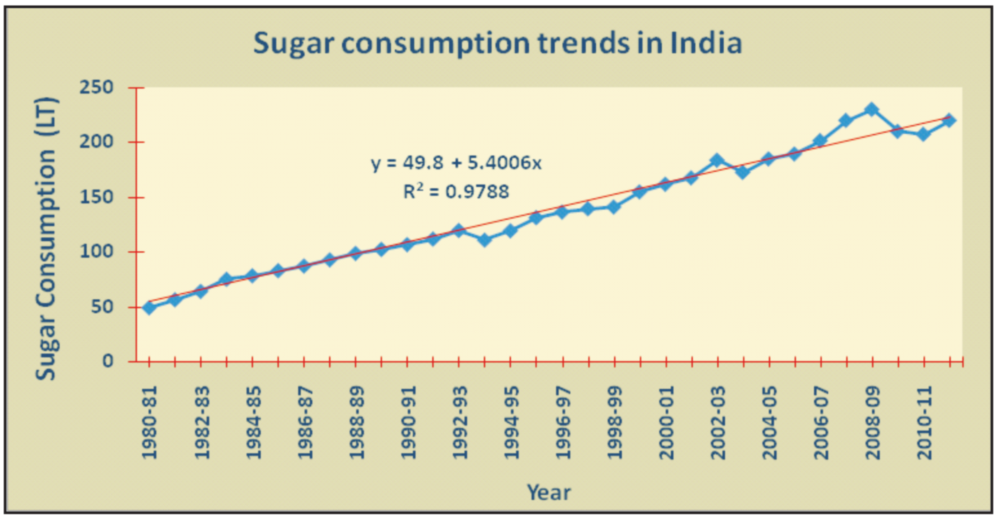
In India, sugar requirement is growing consistently with high population growth. It is envisaged that sugar consumption pattern in India shall grow @5-6 per cent per year in forth coming decades, Mohan (2014). Sugar consumption by year 2020 expected to reach 30 million tonnes due to improved domestic production and strong demand, fueled by the growing population and economy growth. The estimated sugar requirement for domestic consumption by year 2030 may reach 32 million tonnes, which would be 40 per cent more than the current sugar production. To achieve this stiff target, the sugarcane production should be enhance to 550-600 million tonnes from current production of 350 million tonnes for which cane production has to increase by 8-10 million tonnes per year. The increase production has to be obtained from the existing sugarcane acreage through higher productivity 100 tonnes/ha and better sugar recovery 11-12 per cent as further cane area expansion may not feasible. Keeping in view, high cost of food grains imports and strategic significance of food security, India would need to target its production in excess of domestic consumption. The trend analysis reveals that the sugar production and consumption in India expected to grow further due to better purchasing power and ever increasing population in next three decades. Therefore, to fulfill the future demand of sugar and bio-energy, production of sugarcane and alternative sugar crops should be enhance faster than India's food grains production during 2015 to 2050.

Figure 10 : Trends of sugar production in India during 1980 to 2012



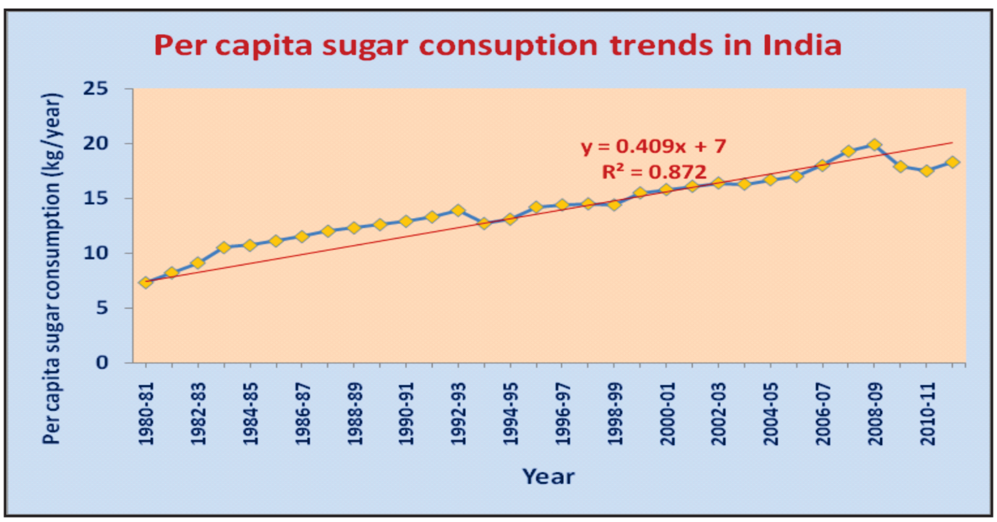
Data source: Cooperative sugar 45(1) : 2013

Figure 11 : Trends of sugar consumption in India during 1980 to 2012



Data source: Cooperative sugar 45(1) : 2013

Figure 12 : Trends of per capita sugar consumption (1980 to 2012)



Data source: Cooperative sugar 45(1) : 2013

Figure 13 : Flow chart of jaggery and *Khandsari* production in India

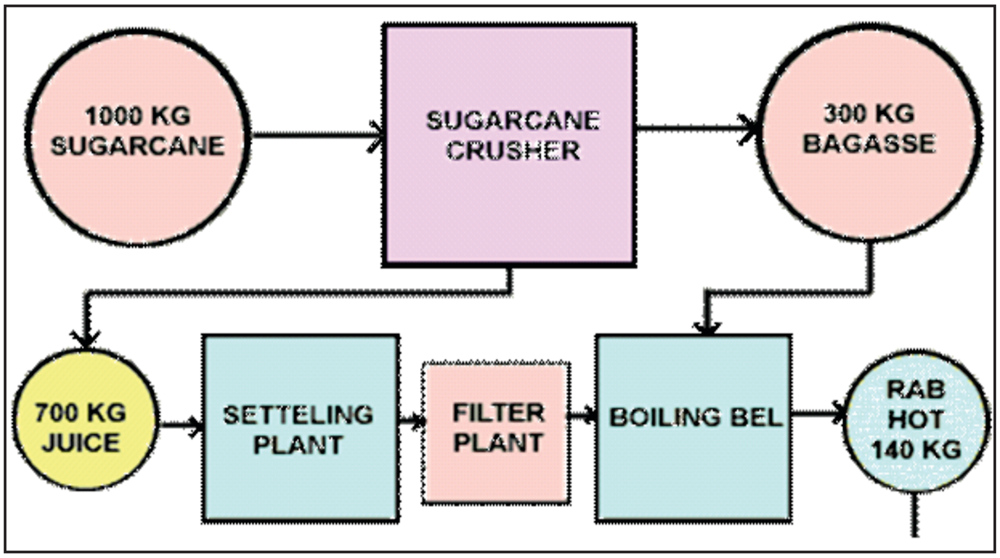
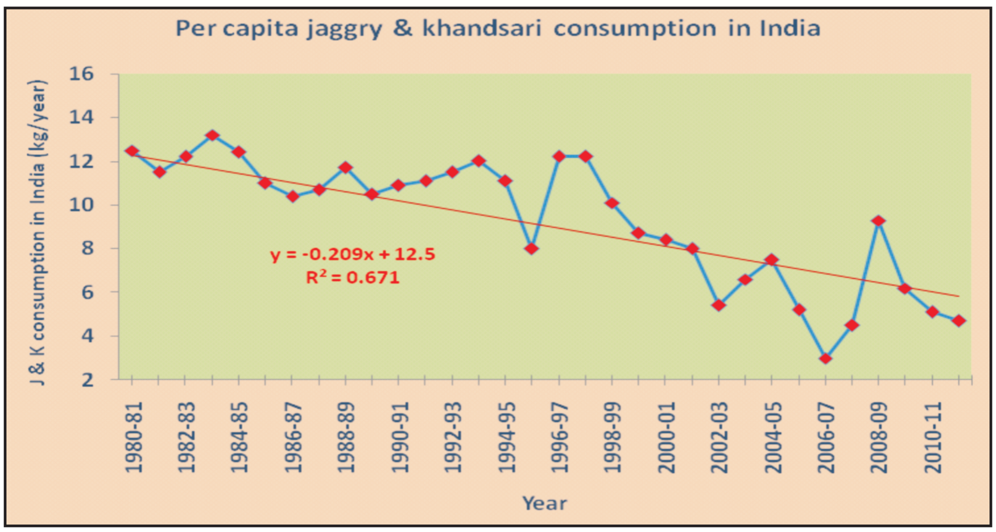
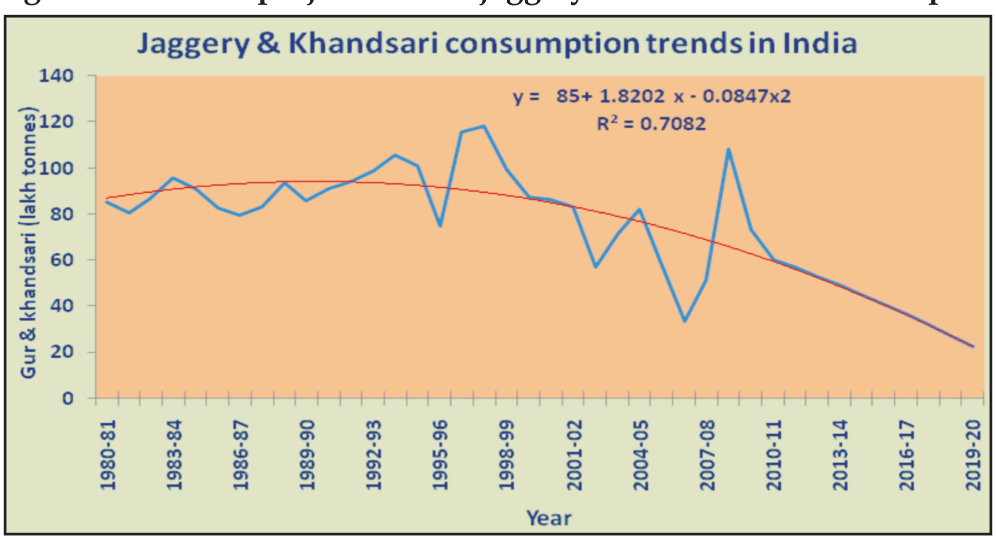


Figure 14 : Trends of per capita jaggery and *Khandsari* consumption



Data source: Cooperative sugar 45(1) : 2013

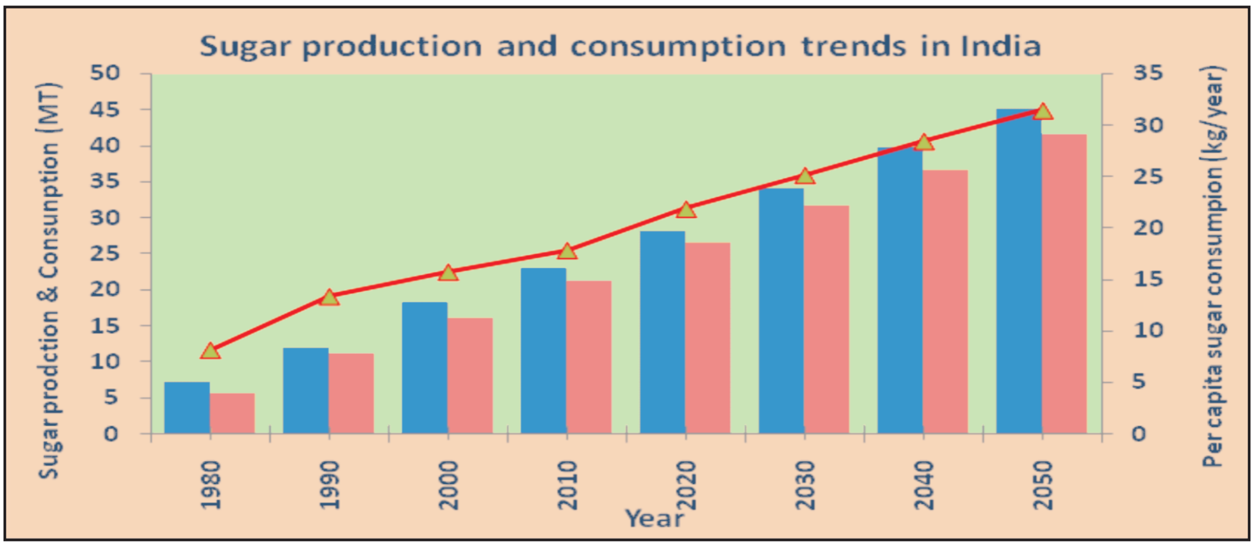
Figure 15 : Future projections for jaggery and khandsari consumption



Data source: Cooperative sugar 45(1) : 2013

The expected demand for sugar, bio-ethanol and power may further enhance due to ever growing Indian population, better living standard, high economy growth and rising per capita income. The anticipated sugar requirement by year 2030 and 2050 would be 32 and 42 million tonnes respectively. The estimated sugar production in India by year 2030 and 2050 would be 34 and 45 million tonnes respectively **Figure 16**. Indian sugar industry has potential to fulfill its future sugar demand and also have 3-4 million tonnes exportable sugar surplus for maintaining buffer stock and global market. To realize these targets, sugarcane production should be enhance up to 550-600 million tonnes per year, from its current production of 350-360 million tonnes / annum. The Indian sugar sector has to be strengthened significantly through modernization of old infrastructural facility with advanced processing technologies to fulfill the galloping future sugar, energy and power demands of domestic consumers. The additional sugarcane production should be achieved from the existing cane acreage through higher productivity and better sugar recovery as the scope of further area expansion may not be feasible in future due to more demand of other food crops. The concerns of static cane productivity, high cultivation cost, natural resources depletion and climate change may also affects sustainability of sugarcane production. Therefore, cane productivity enhancement and higher sugar-energy processing efficiencies with the resource availability and constraints for achieving the future production targets of year 2030 and 2050 would be the real challenge for sugarcane R&D institutions and Indian sugar sector. The efforts should be made to develop demand driven technologies, location specific processes based on niche products demand, market trends and socio-economic condition. The infrastructure and extension support should be strengthened for bridging the gaps in technology adoption, research and extension needs.

Figure 16 : Future projections for sugar production and consumption



Source: Author's own projection

2.12 Estimated potential of bagasse based power co-generation in India

The combined heat and power (CHP) or cogeneration is the concurrent production of electricity, heating and cooling from bagasse a by-product of sugar mills as fuel, with the high power production efficiency. India is the third largest power consuming nation in asia after China and Japan. The electricity energy demand and supply gaps has 25-30 per cent deficit in India. The power cogeneration in integrated sugar-energy complexes is the combined generation of steam and electricity using bagasse as raw material, **Figure 17**. The bagasse is a renewable raw material did not produce GHG emission on its burning produce environmentally safe and clean bio energy. The large amount of surplus bagasse production by the sugar mills could generate electricity to fulfill the sugar mill requirement and sold surplus electricity to the national power grid. The promotion of power cogeneration from renewable sources should be priority policy for GOI. There are more than 526 functional sugar mills with collective power cogeneration potential of 5500 MW. However, the total power cogeneration 2500 MW is hardly 45 per cent of current installed capacity. If sugar processing sector utilize its full installed cogeneration capacity of 5500 MW could supplement handsomely and facilitate in accomplishing the growing power needs. It would be achievable only when the sugar mills utilize its installed production capacity to generate surplus bagasse for power cogeneration. Hence, it is essential to improve sugarcane productivity and ensure its timely availability for better capacity utilization of sugar mills. The ethanol production and cogeneration are totally dependent on sugar production as bagasse used as the raw material are generated as by-products during sugar production. The potential of power co-generation in India could be further enhanced up to 9700 MW to supplement 6 per cent CGR of additional power requirement by year 2017 and also produce about 48 million carbon credits. The green energy production from bagasse through power co-generation may further improve and its demand may be doubled by year 2030.

Figure 17 : Integrated sugar-ethanol-cogeneration complex in India

Government incentives for bagasse based power cogeneration

The thermo chemical process for conversion of bagasse into power cogeneration involves combustion, gasification or pyrolysis. The widespread old process used for cogeneration is combustion. Similar technology is also used in the thermal plant based on coal, except for the boiler. In conventional production cycle bagasse burnt in high pressure boiler to generate steam to run the turbines **Figure 18**. The realize energy efficiency may be 23-25 per cent. The exhaust of steam turbine can be condensed to generate power, or another heating activity. Sugar industries are customarily practicing cogeneration through bagasse as fuel. The technological advancement for steam generation and its optimal utilization at high temperature and pressure, sugar mills would produce electricity and steam for sugar processing requirement. They may produce surplus electricity for its sale to national grid from bagasse. If steam generation temperature/pressure rose from 400°C/33 bar to 485°C/66 bar, nearly 80 KWh of more electricity could be produced per tonne cane crushed. The surplus power supply to national grid through cogeneration may improve sugar mills economic profitability and adds power production capability of India. The government of India provides the financial assistance and monetary incentives up to 80 per cent depreciation, concessions on equipment import duty, excise duty and tax holiday for 10 years for establishing the integrated sugar-power cogeneration complexes. The state electricity regulatory commissions (SERC) has fixed electricity purchase price, determine tariffs and renewable electricity purchase standards (RPS), presented in **Table 19**.

Figure 18 : Process of power cogeneration from bagasse

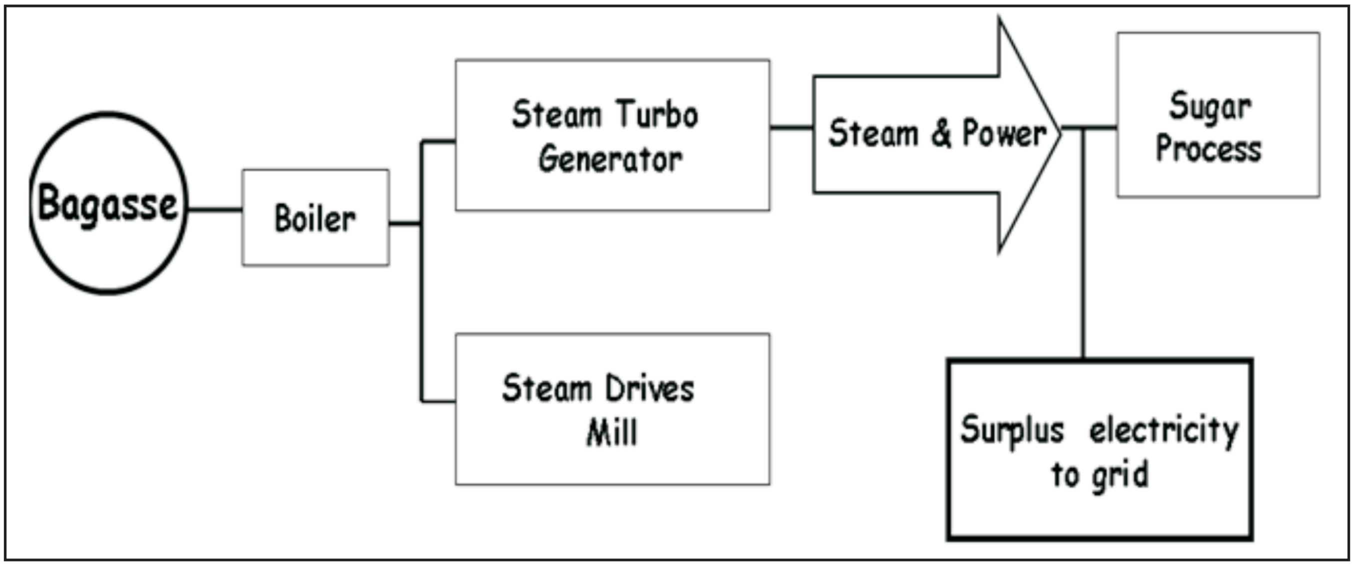


Table 19 : Status of tariffs on power cogeneration supply to national grid

State	Electricity/power purchase price and tariffs *(In ₹/kWh or unit)*	Renewable purchase standards (%)
Andhra Pradesh	3.48	Min. 4
Chhattisgarh	3.93	5
Gujarat	4.55/unit with accelerated depreciation for 10 yrs	10
Haryana	3.74 with 3 per cent increase per year	1
Karnataka	Public Private agreement date 3.59 - 4.14 (10th Year)	Min.10
Maharashtra	4.79	6
Madhya Pradesh	3.33 to 5.14 for 20 yrs with increase of 3- 8paise/year	0.8
Punjab	4.57 with 5 per cent annual raise	Min. 3
Tamil Nadu	4.37-4.49 with annual escalation 2 per cent	Min. 13
Uttaranchal	3.12 from new power cogeneration projects	9
U.P.	4.29-4.38 with escalation of 4 paisa / year	4

Source: http://www.mnre.gov.in/schemes. accessed in July 2014

The Indian renewable energy development agency (IREDA), lending arm of MNES, has provided development finance for harnessing production of green bio energy in India during first decade of 21st century. It has made significant contribution for advocating commercialization and establishment of bagasse based cogeneration integrated projects with sugar mills in India. It offers loan for establishment of bagasse based cogeneration integrated sugar complexes. The state-wise prevailing prices, tariffs and purchase standards for renewable green energy cogenerated by sugar mills are listed in **Table 19**. The sugar lobby and other industrial associations such as the cogeneration association of India, financial institutions and other stakeholders has pursued the central electricity regulatory commission (CERC) to guide SERCs for adoption of an uniform electricity purchase prices and tariff for bagasse based power cogeneration. The bagasse based power cogeneration had achieved the take-off stage in India. It is expected that by 2030, bagasse based power cogeneration may have total power supply potential of 9700 MW to national grid. The bagasse based power cogeneration from sugarcane biomass is an environmentally safe and viable option to supplement the power requirements. Hence, sugarcane production and productivity has to be enhanced to ensure full installed crushing capacity utilization of sugar mills. It would be useful to develop high biomass, high fibre and moderate sucrose varieties for upcoming integrated sugar-energy complexes in India. The bio-ethanol production and cogeneration are completely dependent on sugar production as the required raw materials are generated as co-products during the sugar processing. If the sugar production goes up the cogeneration and bio-ethanol production would also enhance. The lessons learned from last decade would be useful in achieving accelerated power cogeneration growth for fulfilling the future demand targets. The enactment of electricity bill 2003 and its adoption by the states ensure level-playing ground for green energy along with sustainable policy regime. The forthcoming financial initiatives of GoI and trade emission reductions on such projects under clean development mechanism (CDM) of Kyoto Protocol would be useful in removing trade barriers to accelerate growth of bagasse based power cogeneration in India.

2.13 Potential of other value added niche products from sugarcane processing

Sugar processing industry co-products viz., bagasse, molasses, press mud has enormous potential for human, animal feed consumption and has capability of providing renewable energy. Sugarcane and its by-products are used as raw material for 25 industries such as ethanol, pulp and paper, boards, pharmaceuticals and many other valuable chemicals. The Indian sugar industry has necessary technological knowledge to tap commercial potential of other value added niche products listed as follows.

- Butanol- In India, sugarcane bio-ethanol is made primarily from molasses. The present processing technology exploits merely one-third of total energy sugarcane can offer. The two-third potential energy remains locked in leftover cane fibre (bagasse) and trash or dry straw. The process of bio-conversion of bagasse and ligno- cellulosic biomass to bio-ethanol and butanol is another emerging area which requires huge R&D investments. In India, it could be vital where scope for increasing the production of ethanol from molasses or sugarcane juice is limited. However, the key constraint is the lack of cost effective technologies to convert bagasse to bio-ethanol. Butanol, a promising next generation bio-fuel which packs more energy than bio-ethanol is an aliphatic saturated alcohol could also be used as transportation fuel. It has higher octane value than bio-ethanol may be used in existing automotive engines, non-hygroscopic and non-corrosive engines. Butanol may also be produced from sugarcane juice and molasses using bacterial strains. The butanol production could be obtained from crystalline cellulose by co-cultured *Clostridium thermocellum* and *Clostridium saccharoperbutylacetonicum*. The new strains of *Clostridium bejerinckii* have efficient conversion of sugarcane juice and molasses to butanol.

This promising technology could play a vital role in revolutionizing production of butanol as an alternate bio-fuel in future.

- Bio-plastics- Sugarcane ethanol has emerged as key ingredient to substitute petroleum in production of bio-plastic. The bio-plastics have similar physical and chemical properties as regular plastic known as polyethylene or PET. The bio-plastic has recycling capabilities. The eco-friendly green plastics and polyethylene produced from bagasse has enormous future market potential. Some R&D study indicates that the unit tonne of bio-plastic may avoid emission of 2.0 to 2.5 tonnes carbon dioxide on life cycle basis. The utilization of bio-plastics is still in developing phase. It has enormous future potential in India
- Bio-hydrocarbons- Production of bio-diesel from sugarcane is one of the successful models of bio-hydrocarbon production in Brazil. The Farnesene, a chemical compound could be used for production of number of renewable chemicals, including diesel from sugarcane. In partnership with its Brazilian subsidiary, Sao Martinho Group, Amyris is producing sugarcane-based diesel that is being tested in Brazil. The bio-hydrocarbons would have huge scope and future potential. The general electric (GE) and Amyris had standardized process of jet fuel production from sugarcane.
- Paper and pulp industries- The bagasse pulp could be a perfect substitute for wood pulp in paper industry. The large scale use of wood pulp for paper manufacture has serious concern for social scientists and environmentalists, in view of declining natural forest resources. Hence, paper and pulp industry has to look for alternative raw material for paper and ply board production. The bagasse which has similar fibre properties has been utilized for paper production in India and Thailand. The bagasse accounts for 20 per cent of raw material for paper production in India, China and South America. The paper and pulp industry consumes 10 per cent of total global bagasse production. In future, bio-ethanol may be produced from bagasse with second generation technologies. Therefore, new and innovative technological interventions to be explore for efficient utilization of bagasse as precious resource. It is expected that nearly 100-125 million tonnes bagasse would be available as raw material by 2030 and half of it should be diverted for production of bio-ethanol / butanol, paper, bio-plastics and other industrial products, Solomon (2014). To accomplish future targets, it would be useful to develop high energy sugarcane varieties with high fibre content. The bagasse may be replaced by sugarcane dry trash or other crop residues as boiler fuel in phased manner. The other agro-forestry plantation in sugar mill command area may be used as fuel to save bagasse and utilization of saline soil or degraded lands for higher biomass production. It could be useful to develop microbial consortium for conversion of ligno-cellulosic biomass for bio-fuels production and improve fermentation efficiency.

Hence. there is enormous opportunity and attractive proposition for sugarcane crop as molecular farming for considering high biomass and its ratooning potential. Sugarcane had already been engineered to produce high value molecules such as therapeutics, industrial enzymes, vitamins, vaccines, bio-plastics etc. Therefore, it is essential to develop suitable technologies and processes for expression of desirable genes in sugarcane and target their storage in vacuoles for facilitating extraction products and its purification from sugarcane juice.

3

Policy Framework and Enabling Factors

Food and nutritional security is the national priority for India due to its 1.21 billion population, 22 per cent below poverty line family, ever increasing domestic demand for food, stagnate agricultural productivity and hardly any scope for further area expansion in crop cultivation. Recently, GoI, had passed an ambitious **"National Food Security Bill 2013"** to give right of subsidized food grains to 67 per cent of its total population and also provides food security allowances for non-supply of food grains through its PDS shops. As per the provisions of food security bill, 75 per cent rural and 50 per cent urban population is entitle for 5 kg of food grains per month at subsidized price. Therefore, GoI could not afford to promote use of food grains/animal feedstocks for bio-ethanol production. Besides it, India is one of the largest importers of vegetable oils from the world market as the edible oil demand of Indian consumers outstrip domestic oilseeds production. The growth of food grains production such as wheat, corn and coarse cereals had stagnant or slowdown during past few decades, raised concerns for their potential scarcity to fulfill the commitment made by the government in food security bill 2013. Besides it, high global prices of food grains in international market have been the major concern for the government. Therefore, the government does not want to further intensify the crisis through promotional use of food grains for bio-ethanol production. In nutshell, India's bio-fuel policy must address these key concerns and give adequate emphasis to adopt a pro-poor dimension for harnessing the country's potential for safe and green bio-energy production.

3.1 National biofuel policy of India

Government of India has undertaken several policy measures to augment production and blending of bio-ethanol during past one decade. The initiation of national biofuel mission (NBM) during year 2003 under the aegis of Planning Commission, GoI, is the front runner for such efforts in our country. The NBM laid special focus on phased expansion of area under alternative bio-ethanol feedstock crops such as sweet sorghum, sugar beet, palm, Cassava etc. The ethanol blended petrol programme EBPP is an integral part of NBM, aimed to initiate blending of green bio-ethanol with transport fuels like petrol / gasoline on large scale. In order to make bio-ethanol blending obligatory to the states, the ministry of petroleum and natural gas MoPNG, GoI, 2003 made five per cent ethanol blending with petrol mandatory in nine states and five union territories. It was implemented partially due to the non-availability of bio-ethanol because of low sugarcane production during 2003-05. The ethanol blending with petrol was further extended to 20 states and eight union territories in 2006. The ethanol blending targets were partially implemented because of oil marketing companies OMCs inability to procure sufficient bio-ethanol from the distilleries at the existing market price. Later on national biofuel policy (NBP) formulated by the ministry of new and renewable energy (MNRE) was approved by the Cabinet Committee in 2008 and released in 2009. The policy foresees the bio-ethanol as a prospective means to stimulate economy of sugar processing industries, sugarcane farmers and rural development. It also generate additional employment opportunities to reap the environmental and economic benefits arise of its large-scale use as automobile fuel. It also outlines research and development, capacity building, price policy for procurement of bio-ethanol and registration for enabling use, including utilization of second generation feedstocks. The policy envisages utilization of wide range of sugar crops such as sugarcane, sugar beet, sweet sorghum, cassava etc., for bio-ethanol production. The establishment of national biofuels development board (NBDB) helps in developing road map for utilization of bio-ethanol in petrol engines in a time bound manner, besides formulating suitable policy measures. The ambitious national target of five per cent ethanol blending with petrol by 2012, 10 per cent by end of 12th FYP and 20 per cent after 2017 has been recommended. The minimum procurement price (MPP) for purchase of bio-ethanol by the OMCs should be based on actual cost of molasses production and import price of bio-ethanol.

NBP also reveals that bio-ethanol should be brought under the ambit of "declared goods" by the GoI to make sure unrestricted movement of bio-ethanol within and outside the states. It is also stated that the minimum taxes and duties should be levied on bio-ethanol. It is recommended to set-up the national biofuel coordination committee (NBCC) under the chairmanship of the Prime Minister and the biofuel steering committee (BSC) under the chairmanship of cabinet secretary, GoI, for high level coordination and policy reviewing on different aspects of bio-ethanol production in India. The Government has also created NBF to provide financial incentives such as subsidies and grants for utlization of second generation feed stocks, advanced technologies for molasses conversion processes and establishment of bio-ethanol production units based on second generation feedstock. Endowed with significant potential for energy generation from renewable resources, GoI has been promoting production and use of bio-ethanol from molasses for blending with petrol / gasoline. Besides, it the bio-ethanol processing technologies and projects were allowed 100 per cent foreign equity through automatic approval to attract FDI for domestic sugar-energy sector development, (GoI 2009).

3.2 Research and development initiatives for bio-ethanol production

In India, bio-ethanol production depends primarily on availability of molasses. Sugarcane production in India is cyclical, bio-ethanol production also fluctuate with sugar and molasses production. Therefore, it did not ensure optimum bio-ethanol supply required to meet the total demand. If sugarcane production decline in a year, there would be less molasses availability which lead to higher molasses prices and ultimately to higher ethanol production cost. Hence, this production scenario disrupts the bio-ethanol supply to the OMC's for the EBP program on pre-determined prices. Therefore, research and development for identification of alternative feedstock's for bio-ethanol production is the foremost mandate of the NBP. It is stated in NBP document that the R&D efforts should be focused on sugarcane, sweet sorghum, sugar beet and cassava production and processing bio-ethanol technologies to maximize utilization efficiencies of sugar mills by-product molasses. It envisage top priority for indigenous R&D and bio-ethanol processing technology development based on the locally available feedstock's and need. It should be benchmark at par with international standards. The GoI did not allow the import of bio-ethanol for the EBP program. It focused on promotion of domestic capacity for bio-ethanol production. In India the bio-ethanol has manufactured only from molasses. However, the government should grant permission for bio-ethanol production directly from sugarcane juice on experimental basis during upswing cycle in sugarcane production. It could be a viable alternative for bio-ethanol processing especially during surplus sugarcane production. The government should also offer subsidized loans from sugarcane development fund (SDF) to sugar mills for

Table 20 : Chronology of EBP programme implementation and constraints in India

Sl.	Particulars	Initiatives taken by Govt	Constraints/ achievement
1.	EBP Gazette 2003	MoPNG made five per cent ethanol blending with petrol compulsory in nine states and five UTs	Partially implemented due to non availability of required quantity of bio-ethanol for petrol blending
2.	Sept. 2006	GoI made mandatory five per cent EBPP for 20 states and four UTs excluding (NEH, J & K, and A & N)	OMC's awarded contract for supply of 1.4 billion litre bio-ethanol for EBP @ ₹ 21.50 / litre during 2006-09. However, 0.54 billion litre (only 40 per cent) bio-ethanol supplied due to less supply of molasses. The government deferred EBP due to poor supply
3.	Sept. 2008	GoI approved the NBP and five per cent bio-ethanol blending mandatory nationwide.	The government again deferred EBP implementation due to molasses scarcity for bio- ethanol production.
4.	October 2008	The second phase of EBP implementation enhance blending targets up to ten per cent.	No official notification and OMC's did not commence ten per cent ethanol blending. EBP status *quo ante* remains five per cent .
5.	August 2010	The GoI fixed bio-ethanol procurement price @ ₹ 27 per litre to OMC's for EBP program.	Expert committee recommended that bio-ethanol price should be 20 per cent less than petrol price. If diminutive ethanol supply, government should reduce import duty on bio-ethanol and molasses. The OMC's suggested that bio-ethanol should not imported for EBP. Hence, no consensus on bio-ethanol price policy for EBP procurement.
6.	2010-11	OMC's unable to procure required quantity of bio-ethanol for EBP from sugar mills / distilleries.	GoI was unable in implementing five per cent compulsory EBP at national level. The failure of bio-ethanol price policy and bureaucratic formalities by the states delayed procurement for EBP. Industries supplied only 365 million litre bio-ethanol against the contract of 570 million litre.
7.	2011-12	OMC's targets for procurement of 1.0 billion litre bio-ethanol for EBP	After deducting bio-ethanol need for EBP in non-implementing states, estimated requirement for EBP was 720 million litre However, distilleries supplied only 610 million litres. In some states, contracted supply was further reduced as molasses was exported to EU nations by sugar-mills.
8.	2012-13	CCEA recommended 5 per cent EBPP mandatory. The procurement prices of bio-ethanol should be decided by OMCs and suppliers. By 2017, GoI has to replace 20 per cent petrol with bio- ethanol as motor fuel.	The surplus sugar production during past three season, 2011-14, bio-ethanol availability after domestic consumption for other purposes was not sufficient to meet EBPP targets of 5-10 per cent. Bio-ethanol supply during past season was just sufficient to meet 3 per cent EBPP target Keeping in view, production, constraints, 20 per cent EBPP target is questionable, unrealistic and seems unattainable by end of 12th FYP.

Source : GAIN Report,(2013)

establishing the integrated sugar-cogeneration- bio-ethanol processing complexes. These subsidized loans from SDF should cover up to 40 per cent of sugar-energy integrated complex installation investment. The efforts made by GoI for EBPP implementation and constraints are listed in **Table 20**.

There is limited scope for further increase in acreage allocation under water-intensive sugarcane crop. The fluctuations in bio-ethanol production, supply and procurement prices could be stabilized through promotion and utilization of alternate crops for ethanol production. Therefore, the R&D institutions should encourage the farmers for cultivation of other alternate crops such as sweet sorghum, sugar beet, cassava and sweet potato for enhancing the bio-ethanol production in India. However, the initiatives of bio-ethanol production from the alternative feed stocks should be explore on pilot scale level. The R&D work should also be initiated for development of low-cost processing technologies to utilize ligno-cellulosic material from agricultural crop and animal residues, poultry and urban municipality waste for bio-ethanol production. The R&D priority areas identified in the NBP framework document were development of high sugar varieties of sugarcane, sweet sorghum, sugar beet and cassava, superior technologies for first and second generation bio-ethanol processing with conversion technologies for ligno-cellulosic materials and sugar industry by-product molasses for bio-ethanol production.

3. 3 Taxing and price policies

National biofuel policy, mentions that except for a concessional duty of 16 per cent on bio-ethanol, no other central taxes and duty has to be levied. However, the tax policies of different states on bio-ethanol for EBPP was not uniform. The tax structure differs widely across the states with the rates and forms of taxation varying from state to state, **Table 21**. Various forms of taxes and fees include sales tax, import fee, licence fee, permit fee, excise administration fee etc, has been imposed on bio-ethanol production and its marketing. The multiplicity in tax structure of major bio-ethanol producing states in India has presented in **Table 21**. These dissimilar tax structures had been perceived as the major constraints in the implementation of bio-ethanol prices and procurement policy by OMC's for blending with petrol, transportation and its inter-state trade. Moreover, these high rates of state taxes, excise duties and levies rendered on bio-ethanol make it commercially uneconomical and financially non-profitable to OMC's in many states. Therefore, the efforts should be made by the MoPNG to resolve the issues of taxation, duties, inter-state transportation of bio-ethanol and bring the uniformity in taxation issue amongst the states.

The procedural hurdles like non-issuance of export permits for inter-state transport of bio-ethanol, delays in issuing no-objection-certificates (NOC), higher taxes and levies across different states have adverse impact on implementation of EBPP. The rules and regulations with high excise tax ₹ 750 per tonne on molasses, which estimated to 25 to 30 per cent ad valorem. However, on industrial alcohol the prevailing central excise duty was 12 per cent ad valorem and inter-state taxes applicable on potable alcohol for industrial use were also applicable on purchase of bio-ethanol for petrol blending thereby sternly constraining its availability and utilization for EBPP. As per provisions of NPB, the minimum processing prices on bio-ethanol used for EBPP should be fixed by the government in consultation with various stakeholders.

Table 21 : Prevailing tax structure on bio-ethanol in different states of India

Sl.	States/UT	Existing taxes/Levies	State wise applicable rate
1.	Uttar Pradesh/ Uttarakhand	Sale or purchase tax	₹ 800/- per kilolitre (kL)
		Import fee	₹ 1500/- per kL
		Export fee	₹ 1000/- per kL
		Licence fee	₹ 150/- per kL
		Denaturation fee	₹ 150/- per kL
2.	Maharashtra	Sale tax	4 per cent
		Import fee	₹ 1500/- per kL
		Export fee	₹ 1500/- per kL
		State excise / administration fee	₹ 300/-kL
		Licence fee	₹ 25000/- per annum per location
3.	Tamil Nadu	Sale tax (VAT)	8 per cent + 5 percent surcharge on sale tax
		Import fee	₹ 1000/- per kL
		Export fee	₹ 3000/- per kL
		State excise/ administration fee	₹ 1000/-kL
		Licence fee	₹ 25000/- per annum per location
4.	Gujarat, Daman Diu & Dadra Nagar Haveli	Sale tax	4 per cent
		Import pass	₹ 50/- per tank lorry
		Import fee	₹ 3000/- per kL
		Licence fee production capacity per year, production capacity per year. ethanol production capacity per year.	₹ 25000/-per distillery of 1200 kL ethanol ₹ 1.5 lakh per distillery of 6000 kL ethanol ₹ 3.0 lakh per distillery of above 6000 kL

Source: MoPNG (2014)

The sale tax and other levies charge depends on the state in which bio-ethanol has been produced. The tax structure also depends on the ultimate use of ethanol. To promote bio-ethanol use for blending with petrol, the government has exempted the excise duty on ethanol for subsequent stage of processing. However, these tax exemptions are not applicable on bio-ethanol utilized for other purposes such as potable and alcohol based chemical industries. As per GoI, customs tariff notification 2010-11, on bio-ethanol imports, a customs duty @ 7.5 per cent has to be paid. However, the customs duty on molasses imports was 10 per cent during 2011-12. The government has fixed MPP of ₹ 21.50 / litre for ethanol in year 2007, after an agreement with the sugar manufacturers and distillers. However, this purchase price became non-remunerative for the producers due to steep rise of molasses price in subsequent years. This left the bio-ethanol producers in a precarious position. Hence, they are unable to supply bio-ethanol to OMCs' and government agencies at minimum procurement price. The molasses being the only feedstock for bio-ethanol production, its prevailing price had distinct impact on ethanol prices. The molasses price depends on sugar production which has been fluctuating considerably over the years, leading to wide variation in ethanol production costs. The OMCs should purchase bio-ethanol from the domestic suppliers through open tender system as per central vigilance commission

(CVC) guidelines. When the bidders' quoted ethanol prices higher than the MPP, fixed by the MoPNG. It is often seen that the government unable to direct OMCs to stick with the pre-determined bio-ethanol price. Keeping in view, bio-ethanol market demand and supply situation, empowered group of ministers (EGoM) decided to revise the bio-ethanol price to ₹ 27 per litre during year 2010. In spite of enormous capacity of sugar mills and distilleries units for supplying bio-ethanol to OMCs at reasonable rates, the GoI has not effectively implemented the mandatory targets of ethanol blending with petrol, which could reduce the petroleum import bill. The Indian sugar mills association (ISMA) has reiterated its demand of price revision for bio-ethanol blending following the increase in petroleum fuel prices. The 10 per cent EBP with petrol has save ₹ 9000 crores of foreign exchange during sugarcane production year 2013-14. It could also reduce sugar surplus by 1.0-1.5 million tonne in domestic market. Therefore, it would be beneficial for the sugar industry as well as ethanol blending by the government will have dual benefits in terms of new market for bio-ethanol and reducing sugar surplus supply. The cabinet committee on economic affairs (CCEA), approved the implementation of the EBP programme of 5 per cent bio-ethanol with petrol vide notification under the motor spirits act. It is mandatory for OMCs to blend 5 per cent bio- ethanol with petrol seems inaccessible during year 2013-14 again due to non clearance of ethanol supply orders. The ISMA reveals that the OMCs had cleared ethanol supply orders only for 250 million litres due to high ethanol market prices. The prevailing bio-ethanol prices were ₹ 36-37 / litre during year 2012-13. The bio-ethanol distilleries demands still high prices, where as the OMCs desire that the price has to be maintained below ₹ 40/ litre offered by the sugar mills and distilleries. The domestic sugar mills have bids to supply 550 million litres. It would be sufficient to achieve 50 per cent requirement of 5 per cent EBPP in India. Hence, the OMCs have to negotiate the bio-ethanol prices with foreign suppliers as they quoted ethanol prices ₹70-90 / litre.

The GoI, wants to reduce import bills to control the escalating current account deficit (CAD) and protect rupee's free fall against international currency U.S. dollar. The ISMA reported that the petroleum import bill may be reduced by 1.3 billion $, a handsome contribution from the neglected sugar and ethanol processing industries. The Indian sugar industry has urged MoPNG, GoI for implementing the EBP programme honestly as mandated by the CCEA in forth coming years. As per the estimated requirement of 5 per cent EBP, the OMCs would require 1050 million litres bio-ethanol during year 2013-14. The state run oil refineries would have to pay ₹ 47 per litre for imported petrol for crude oil to be refined in India. It is estimated that if 400 million litres of ethanol blended with petrol, the government could have savings of ₹ 1845 crores per year on prevailing petroleum prices in India. Therefore, it is imperative as PMO asked, the MoPNG for minimising the petroleum products import bill by $ 25.0 billion. Keeping in view, the petroleum import as the largest contributor, nearly 34 per cent of India's aggregate import bill, saving from bio-ethanol blending could play a pivotal role to save the Indian rupee further devaluation against the US dollar and other international currencies.

3.4 Indian reforms for sugarcane price policy mechanism

The sugarcane farmers and the sugar mills are complementary to each other for sugar and other value added processed products production. To protect the socio-economic interest of sugarcane producers and to maintain regular cane supply to the sugar mills, the central and state government follow the sugarcane price policy and declares prices to be paid by the sugar mills to the farmers during the crushing season as state advisory price (SAP) and fair and remunerative price (FRP) annually. The CACP recommended, sugarcane FRP of ₹ 2100 / tonne at 9.5 per cent sugar recovery level for the sugarcane crushing season 2013-14. The CACP also recommended that for an additional sugar recovery by 0.1 per cent, the FRP for sugarcane would have to increase by ₹ 22 / tonne. If average sugar recovery from sugarcane supplied by the farmers is 10 per cent, the sugar mills of that state had to pay the FRP ₹ 2210 / tonne. The FRP recommended by the CACP after due considerations given to the various factors enumerated in the sugarcane control order (1966), which was amended many time in global economic liberalization era during past two decades. These considerations range from sugarcane cost of production, domestic sugar prices and prevailing prices of allied by-products such as press mud, bagasse, molasses, electricity etc traded by the sugar mills. The CACP projected that the cost of sugarcane production for the crushing season 2013-14 including transportation cost and premium for crop insurance would be ₹ 1970 / tonne. The sugar price in domestic market during 2013-14 could fluctuate ₹ 30000-37000 / tonne. The proposed FRP should not have any adverse impact on food inflation as sugarcane farmers in most states had already received the higher price as the SAP for sugarcane in UP was ₹ 2800-2900 / tonne for sugarcane crushing season 2013-14. Besides it, the CACP also recommended that the state government should adopt the hybrid formula for fixation of sugarcane price paid by the sugar mills to the farmers. Thus, sugarcane price policy should be compose of revenue sharing principle amongst the various stalk holders of Indian sugar sector including farmers. It has to be merged with some minimum FRP (MFRP). The revenue sharing principle should distribute the total revenue generated by the sugar-energy-power co-generation complexes from sugar-energy value chain from sugar and its first stage by-products molasses, bagasse and press mud etc. produced from per unit of sugarcane crushing, between the cane farmers and sugar millers in the ratio of their relative costs incurred in sugarcane production and processing of raw material into sugar, ethanol, energy and other by-products.

The comparative sugarcane and sugar production costs based on the T.E. 2011, suggested that the ratio of benefit sharing between sugarcane farmers and sugar mills should be 75:25 at 10.25 per cent average sugar recovery achieved at country level. If we add the value of sugar mills by-products with the economic value of sugar produced per tonne sugarcane crushed, then the farmer should have the share of 80 per cent in total economic returns obtained from sugar. If average mill gate sugar price during current crushing season 2013-14 was ₹ 32500 / tonne (range ₹ 30000 to 35000 / tonne), the sugarcane price paid to the farmers should be ₹ {32500*(10.25/100)*(75/100)}= ₹ 2500 / tonne. In tropical states such as Maharashtra where higher sugar recovery of 11.50 per cent achieved, the proposed sugarcane price to be paid by the sugar mills to the farmers during crushing season 2013-14 should be ₹ {32500 *(11.50 / 100) *(75 / 100)}= ₹ 2800 / tonne. If there are wide fluctuations in sugar price, high risk and uncertainty of future sugar prices in domestic as well as global market, the revenue sharing principle must be linked with MFRP. The MFRP should be fixed at 50 per cent of standard deviation from the past trend of domestic sugar market price. The sugar price trends reveals that the factory gate minimum price could be ₹ 28000 / tonne during 2013-14 sugar production seasons and 50 per cent of standard deviation below this appear to ₹ 25750 / tonne. In this situation the 75 per cent of value of sugar prices would be ₹ 1932 / tonne. It must be paid to the farmers as the minimum sugarcane procurement price by the sugar mills. It is incidentally less than the total cost of sugarcane production i.e., Cost C_2 (₹ 1970/tonne). It entails that the sugarcane farmer should be paid the MFRP as the minimum support price by the sugar mills during the sugarcane crushing season, no matter what would be the domestic market sugar and other processed by-products price. The MFRP of sugarcane for next crushing season should be declared by the government a prior to crop planting season. Therefore, the implementation of such hybrid formula as an effective economic indicator for realistic sugarcane price policy could be beneficial for maintaining regular raw material supply to sugar mills and play a key role in sound development of Indian sugar sector.

The implementation of trade related economic reforms in sugar sector should be taken up to its logical conclusion from de-licensing to decontrol era. The policy decision could be useful for development of sugar-energy-power cogeneration integrated complexes for efficient production of sugar-ethanol-energy hubs producing sugar, ethanol from molasses, power from bagasse, bio-fertilizer from press mud. It would be useful for additional jobs creation and income enhancement opportunities for millions of sugarcane farmers and rural workers involved in sugar mills. The policy decision for sugar decontrol, sugar levy system and regulated release mechanism should be disposed off completely. The government policy of levy sugar procurement on subsidy for the PDS consumers from sugar mills has tantamount as the implicit tax. Therefore, the execution of revised sugarcane price policy system would be viable for accomplishing the twin objectives without compromising production efficiency.

The CACP and Rangarajan Committee on sugar sector reform, recommended that the compulsory levy on sugar mills should be removed completely. The government should invite tenders from sugar mills for sugar supply to the PDS consumers on prevailing market price. The government may explore the option of direct cash transfer of subsidy money through bank accounts to the BPL families or antodiya families. The direct subsidy cash transfer and complete elimination of sugar from PDS system to all consumers could be useful for improving transparency and check rampant corruption of prevalent PDS system. The sugar release policy for non-levy consumers should be changed with the requirement to maintain the buffer stock of 2 million tonnes sugar to stabilize domestic market prices. The existing sugar buffer stock policy should be re-examined, modified and link with liberal economic trade policy norms.

There is need for imposition of 10-15 per cent import duty on sugar and other related co-products to protect the economic interest of Indian sugar sector and to rationalize sugar imports as per WTO commitments. This policy decision would be useful in checking the overall sugar supply in domestic market. The implementation of such policy would create some pressure on domestic sugar prices and thereby make sugar import less competitive. If import is allowed at zero percent custom duty the overall sugar supply could further enhance and led to gluts in Indian market. It would have adverse effect on sugar prices in domestic market and also make Indian sugar export more competitive and unremunerative. However, if sugar export is banned by the government of India, it would act as an implicit tax and sugarcane farmers should be compensated for it through enhance FRP at least by 10-15 per cent per crushing season to accomodate higher cost of cane production.

Sugarcane is a labour, water and other purchase input intensive crop. Therefore, it is crucial that the sugarcane productivity should be optimized on per unit water, labour wages or environmental cost. In this backdrop, the drip irrigation system for sugarcane should be promoted and popularize in major sugarcane producing states. The study review reported that the adoption of skip furrow method and drip irrigation system could save 30-50 per cent water as compared to conventional irrigation systems. Water is a precious natural resource should be utilized judiciously and also to be saved on priority, like any other scarce resource to meet future complex demand food and energy security. Hence, there is urgent need to formulate a comprehensive policy for sugarcane varieties development and their release on priority, seed cane multiplication and its supply to the sugar mills/farmers, location specific suitable agronomic package of practices, sugarcane farm operations mechanization including harvesting, popularization and adoption of high sugar and water efficient varieties on large scale. It would be essential to implement the water irrigation price policies for motivating the sugarcane growers to follow the new technology for sustainable growth trajectory in cost effective manner to fulfill the future sugar, bio-ethanol and energy security targets.

3.5 Synthesis of bio-ethanol production, taxing and marketing policy

The bio-ethanol production policy in India has yet to mature. It has given emphasis on its practical utility and relevance of ethanol blending targets to be achieved by the end of 12th FYP. The foremost stress of the NBP is that unlike of other developing countries, it gives due thought to food and feed security aspect for the nation. It has permitted to utilize only non-food/feed stocks and sugar industry by-product molasses for bio-ethanol production. Therefore, the primary limitation of bio-ethanol production from molasses based feedstock, the policy confine excessive dependence on sugarcane cultivation which is a labour and water-intensive crop. However, the government decision on permission of direct sugarcane juice conversion for bio-ethanol production should depend on sugar production ceiling for fulfilling domestic demand. There are several points on which the existing bio-ethanol production, taxing and marketing policy seems to be uncertain. The major argument is that there are wide fluctuations in molasses price and prevalence of high taxes and excise duties on bio-ethanol across the Indian states. Hence, there is need for harmonization and rationalization of the concern issues and policies for effective implementation of EBPP to achieve the future blending targets and rationalize the petroleum import bill. In some states, the bio-ethanol distilleries reported that the OMC's tender quoted and the government procurement bio-ethanol prices were highly unremunerative. These ethanol suppliers also complains that the government did not revised bio-ethanol prices regularly after incorporating the changes in sugarcane cultivation cost, molasses production and price fluctuations of sugar and other processed products of sugar industry due to complex demand and supply situation in Indian product market.

Therefore, keeping in view the opportunities to explore the potential of bio-ethanol as green automobile fuels and as clean bio-energy source to moderately counterbalance the growing financial burden of crude oil import bills on Indian economy. Some review study reveals that the economic viability and sustainability of bio-ethanol production from by-product molasses indicate that the sluggish growth in sugarcane area, production and ever rising demand of sugar, energy, bio-ethanol for potable and other industrial purposes, it is doubtful that the future bio-ethanol blending with petrol targets could be met as projected by the GoI. Hence, to ensure the economic viability of bio-ethanol production, it is necessary to diversify the feedstocks basket by inclusion of crops such as sweet sorghum, cassava, palm and tropical sugar beet. The R&D on bio-ethanol industrial production from second generation raw material like agro-industrial waste ligno-cellulosic biomass and household waste should also be explored on priority. Therefore, to accomplish the future EBPP targets and address issues related to climate resilience, appropriate policies must be fine tuned and re-organized to address socio-economic, food and energy security, sustainability and judicious natural resources utilization for a addition unit acreage allocation for sugar crops. The policies should be practically sensitive for reversal of existing unhealthy practices and natural resources wastage tendency.

4

Sugarcane Product Diversification Potential and Future Challenges

4.1 Sugar-Bio-ethanol-Power cogeneration potential and challenges

Although in terms of sugarcane production, India and Brazil were almost equally placed. In Brazil, out of total sugarcane offered for crushing, 45 per cent utilized for sugar production and 55 per cent for ethanol production directly from cane juice. In contrast, Indian sugar industry crushes 70-75 per cent of total sugarcane for sugar production, remaining being used for traditional sweeteners jaggery and *Khandsari* production, seed, feed, chewing and wastages. Therefore, only molasses, a by-product, produced during sugar processing is utilized for bio-ethanol production. Sugarcane crop has subject to periodic and alternate production cycles lead to gluts and shortages with the typical 6 to 8 year, wherein three to five years have higher cane production followed by two to three year with lower production. The basic reasons of cyclical production behaviour consist of factors such as seasonal rainfall variations, incidence of extreme climatic conditions like floods, droughts, etc., variations in economic returns and profitability of competitive crops, unstable sugarcane price and government taxation policies, erratic and delay in price arrears payment by the sugar mills to cane farmers.

The time series data reveals that the sugarcane area and production has increased drastically in India past six decades. The sugarcane area has increased from 1.71 to 5.06 million ha during year 1950-51 to 2012-13. The sugarcane production had also witnessed nearly five-time increase from 69 to 339 million tonnes during the same period **Table 22**. However, the CGR in area has been 1.37 per cent with the few inter-year fluctuations and sugarcane productivity was more or less stagnant during first decade of 21st century. The sugarcane area was 2.6 per cent of gross cultivated area and 6.0 per cent of total irrigated area in India.

Table 22 : Sugarcane area, yield and sugar production in India: 1950-51 to 2012-13

Year	Area (million ha)	Production (million tonne)	Yield (tonne/ha)	Sugar Prod. (million tonne)	Sugar Recovery (per cent)
1950-51	1.71	69.2	40.55	1.10	10.03
1960-61	2.46	110.5	45.01	3.03	9.74
1970-71	2.62	126.4	48.32	3.74	9.78
1980-81	2.67	154.3	57.84	5.15	9.98
1990-91	3.69	241.1	65.40	12.05	9.85
2000-01	4.32	296.0	68.60	18.52	10.48
2006-07	5.15	355.5	69.02	28.36	10.17
2010-11	4.89	342.4	70.1	24.40	10.17
2011-12	5.04	361.0	71.6	26.34	10.25
2012-13	5.06	339.0	66.9	25.14	10.03

Source: Cooperative sugar 2014, 45(9) : 42 - 60

Sugarcane is a long durational, labour and capital intensive crop. The farmers who had better accessibility to financial institution for agricultural loan, assured irrigation facility, fertilizers and pesticides desire to cultivate sugarcane as a cash crop. The subsistence resource poor farmers avoid sugarcane cultivation as lone reliance on monsoon water is inadequate for fulfilling the water requirement. The price payment for sugarcane supplied by the farmers to sugar mills also comes in lump sum, after the harvested cane crushed, sugar and other by-products sold by the sugar mills in domestic market. Therefore, only those farmers who had risk bearing capacity and can survive on deferred payments system may accept the challenge of sugarcane cultivation.

The availability of molasses to meet the ethanol demand depends on sugarcane production and subsequently on sugar production and government policy for utilization of ethanol produced for various purposes. In India, it is observed that the 70 per cent of total bio-ethanol produced is utilized for industrial and potable purpose and remaining 30 per cent for EBPP purpose. The poor availability and inadequate molasses supply leads to its higher prices and have direct impact on bio- ethanol production cost. It is forecasted that the existing allocation rate, ethanol production capacity could hardly be sufficient to meet the ethanol demand for five per cent blending with petrol. Therefore, it is essential to note that it would be inadequate to fulfill the future targets of 10 per cent and 20 per cent blending with petrol. With rising per capita income, urbanization, infrastructural development and the resultant increase in vehicular density, the petrol demand in India has galloped with growth rate of 8.5 per cent during XIth FYP period (2007-12). This growth pattern of petrol demand is expected to continue uninterrupted over the next two to three decades. If we take the cognizance of the government future plan for implementation of 20 per cent EBPP by year 2017, the bio-ethanol demand for fuel and other alternative uses has been projected by using the growth rate for year 2004-05 to 2011-12. It was found that the estimated ethanol demand for fuel during 2012-13 for 5 per cent, 10 per cent and 20 per cent EBPP was 0.78 million tonne, 1.56 million tonne and 3.12 million tonne respectively equivalent to 988 million litres, 1976 million litres and 3953 million litres. The equivalent total bio-ethanol demand after accounting for potable, industrial and other uses could be 2.21 million tonne, 2.99 million tonne and 4.55 million tonne, respectively. By terminal year of 12th FYP, 2017, when government future EBP targets of 20 per cent shall be commenced, the estimated total bio-ethanol demand could be 6.11 million tonne, which would be equivalent to 7741 million litres. The projected petrol demand for India would be 44.34 million tonne by the year 2030-31. The projected bio-ethanol demand only for EBPP during 2030 @ 5 per cent, 10 per cent and 20 per cent blending could be 2.22 million tonne, 4.43 million tonne and 8.87 million tonne, respectively.

4.2 Economics of bio-ethanol production in India

In India, sugarcane as raw material utilized mainly for sugar production as primary product and the bio-ethanol produced only from sugar mill by-products molasses. The molasses availability and its supply to the ethanol distilleries primarily depend on sugarcane production. Therefore, the economic viability of bio-ethanol production depends on processing efficiency of molasses- ethanol conversion and its prices. The government of India did not permit to produce bio-ethanol directly from sugarcane juice to fulfill its commitment of food security through regular sugar supply for domestic consumption at affordable market price. During years of less sugarcane production and brief sugar crushing seasons, high molasses prices and its inadequate supply forced most of the bio-ethanol distilleries units to work for short duration and under-utilization of installed ethanol processing capacity. The reviewed studies reveal that the molasses prices fluctuated considerably and varied from ₹ 1000 to ₹ 5,000 per tonne during first decade of 21st century. The molasses price was hardly ₹ 1000 per tonne during 1998-2003. However, in subsequent years the molasses price has shown increasing trend as prices burst up to ₹ 3500 per tonne during 2004-05 and again declined to ₹ 2000-2500 per tonne ICRA (2006). During crushing season 2008-09, the drought condition led to decline in the sugarcane production substantially which again led to shooting up of molasses prices up to ₹ 5,000 / tonne. The unprecedented increase for molasses price had serious implications on financial feasibility and economic viability of molasses based solitary ethanol distilleries plants. The Planning Commission GoI (2003) reported that the bio-ethanol cost of production was ₹ 9.74 / litre, when the molasses price was ₹ 1000/tonne. Based on this estimated cost of bio-ethanol production, government has fixed the minimum purchase price of ₹ 21.50 / litre for bio-ethanol during year 2006 (MoNRE 2009). The sugar industry and associated distilleries plants were also agreed to supply ethanol to OMCs for blending with petrol on this prevailing price. The ethanol cost of production surpassed the minimum purchase price when the molasses price rose up to ₹ 5,000 / tonne during sugar crushing season 2008-09. Based on the study conducted by NCAP (2010), in Uttar Pradesh reported that the average cost of bio-ethanol production varied from ₹ 24.10 to 30.61 per litre for standalone distilleries plants and ₹ 19.62 to 26.13 / litre for ethanol distilleries units integrated with sugar-power cogeneration units **Table 23**. The bio- ethanol production costs were estimated on market prevailing molasses prices of ₹ 3500 and ₹ 5000 / tonne. The study suggested that the molasses price fluctuations would also continue in future. Therefore, the high prices instability for bio-ethanol as well as petrol discourages OMCs for long-term ethanol supply contracts with the distilleries. Besides it, the bio-ethanol distilleries could also fetch higher price due to assured demand from the beverage and pharmaceutical industries which prompt them to have further affinity with these industries as compare to OMCs. Therefore, the OMCs could be unable to procure required quantity of bio- ethanol at the prevailing market prices to accomplish the 5 per cent mandatory blending target with petrol. Subsequently, the government had revised the minimum procurement price for bio-ethanol many times during past decade, EBP still remains well below the target levels. Therefore, it could be the key issue argued in favour of EBPP may be economical only when the petrol prices are higher.

The aggregate bio-ethanol supply of 2.06 billion litres during cane crushing season 2012-13 was insufficient to meet the total consumption demand of 2.15 billion litres as the utilization pattern was in favourable of beverage, pharmaceuticals and other industrial uses. The estimated projections reveals that the total bio-ethanol demand may reach up to 5.64 million tonnes by the year 2025-26 and 6.50 million tonnes by the 2030-31 for achieving the 10 per cent EBPP targets. The fuel bio-ethanol demand would be 7.36 million tonnes and total demand would be 9.32 million tonnes for accomplishing 20 per cent EBPP targets. Therefore, it is imperative to make projections that how much sugarcane area and production would be required for accomplishing the future EBPP requirement and total bio-ethanol demand. The study conducted by Raju et.al, (2012) for better understanding of EBP demand and translate in to future requirement reported that the required sugarcane area and production for achieving the bio-ethanol demand for different purposes for the year 2016-17 and 2020-21. The estimated fuel bio-ethanol demands for 5 per cent and 10 per cent blending levels for estimation of sugarcane area and production with some assumptions. The study reveals that the sugarcane area would be 7.5 million ha and 9.3 million ha for sugar crushing season 2016-17 and 2020-21 respectively. If the government wants to achieve the 10 per cent EBPP target as per NBP documents the estimated sugarcane production should be 736.5 million tonnes from 10.5 million ha area, with average productivity 71 tonne / ha. It would be which 20-25 per cent more than sugarcane required to meet the domestic sugar demand. The study concluded that the sugarcane acreage as well as production should be more than double to achieve the target of 10 per cent EBPP. Keeping in view, the sugarcane production constraints, 20 per cent EBPP targets seems to be astonishing, superficial and unrealistic.

Table 23 : Cost of ethanol production from molasses in Uttar Pradesh, India: 2010 **(In ₹/litre)**

Particulars of Inputs	Stand alone distillery	Distillery integrated with sugar mill)
Cost on steam	0.36	0.00
Cost on power	1.30	0.00
Cost on chemicals	0.20	0.20
Cost on labour	0.10	0.06
Cost on repair and maintenance	0.18	0.18
Total variable cost excluding molasses	2.14	0.44
Interest on fixed capital	2.19	2.19
Depreciation on machinery and other fixed assets	1.83	1.83
Total fixed cost	4.02	4.02
Cost of molasses (@ ₹ 3500 / tonne)	15.22	15.22
Cost of molasses (@ ₹ 5000 / tonne)	21.73	21.73
Transportation cost	2.83	0.00
Total cost of ethanol production	24.10-30.61	19.62-26.13

Source: Raju *et al.,* (2012) *Note:* Recovery of ethanol was assumed to be 230 litres / tonne molasses.

4.3 Alternative feedstock for bio-ethanol production and power cogeneration

Keeping in view, environmental concerns and the limitations of enhancing the sugarcane production and productivity, there is an urgent need to explore the practicability of alternative feedstocks accessibility, economic viability and sustainability to minimise solitary dependence on molasses based bio-ethanol production in India. Therefore, it is essential to conduct R&D work on alternative feedstocks for enhancing ethanol production to fulfill the future demand targets for various purposes. The sweet sorghum could be a potential raw material source for commercial bio-ethanol production due to diverse advantages. Sweet sorghum is similar to the grain sorghum crop and has rapid growth, wider adaptability and high biomass production ability with sugar rich stalks, suitable for seed propagation and industrial crop production, Reddy *et al.,* (2005). The presence of reducing sugars in sweet sorghum prevents crystallization and have high fermentation efficiency of 90 per cent, Ratnavathy *et al.,* (2004). It is a short durational crop of 4-5 months and water requirement of 8000 m^3 / ha for two crops per year. It is barely 25 per cent of water requirement for sugarcane, **Table 24**. The bio-ethanol production from biomass of two sweet sorghum crops cultivated per year was 700-800 litres / ha. It was more than the ethanol produced from molasses of unit ha sugarcane produced per year.

The alternative feedstocks sweet sorghum based bio-ethanol production have comparative advantages as the per unit bio-ethanol cost of production was ₹ 17- 19 per litre. It was less than the bio-ethanol production cost of molasses, transportation and its processing ₹ 24-32 per litre. The economic feasibility of sweet sorghum based bio-ethanol production has been worked out by the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) through its bio-power and agri-business incubator (ABI) initiatives programme. However, the exploitable potential of sweet sorghum for bio-ethanol has not been visualized by the policy makers. It was reported that through suitable extension approaches, along with farmer's field technological demonstrations and industrial trials, sweet sorghum production potential, in India will have to sensitize the farmers and ethanol distilleries owners for its large-scale adoption and potential socio-economic and environmental benefits Rao *et al.,* (2004). Sugar beet could be another potential feedstock for bio-ethanol production, even though its commercial exploitation capacity has not been widely studied and evaluated in tropical Indian conditions so far.

Table 24 : Comparative ethanol production cost from sugarcane and other feed stocks in India

Particulars	Sugarcane	Sweet sorghum	Sugar beet
Sugar content (per cent)	11-12	10-14	12-15
Bio-ethanol yield (litre/ha)	700-800[(1)] (from molasses)	1,400[(2)]	6,000-6,400[(3)]
Cost of ethanol production (₹/litre)	24-32[(4)]	17-19[(5)]	12-14[(6)]
Crop duration (months)	12-16	4	5-6
Water requirement (m^3/ ha / crop)	20,000-30,000	4,000	8,000-10,000
Fertilizer requirement (NPK kg / ha)	250:125:125	80:50:40	120:60:60

Source: FAO, (2008), Reddy et al. ,(2005), ICRISAT (2009), TNAU (2009), Raju et. al., (2012),

Notes :

1) *Molasses production in sugarcane processing 2.8-3.4 tonne / ha @ 250 litre / tonne. Direct ethanol production from sugarcane juice may yield 4800-6000 litres/ha.*
2) *Two crops of sweet sorghum may be grown per year. Millable stalk productivity @ 35 tonnes/Ha crop and ethanol yield @ 40 litre/tonne.*
3) *Sugar Beet Productivity 75-80 Tonnes/ha and ethanol production @ 80 litre/tonne.*
4) *Cost of molasses ranges ₹ 3500 to ₹ 5000/tonne.*
5) *Cost of sugar sorghum stalk @ ₹ 500-600/tonne.*
6) *Cost of sugar beet @ ₹ 700/tonne.*

Based on some experimental field trials conducted by Tamil Nadu Agricultural University, (TNAU), Coimbatore, it was observed that the sugar beet could be successfully cultivated on commercial scale in India. It is a short durational crop of nearly 5-6 months and could grow well on sandy loam soil. Sugar beet may also thrive well on saline and alkaline soils. The bio-ethanol may be processed directly from sugar beet juice with the average productivity of 80–90 litres bio-ethanol / tonne. Hence, the achievable bio-ethanol yield from sugar beet could varies from 6000 to 6400 litre / ha. This bio-ethanol production level was more than that obtained from sugar mill processing by-product molasses and sweet sorghum. The ethanol production was realized at low processing cost of approximately ₹ 12-14 / litre. Some studies revealed that if the farmer change a unit hectare sugarcane acreage with sugar beet, he could save 10,000 to 20,000 m^3 irrigation water every year in different states. It is well documented that the sugar beet could be utilized as raw material for sugar production and numerous value added products in addition to bio-ethanol. Therefore, we have to initiate R&D and look forward for improved sugar beet production, crop management practices and processing technologies to maximize sugar- energy processing efficiency from the available alternative sugar feedstock crops. The reviewed literature highlights the inappropriate processing plant capacity, application of batch process technology, lack of supportive transportation and processing infrastructural facility, inefficient by-product and effluent management practices as the major socio-economic and technological constraints faced by the sugar processing agro-based industry in India. Therefore, the long term strategies for further development of integrated sugar-energy-cogeneration sector should be the adoption of modern tools and advance cutting edge technological options such as biotechnological approaches for development of high sucrose, fibre content and better sugar recovery varieties of sugarcane and other feedstock sugar crops, commercial use of microbes and membranes techniques should be explored on priority, Raju *et al.,* (2009). The reviewed R&D studies revealed that the ligno- cellulosic agro-biomass, industrial and agricultural waste such dry sugarcane leaves, bagasse, cereal crop residues, forest tree pruning and thinning biomass, saw dust, paper, etc. could be utilized efficiently as excellent feedstock for bio-ethanol production. However, the socio-economic viability, adaptability and industrial feasibility of alternative feedstocks crops is yet to be worked out and properly documented. The bio-ethanol cost of production for alternative feedstock probably utilized as raw material could be higher as compared to the conventional sugar feedstocks. The government should formulate strategic policies and provide some incentives for development of bio-ethanol and other value added products processing infra structural facilities and subsidies to the farmers for short duration to make these alternative feedstocks competitive in comparison to other renewable biofuels substitutes. Therefore, to realize the future targets and goal, there is urgent need of paradigm shift in planning, policies implementation to focus the R&D priorities for developing cost effective second generation biofuels processing technologies, along with sustained political determination and commitment for making adequate financial investments provision to create transportation and ancillary facilities. The government should make efforts for reflecting the fine tuning of priorities, desired change in policies formulation and their proper implementation, monitoring followed by the impact assessment studies.

Indian sugar sector encounters up and down situations of sugar production and price fluctuations after few years. During favourable market conditions the sugar mills earn profit in some years and faces huge losses at the time of low ex-factory sugar prices. Hence, it realized that the importance of integrated sugar- energy complexes to counterbalance the problem of wide sugar price fluctuation in domestic market. It is observed that the economic returns on capital invested on sugar mills would be stable, when the co-products i.e. bagasse, molasses and press mud are efficiently used for production of bio-ethonal, power and bio-fertiliger. Indian sugar industry has made some progress in supply of surplus electricity to the national grid. The sugar mills started power co-genesation at 45 kg/ cm^2 steam pressure. They have shifted to boiler pressure up to 110 kg/cm^2 . The higher super heat temperature resulting reduction in steam consumption by the turbines and enhance net power generation in the sugar mills . As per ISO report, potential of power generation by Indian sugar mills is estimated to 10500 MW including, 3500 MW for internal consumption and approximately 7000 MW surplus power production to national grid, Mohan, (2014). With the adoption of new technologies of high pressure boilers and installation of other energy saving gadgets, the power cogeneration potential may be much higher in future. There is urgent need for maximum exploitation of power cogeneration potential through reduction of power consumption in sugar processing plant, steam consumption, configuration of boiler and turbines, bagasse drying and partial use of sugarcane trash along with bagasse as fuel. The Biomass Integrated Gassifier - Gas Turbine Combined Cycle (BIG-GTCC) is a promising technology for power cogeneration. It is stated that the adoption of BIG-GTCC may increase power cogeneration in existing sugar processing plants from 125-150 KWH to 220-240 KWH per tonne of sugarcane.

5

Conclusions and Policy Implications

The backbone of green revolution in India was the high yielding varieties (HYV) of wheat and rice and availability of quality HYV seed through effective extension support system. The same strategy should be followed for development of sugarcane and other alternative feed stocks sugar crops to achieve the galloping sugar-ethanol, energy demand. As per estimates of NCA (1976) and other agencies, Indian population may reach up to 1.5 billion by the year 2030 at the average compound growth rate of 1.6 per cent per annum. The estimates of per capita aggregate sweeteners consumption could further improve due to better purchasing of Indian consumers, high human development index (HDI) and economic prosperity. It may reach up to 25 kg and 32 kg per year for white sugar by the year 2030 and 2050 respectively. If the annual growth rate of sugar demand and likely rise in human population, India's aggregate future sweeteners demand may be 32 million tonnes by year 2030. There were downward trends for the jaggery and *Khandsari* production and the per capita consumption. The estimated white sugar demand may reach up to 42 million tonnes by 2050. The expected demand for eco-friendly renewable green energy products (such as bio-ethanol, power cogeneration) has expected to grow by more than 110 per cent by 2030 and it could be double by 2050. Though, in India 5 per cent EBP has been made compulsory for the year 2013-14, the target could not be achieved due to inadequate accessibility of bio-ethanol, even necessitating imports. The NBP has proposed to scale up the EBP up to 20 per cent by 2017, for which the projected bio-ethanol requirement would be 4.4 million tonnes as against the present production of nearly 2.2 million tonnes. The estimated bio-ethanol requirement for fuel, potable and industrial use would be 10.94 million tonnes by 2030. The Indian power sector is the third largest in Asia after China and Japan. In India, the energy demand and supply dis- equilibrium was more than 30 per cent. The encouragement of electricity cogeneration from agro-based renewable sources has declared as priority policy by the Indian government. There are more than 526 operational sugar mills in our country. They have economic potential of 5500 MW electricity through bagasse based co-generation. However, the existing installed capacity was merely 2400 MW. Therefore, it is imperative to enhance cogeneration potential capacity up to 6000 MW to supplement the ever growing electricity demand of various sectors. It could be possible only when all the operational sugar mills and sugar-energy integrated complexes should utilize their full installed sugarcane crushing capacity optimally for required quantity of bagasse production.

The emerging energy demand as green fuel for the EBP would also require additional sugarcane production as raw material over and above the requirement for sugar production of 33 million tonnes in next two decades. Therefore, to fulfill the ever-increasing sugar and renewable energy demand by year 2030, India should have to produce 520 million tonnes sugarcane with average sugar recovery 10.75 per cent (345 million tonnes sugarcane for white sugar, jaggery and *Khandsari,* and 92 million tonnes cane for ethanol production and power cogeneration). The emerging sugarcane scenario as the renewable energy crop for ethanol production, to partially supplement the automobile petrol fossil fuel would provide further scope for increasing sugarcane production. Because of its renewable energy potential, it has become the preferred choice, since the Brazilian venture in 1980's for utilization of ethanol as fuel blended with petrol for running automobiles on flexi green fuel. Brazil made major stride in this direction and has diverted 50 per cent of its sugarcane for bio- ethanol production.

In India, molasses, a by-product of sugar mills would remain lone raw material for ethanol production. Bagasse, another sugar mills by-product will continue as the basic raw material for power co-generation in sugar mills. Indian sugar sector planners envisaged that by year 2030 all operational sugar mills must be transformed into integrated sugar-ethanol-energy complexes for supplementing the growing sugar-energy demand and give further impetus to the rural economy scenario. Therefore, it is presumed that the sugarcane production and diversification would play a pivotal role in socio-economic transformation of agro-based rural industrialization in future. Hence, India should gear up its sugarcane R&D efforts for mitigating the new challenges of productivity improvement, better sugar recovery, bio-ethanol processing efficiency and electricity cogeneration to meet the future demand. If the present CGR trends of sugarcane area, production and sugar recovery would continue, India could barely accomplish 75 per cent of projected demand targets of sugar and energy. Therefore, the effort should be made to increase the CGR's for sugarcane production, processing efficiency and associated sugar sector infrastructural development to make India not only self sufficient in sugar and energy production, but also become the surplus sugarcane based agro-industrial value added products exporter. The emerging sugarcane scenario would be multi-dimensional in terms of future demand, climate resilience, socio-economic production constraints, opportunities and processing technological advancement. Hence, for achieving the future sugar and energy demand targets, strategic planning and its implementation would become extremely essential after accounting the SWOT analysis of Indian sugar sector for addressing the core issues.

The review studies reveal that the sugarcane productivity could be enhance by 15 per cent through effective implementation of high sugar varieties, seed multiplication, distribution and old variety replacement, if all other agronomic input application remains static. Though many sugarcane varieties have been released and seed material of these high sugar varieties is available with ICAR Institutes / SAU's. The foremost problem associated with the availability of quality seed material was the lack of seed multiplication, inefficient distribution system and inadequate sugar mills financial support for adoption of sugarcane seed replacement programmes in their factory command area. The sugarcane breeders, sugar mills and the farmers, who are the key stakeholders of entire sugarcane processing value chain, cited numerous reasons for non existence of credible seed production programme. This policy paper tried to accommodate the views of various stake holders and summarized the major problem, socio-economic constraints and appropriate policy intervention for fulfilling the future targets of sugar-energy demand and listed them on priority basis as follows:

- The non-availability of quality seed and lack of consistent extension support for adoption of agronomic and plant protection recommendations has become curse for sugarcane cultivation. There are soaring expectations of sugar mills and state cane development department from the public funded R& D institutions for technology transfer and extension support. There could be various reasons for ineffective sugarcane extension support by the state government extension agencies. The sugar mills do not come forward for financial support for seed multiplication and its distribution to the farmers. They are least interested for supporting the sugarcane extension and seed development programme in their factory command area due to various reasons. However, it should be the top priority activity for their economic benefits, profitability and survival. Sugarcane price paid to the farmers accounts for 70-75 per cent of entire raw material cost of sugar mills. Hence, the bilateral linkage between sugarcane production and its processing industry exists nowhere else. The public funded R&D institutions should have sole vision and mission for conducting the basic and applied research on all aspect of sugarcane production and its processing technological innovations. The sugar mills should play the pivotal role in sugarcane production technology transfer, extension support and farmers training activities. Sugarcane research and extension programme should be self-reliance. It should be formulated and developed in PPP funding mode with research handled by the government funded institutions, technology transfer and extension work by the sugar mills. The budgetary and financial arrangements for conducting trials and frontline demonstrations, publication of technology package of practices, audio-visual extension materials, etc. should be supported through government funded rural development and social welfare schemes such as RKVY and facilitated by the sugar mills.

- There is need of a mission mode programme to take up the challenge of sugarcane productively and sugar recovery enhancement. It is also essential to improve technical efficiencies of sugar mills and to fully exploit the potential of co-products utilization in a better way through new innovative technologies to make sugarcane production and diversification profitable and a win-win situation to farmers and sugar millers in facing future eventualities. It should aim at sugarcane productivity and supply chain, crushing and boiling efficiencies, minimize energy consumption per unit of raw material crushed.
- There would be various strategies for identification and development of seed villages, cane seed farmers and captive seed multiplication farms of the sugar mills for achieving the targets and objectives of seed multiplication. It may be pointed out that the sugarcane seed model adopted by the Bihar Government should be up-scaled and adopted by other states. In this model, the sugarcane breeder seed production has been outsourced to the public funded R&D institute IISR, Lucknow with buyback arrangements with the sugar mills / sugarcane farmers for seed multiplication and its distribution to the cane farmers. The government should support the cane seed programme through the SDF governed by the department of food and public distribution system and by the subsidy/grants-in-aid schemes of the department of agriculture and cooperation, GOI. The SDF financial support should associate the research organizations who were involved in development and release of suitable sugarcane variety as a key partner for both as supplier of breeder seed or elite genetic material to raise breeder seed as well as technical consultant for its further multiplication down the seed value chain along with sugar mills. In long term, the ultimate aim should be robust adoption of three-tier seed nursery programme with cane seed replacement atleast once in 6 years. It could also be useful to exploit the potential of tissue culture for multiplication of the basic genetic material for establishing cane breeder seed nurseries. The succeeding multiplications of foundation-I and foundation-II seed nursery could be developed through seed set based techniques. SBI, Coimbatore recommended that the 40 per cent sugarcane plant crop area should be planted with the new recommended variety seed and the farmer must be mentaly prepared for seed replacement readily. The foundation-I and foundation-II level cane seed multiplication should be planned and

implemented through progressive sugarcane seed farmers, seed villages and captive seed farms by the sugar mills.

- Sugarcane is the extremely water intensive crop. Therefore, it is essential to educate the sugarcane farmers about the benefits of judicious use of irrigation water conservation technologies, integrated pest and nutrient management techniques to address issues of climate change, environmental protection and sustainability. The farmers should adopt the integrated nutrient management and water saving techniques. The review studies reveals that the skip furrow method and drip irrigation system has potential to save 30-50 per cent irrigation water in sugarcane. It also helps in enhancing sugarcane productivity and sugar recovery through efficient irrigation water delivery in plants root zone. The previous drought in tropical sugarcane production states has enhance the awareness amongst the sugar millers and farmers for quick adoption of drip irrigation systems in these states. The state governments have offered the financial subsidy for fertigation promotion. The fertigation is a drip irrigation system with inbuilt fertilizer application mechanisms for better nutrient absorption efficiency. The soil testing labs and sugarcane advisory support system should be strengthened through modern equipments. It does not require huge capital investment as the low cost soil testing models for establishing mobile labs are readily available in India.
- Sugarcane production and diversification draws attention of the policy makers and researchers for imbalance plant nutrients application in the form of chemical fertilizer and pesticides. The farmers has applying excessive dose of nitrogenous fertilizers and less quantity of phosphate / potash fertilizers due to high price disparity. Lack of farmer's awareness and technical knowledge guide them to apply economically cheap and readily available fertilizer in the market. Besides it, they don't apply the FYM / organic manures / bio-fertilizers in the cane crop. The poor adoption of soil conservation techniques and tillage practices lead to poor organic carbon content in soils. Hence, farmers have to adopt the integrated nutrient and pest management strategies for better soil health and sugarcane productivity improvement to fulfill sugar-energy demand targets of our nation.
- The appropriate policy should be formulated and implemented to improve economic returns and net profitability of sugarcane based farming systems through adoption of inter-cropping during initial crop development phase. Similarly, sugarcane ratoon management should also be given due attention. Sugarcane ratoon management may furnish better results as the labour and other inputs requirement was less *vis-à-vis* the higher expected economic returns due to high yield. There is need for adoption of sustainable cultivation practices for entire crop duration. It includes suitable tillage operations, seed quality, planting methods, spacing, inter cropping, irrigation, fertilizer, integrated pest, ratoon management strategies and timely supply of fresh cane to sugar mills.
- Mechanization of sugarcane farm operations is the dire need of Indian farmers. It would be useful for optimizing and cutting down the cost of cultivation and maximize net profit to sugarcane growers. Besides, timely field preparation, such as planting, intercultural and harvesting operations would also add to sugarcane productivity. The mechanised operations could also help superior ratoon management by suitable implements. The raised bed sugarcane (RBS) planter, inter crop planters could be used for simultaneous potato / wheat / pulse / oilseeds planting with winter season cane crop. The field preparation operations should be performed by the heavy machinery for deep ploughing. It may also

enhance 5-10 per cent sugarcane productivity due to better nutrient absorption, water holding capacity, moisture conservation and rainwater percolation. The specialized sugarcane machines such as cultivator, harrow cum furrow openers has huge potential for time and fuel saving during field preparation and furrow opening operations. The trash burning was an unhealthy practice used by the farmers. This issue may also be addressed, if they use plant residue shredder (PRS) for trash management in sugarcane ratoon crop.

- Labour shortage for sugarcane harvesting is the regular problem in all the states including U.P and Bihar. The harvesting delay and late cane supply to the sugar mills drastically reduce the weight and sugar recovery. The time lag between cane harvest and its crushing add losses to both farmers and sugar mills apart from accentuating cultivation cost. Therefore, adoption of mechanical cane harvester is essential. However, it has relationship with row spacing and sugarcane planting density. The prototypes of cane harvester developed by various R&D organizations has not been adopted by the farmers. Hence, it is imperative to develop the location specific small cane harvesters, which should be suitable for small farmers have scattered and fragmented land holdings.
- The slow adoption progress of sugarcane farm mechanization is also hampered by the limited manufacturers and provision of government subsidy on few machines. In some states, farmers are unable to take advantage of subsidies due to provision of farm equipments test reports. The possible way to solve this problem should be inclusion of exhaustive equipments list for government subsidy. The test certificate of designer R&D institute / SAU should be recognized by the states for giving subsidy on farm machine. The R&D work to develop location specific sugarcane harvesters, department of agriculture and cooperation (DAC) should explore possibilities of revenue neutral machine development in PPP mode with partnership of ICAR institute / SAU's / ISMA / NFCSF / IAMM. The GoI, ministry of food, civil supply and public distribution should provide subsidy on proven farm machineries and also extent financial support for budding entrepreneurship incubators on custom hiring basis for region specific cane harvesters.
- Enormous capital investment and other infrastructural facilities requires for creation of a sugar mills / integrated sugar-energy complexes. Once, the sugar mills has established, they become source of income, employment and livelihood security for thousands of cane farmers and rural workers engaged in ancillary activities. In nutshell, integrated sugar processing complexes are vibrant mini townships in the limited rural vicinity. The money invested on establishment of these projects is not primarily of private business entrepreneurs but also loan from financial institutions and SDF soft loans from GoI. Therefore, sugar mills should be functional and economically sound for 50-60 years to repay bank loan and other financial commitments related to investment liabilities. The sugar, power cogeneration, ethanol distilleries capacity built up during past decades and additional forthcoming integrated sugar complexes should be treated as national resources. These should be utilized judiciously for production of various valued added products and there aggressive marketing for earning profits. Keeping in view, the farmers socio economic structure, sugar industry and state policy, sugarcane price have 75-80 per cent share in sugar processing cost. Sugarcane is grown on small and scattered land holdings, by large number of farmers. Indian sugarcane cost of production may not match the economies of scale achieved by the major global sugar production and exporters such as Brazil and Australia. In these countries, large sugarcane farms were owned and managed by the sugar mills or

the farmers have large holdings size. So the question arises, how to deal the surplus sugar produced during the crushing season to maintain domestic sugar price and market supply? Whether the government should allow the sugar production only up to 25-28 million tonne per crushing seasons ? As per the conventional estimates, the domestic sugar consumption was 22 to 23 million tonne during sugar production season 2013-14. It has serious economic implication not only on idling surplus capacities, but also lead to increase sugar production inefficiencies by added cost.

Indian sugar industry should attempt to consolidate the production of proven value added products and access sugar commodity markets with the value added niche segments to mitigate processing cost inefficiencies. In this backdrop, policy paper conclusions for government priority, planning, strategic R&D interventions, infrastructural facilities and their effective implementation have been summarized as follows :

- Policy for promotion of sugar-ethanol-power cogeneration integrated complexes : The government of India should utilize the success evidence of Brazilian sugar industry products diversification. Hence, we should initiate drastic change in policy norms for establishment of new upcoming sugar-energy integrated processing industrial arrangement. India should produce sufficient sugar for domestic consumption and utilize surplus sugarcane raw material for bio-ethanol production to fulfill the EBPP, chemical, potable industry requirement and electricity cogeneration to supplement ever-growing renewable energy demand. Indian sugar industry may adopt concept of flexi factories for diversion of intermediate products for bio-ethonal production with flexibility in the processing sugar and other products as per domestic requirements.
- Keeping in view, operational sugar mills crushing capacities and key assumptions of regular sugarcane supply during crushing for integrated sugar production and cogeneration facilities with optimal size distilleries could be valuable for improving Indian sugar sector economic profitability in long term. Indian sugar industry has potential to produce the combination of 30 million tonne sugar, 3.0 billion litres bio-ethanol and 5500 MW bagasse based power cogeneration. The sugar and value added products production may be modified to various level of product combination such as 24 million tonne sugar, 5.9 billion litres bio-ethanol (2.4 billion litres from molasses and 3.5 billion litres directly from sugarcane juice) and 5000 MW electricity cogeneration. The upcoming additional processing capacities of Indian sugar mills, which would be functional by sugarcane crushing season 2016-17. The sugar industry could achieve the diversified products combination of 26 million tonnes sugar, 2500 MW power co-generation and 10.0 billion litres bio-ethanol adequate to fulfill the sugar products demands of all stake holders. The solitary catalyst requirement would be guaranteed bio-ethanol demand for EBPP from OMCs, 5plenty availability of sugarcane raw material, cogeneration facilities and the bio-ethanol distillery capacity. Therefore, Indian sugar industry could be the main player for saving valuable foreign exchange outflows and reduce current account fiscal deficits. The major obstacle for proper EBPP implementation in India are concerns of ethanol price parity with petrol, its availability and possible resistance from beverage and chemical industry.
- Surplus water available in sugar processing plants may be tapped through proper recyling and effluent management. Sugarcane contains 70 per cent water. It is sufficient not only to fulfill the sugar processing plant requirement, but also render surplus water for other uses including for irrigation and drinking purposes. Sugar mills utilizes 200-300 litre fresh water

per tonne cane crushed and in turn produce large quantity of effluent. There is enormous potential not only to reduce the quantity of waste water i.e. effluent to the level of zero effluent, but also to produce water as coproduct, which may ultimately leads to higher revenue generation and cost saving for the sugar mills.

- Adoption of extensive programme of bio-ethanol production based on agricultural feed stocks may have significant implications on food and livelihood security. The current debate on rising global food prices and the associated large-scale acreage shift from food grain to alternative feedstock crops. This has concerns for policy makers, scientists and consumers in developed and developing nations. It was due to market shift response against food crops at global level. If such trends continues in future, they may affect agricultural as well as other sectors, irrespective of countries participation in bio-ethanol production. The enormous subsidies for bio-ethanol production leads to money shift from vulnerable poor families who would have to spend more on food products due to high prices.
- In India, 58 per cent population lives in villages primarily, depend on agriculture and related activities for their income, employment, food and livelihood security. It is estimated that 23 percent rural population belong to the below poverty line (BPL) family due to their poor socioeconomic status. Food security for them would continue remain as the social welfare priority for Indian government. Though, India has achieved self-sufficiency in food grains production, 50 percent children and BPL women were under nourished. Thus, India can not compromise on food and nutritional security of BPL families for expansion of bio-ethanol production for EBPP implementation.
- The sugarcane alternative feedstock crop productivity and adoption of conventional processing techniques of bio-ethanol production hardly seems cost-effective. Therefore, concerns were raised on their long term sustainability, economic viability and commercial feasibility of bio-ethanol production. The studies support the ethanol production focused on sugar mill by-product molasses as the primary feedstock was neither economically viable nor sustainable with conventional distillation processing technologies. Therefore, we should look forward for cost effective superior processing technology and better management practices to minimize bio-ethanol distillation costs. The uneconomic distilleries plant size, batch type processing technology, inefficient by-product and effluent management practices were considered as major technological constraints. To achieve long run EBPP targets, it is necessary to adopt modern biotechnological techniques for breeding high sucrose sugarcane varieties, commercial use of membranes and microbes technologies for bio-ethanol production. Though the direct conversion of sugarcane juice for bio-ethanol production yields higher recovery as compared to molasses, it may not be the feasible alternative considering the huge domestic sugar consumption demand. Further, sugarcane acreage expansion for bio-ethanol production may bring down the food crops area. It may lead to food and nutritional insecurity for the weaker section especially BPL families. Therefore, it is concluded that the sugarcane based ethanol production may not be cost effective, economically viable and sustainable in India.
- Government sugarcane and sugar price policy has twin objectives to ensure remunerative prices to the cane growers for their produce and to encourage them for higher investment and production. Government also had to safeguard the interests of consumers by ensuring sugar supply at reasonable prices. The CACP recommends minimum support prices (MSP) / fair remunerative prices (FRP) for sugarcane, prior to start of crushing season, taking into

account the views of state governments and the concerned departments. The sugarcane price policy is governed by the statutory provisions of sugarcane control order (1966) issued under the essential commodities Act 1955. The FRP is recommended after taking into account the cost of sugarcane production, sugar recovery percentage and prices of sugar and its co-products, such as molasses, bagasse, and press mud. The sugar industry claims that the FRP is uni-directional upwards due to political pressure of cane farmers lobbies. The arbitrary fixation of sugarcane prices by the state governments as SAP above the FRP fixed by the centre has adverse affect on sugar mills. Rangarajan Committee recommended to link sugarcane prices with sugar prices have not yet accepted by all the states. Due to excess opening stock and high production during current production season, sugar prices were subdued leading to huge cane price arrears on sugar mills. To help in clearance of cane price arrears of previous sugar seasons and timely payment of sugarcane price for current sugar season to the farmers, the GOI, notified a scheme for extending financial assistance to sugar undertakings SEFASU (2014) envisaging interest free bank loans of worth ₹ 6600 crores for revival of Indian sugar sector. Besides, it GOI, also restored sugar export subsidy of ₹ 3300 per tonne and enhanced sugar import duty from 15 to 40 per cent for export promotion.

- Keeping in view, the limited supply of sugarcane as raw material for sugar and bio-ethanol production, it is essential to prioritize other alternative sugar feedstocks crops options. The efforts should also be directed to make these crops economically viable and production resource efficient. The alternative feed stocks crops, such as sweet sorghum based ethanol could be a better option. It would be the crop suitable for resource poor farmers as well cultivated on marginal land and rain-fed condition. It may also true for tropical sugar beet cultivation. The selection of excellent feedstocks with long-term prospects should be a primary course of action. The efforts should be made to improve the processing efficiency through technological advancement for realization of better production and higher recovery.

Government policies and private entrepreneurial priorities for sugar sector

- **Strengthening of public funded sugarcane research institutions :** Majority of states sugarcane research institutes suffer paucity of trained manpower, financial resources etc. The viable mode to strengthen their activities could be through institutional structure which could be on lines of VSI, Pune. The Special Purpose Vehicles (SPV) should be floated for sugarcane supply from fields to sugar mills. It needs huge financial investment on infrastructural development for which various stake holders such as the state government, research organization, sugar mills and sugarcane farmers must be partners in sharing financial resources and responsibility.

- **Promotion of integrated distilleries and bagasse based cogeneration units :** There are 526 operational sugar mills in India and nearly 25 per cent of these sugar mills have ethanol distilleries. These distilleries have production capacity of 2.15 billion litres per annum. Besides it, there are about 175 independent distilleries working on procured molasses. The total distillery capacity in India is 4.0 billion litres rectified sprit. Similarly, operational sugar mills in our country, only 40 percent sugar mills has power cogeneration facilities. Technically, the surplus electricity generation possible from the operational capacities of sugar industry requires financial resource of nearly ₹ 21000 crores. The review studies suggests that the integration of distillery and cogeneration plant in sugar mills would be economically viable except for the sugar processing plants having capacity of below 2500

TCD, where benefit cost ratio of initial investment may not be favourable because of sugar mills less exportable power production possibilities to the national grid. There is need to synergize the efforts with the MNRE, MoPNG as well as the ministry of power, so that the integrated sugar processing, distillery and cogeneration power capacity would be upgraded in a time bound manner.

- **Encouragement for sugar beet / sweet sorghum as alternative feed stocks crops :** It could be viable option to increase the crushing duration for sugar mills. The adoption of sugar beet, cassava as well as sweet sorghum could be used as the complementary feedstock crops. However, there have been numerous hurdles, which are expected in any new endeavour. These crops, especially sugar beet definitely present a viable alternative to sugarcane crop in the sub-tropical India. However, the initiative for commercial adoption of these crops largely depend on sugar mills. The government of India should appropriately supportive policy environment to assist cheap seed, pesticides availability to the farmers. It is necessary to make appropriate changes with regards to import policy and tariffs. The domestic availability of quality raw materials for sugar beet could be a concern during initial phase of establishment of this crop in India.
- **Adoption of sugarcane sampler for judging raw material quality :** The world over technology for determining sugar percent in sugarcane has been adopted to facilitate cane price payment to the growers. However, in India, sugarcane price payable to the farmers are still on the weight basis. The cane samplers suitable for Indian conditions should be develop and promoted by the sugar mills on voluntary basis with required policy support. Once the sugarcane growers become aware that they will be paid cane prices by the sugar mill on sugar recovery percentage, they will plant the high sucrose cane varieties which are superior in sugar recovery.
- **Method of sugarcane price fixation on revenue sharing with minimum FRP** : Indian sugar mills have to follow the revenue sharing formula for putting sugar sector on higher trajectory of growth, transparency, stability and objectivity. Amongst the leading sugarcane cultivating nations in the world, India perhaps is the only country where fixed price payment system on weight basis against revenue sharing formula is in vogue. In this backdrop, it could be suggested to modify the prevailing sugarcane price mechanism to revenue sharing formula with MFRP on sugar recovery basis. This sugarcane price fixation policy and payment approach has potential of breaking the cycle of boom and bust and also bring stability in Indian sugar sector.
- **Long durational sugarcane reserve area allotment policy for sugar mills :** The annual sugarcane acreage renewal to sugar mills by the cane commissioners in sub-tropical states such as Bihar, UP and Uttarakhand has perceived as lack of enthusiasm amongst sugar mills for implementation of development programme and nurturing sugarcane crop in their command areas. It is recommended that the state government should adopt the long duration sugarcane command area reservation policy to the sugar mills. The annual area allocation should be pursued by the sugar mills with the cane development staff of state governments at appropriate forum. The policy reform related to maturity based cane harvesting could facilitate sugarcane harvest by the sugar mills as practiced in tropical belt. These policy interventions may drastically change the socio-economic status of sugarcane growers. It could be a possible solution to minimize sugarcane supply gaps to mills in sub-tropical India.

In nutshell, forward way engaged concurrent efforts for rejuvenation of backward linkage such as raw material supply and consolidation of forward linkages to nurture new innovative demand driven products markets through channelization of processing infrastructural facilities and assets to produce the diversified value added product mix from sugarcane and other alternative sugar crops. Sugarcane cultivation and integrated sugar industry in India may offer massive potential for production of food, feed, fuel, fibre and energy, through electricity cogeneration and bio-ethanol. The strong linkages between global sugar and oil prices had emerged as driving force for valuable relationships between raw sugars as prime bio-ethanol feedstock. The global demand for fuel bio-ethanol has increased drastically during past few decades, governed by concerns of safe bio-energy security, environmental sustainability and requirement of mitigating climate change through greenhouse gas emissions reduction.

Though, sugar power and bio-ethanol production programme had to address the concerns of gender empowerment, food and livelihood security etc. There are numerous aspects that need proper attention and involvement. This policy paper highlights several untackled issues of economic viability and sustainability of sugarcane based ethanol programme, technological constraints, development of second generation bio-ethanol industry, open ended provisions in domestic sugar, electricity and bio-ethanol production and marketing policies. The key challenge for Indian government is to bridge the existing gaps of bio-ethanol for petroleum fuel and consumer friendly and market oriented safe green bio-energy revolution which should be pro poor, affordable and also address the environmental protection concerns on priority. The prospective future growth of the Indian sugar sector would rely a lot on productivity and efficiency improvements especially at processing plant and farm level. In order to accomplish higher sugar productivity of over 10 tonnes/ha/year, it is essential that the R&D efforts for sugarcane development must be revisited afresh with a clear cut focus, renewed approach and newer tools, encompassing agro-production technology, biotechnological application and active national and international collaborations. In this direction, resource conservation technologies that improve input use efficiency along with conservation of natural resources should be developed and promoted aggressively. The growing economy and the projected highest population base beyond 2030 shows that the sugar industry need not look outside country for their sustenance. The domestic sugar, ethanol, electricity demand-supply scenario for cogeneration, bio-ethanol or other value added co-products has expected to remain favourable during forth coming three decades of 21^{st} century.

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Annexure-I

Survey Schedule
Economic Analysis of Integrated Sugar-Energy Processing Complex in India

Date of survey: ________________

1. Name of the Industry: ____

2. Address of the Industry:

   Place:____________________District:__________________State:__________________

3. Ownership of industry:

   (a) Private sector owned _________ (b) Govt. owned: ___________ (c) Co operative sector

4. Whether sugar industry is diversified: Yes/No

   (a) Stand alone distillery:_____(b) Integrated with sugar mill:_______(c) Electricity/ Power cogeneration_____________(d) Integrated with sugar- energy production

5. Particulars of the sugar power and ethanol plant: (a) Sugar mill

Particulars	
Year of machinery installed/establishment	
Value of machinery installed (₹)	
Revenue earned per year (₹)	
Total labour force employed(permanent)	
Total labour force employed (seasonal staff)	

Cane crushing capacity (TCD) :

Sugar recovery percentage/crushing duration :

(b): Ethanol distillation plant :

Particulars	
Year of machinery installed/Establishment	
Value of machinery installed (₹)	
Revenue earned per year (₹)	
Total labour force employed per annum (man days)	
Quantity of bio-ethanol produced tonnes	

c Power cogeneration plant

Particulars	
Year of machinery installed/establishment	
Value of machinery installed (₹)	
Revenue earned per year (₹)	
Total labour force employed(permanent)	
Total labour force employed (seasonal staff)	
Distillation capacity (litre/day)	
Ethanol recovery percentage/quantity of ethanol produced	
Revenue generation from power sold (₹/year)	

6 -Sugarcane crushed and sugar production during last four years

Particulars	2011-12	2012-13	2013-14	2014-15
Sugarcane purchased (000'tonnes				
Crushing capacity (TCD)				
Capacity utilized (per cent)				
Sugar recovery (per cent)				
No. of employees (permanent staff)				
No. of sugarcane farmers in mill command area				
Sugarcane purchase centre (No.)				
No. of workers (seasonal staff)				
Sugar production (000'tonnes)				
Cane price payment/cane price arrears(₹)				
Profit loss status of sugar mill.				

7. What feedstock do you use for ethanol production?

(a) Molasses: ______________ (b) Any others: __________________

8. Bio- ethanol production states during last four year :

Particulars	2011-12	2012-13	2013-14	2014-15
Total molasses utilized (MT)				
Ethanol production (*litres*)				
No. of working days of the plant				
Capacity utilized (per cent)				
Processing efficiency				

9. What chemicals do you use in distillation/fermentation of molasses

10. Where do you buy molasses

11. Operational cost of bio-ethanol production from molasses processing (₹/tonne):

Particulars	Quantity	Price (₹/tonne)
Molasses cost		
Electricity/power costs		
Chemical costs		
1.		
2.		
Labour wages		
Managerial cost		
Administrative cost		
Casual labour cost		
Transportation costs		
Misc. or any others		
1. Taxes		
2. Excise duty		

12 Do you use any other power source?

(a) Yes ______________________ (b) No __________________

If yes, list them and the cost:

Other source	Quantity used (per ton molasses produced)	Value(₹)

13. What is the economic life of plant/machinery installed?

____

14 (a) What is the approx. value of building/land attached with plant?

____

14 (b) How much depreciation do you expect for the integrated plant per year (per cent)

____

15. Expenditure on repairs and maintenance of the plant/ year ((₹) ___________________

16. How frequently do you replace the molecular sieve? How much it cost?

____

17. Do you have taken loan for establishment of sugar mill or integrated plant /working expenses ?
(a) Yes______________________ (b) ____________________No

If yes, give the amount ((₹) _________________ rate of interest (per cent) _____________

18 (a) Source o f loan : SDF/bank

____

18 (b) Type of loan/duration ____

18 (c) Has government provides subsidy /incentive on loan

____

19. What by-products are left after bio-ethanol distillation/molasses fermentation?

20. What do you do with the leftover by products and disposal mechanism ?

(a) No use ________________ (b) Use in productive activity ____________________

If use in productive, list the products and how much do you earn from it

By-products	Use	Quantity(on tonne basis)	Price(₹/tonne)

Note : Quantity of by -product per tonne of molasses used

21. Utilization and marketing of bio-ethanol/alcohol?

Utilization/Particular	Quantity (In per cent)	Price at factory(₹/tonne)
Potable purpose		
Industrial use		
Bio-fuel/EBPP		
Other uses		

22. Who are the major customers of electricity supply to the power grid?

Customer	Quantity sold (MW/annum)	Price received (₹/MW)
1.		
2.		
3.		

23. Has government provided any subsidy or incentive for bio-ethanol/power cogeneration?
(a) Yes ____________________ (b) No ____________________

If yes, please give details ____

24. Has sugar mill associated with R and D on sugarcane/bio-ethanol?
(a) Yes ____________________ (b) No ____________________

If yes, please give details

____

25. Do you treat the sugar mill/distillery effluents? Yes/No

26. Constraints perceived by you for promotion of integrated sugar energy processing complex?

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