Low Carbon Development Pathway for Sugar Mills in Bihar

GHG Inventory and Strategy for Carbon Neutrality

BIHAR
Bihar State Pollution Control Board

Development Alternatives

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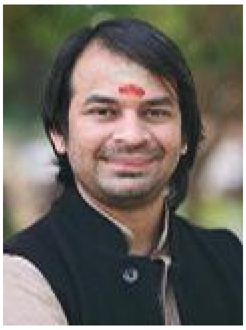
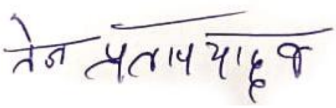
संदेश



अत्यन्त प्रसन्नता का विषय है कि बिहार राज्य प्रदूषण नियंत्रण पर्षद् द्वारा राज्य की जलवायु अनुकूल एवं न्यून कार्बन विकास कार्यनीति विकसित करने हेतु किए जा रहे अध्ययन के अंतर्गत डेवलपमेंट अल्टरनेटिव, नई दिल्ली के सहयोग से राज्य के औद्योगिक क्षेत्र द्वारा हो रहे ग्रीन हाउस गैसों के उत्सर्जन के आकलन के लिए एक अध्ययन किया गया है। इस क्रम में राज्य के चीनी मिलों से हो रहे ग्रीन हाउस गैसों के उत्सर्जन से संबंधित एक विस्तृत प्रतिवेदन प्रकाशित किया जाना एक प्रशंसनीय कदम है।

देश के अन्य क्षेत्रों के साथ–साथ बिहार राज्य भी जलवायु परिवर्त्तन के प्रभावों से अछूता नहीं है। जहाँ एक ओर राज्य के कुछ क्षेत्र बाढ़ से प्रभावित होते हैं तो दूसरी ओर कुछ अन्य क्षेत्रों में सूखा होता है। ऐसे में जलवायु परिवर्त्तन के क्षेत्र में किये जा रहे इन अध्ययनों से राज्य की जलवायु अनुकूल कार्यनीति विकसित करने में सहायता मिलेगी एवं इस क्षेत्र के सभी हितधारकों, शिक्षाविदों, विद्यार्थियों, शोधार्थियों आदि को लाभ होगा।

शुभकामनाओं सहित।



(तेज प्रताप यादव)
मंत्री,
पर्यावरण, वन एवं जलवायु परिवर्त्तन,
बिहार।

MESSAGE

It is a pleasure to note that the Bihar State Pollution Control Board, in association with Development Alternatives, has conducted a study to evaluate the Greenhouse Gas (GHG) emissions in the industrial sector of Bihar as part of the study being conducted for a ***'carbon resilient and low carbon development pathway for Bihar.'*** This study embarked upon the formidable endeavor of quantifying greenhouse gas (GHG) emissions across diverse industrial sectors in Bihar. Notably, it scrutinized the specific domain of sugar mills, meticulously assessing and estimating the associated environmental impact.

Approximately 6% of Bihar's agricultural land is dedicated to sugarcane cultivation. This cash crop plays a pivotal role in the state's agrarian economy. Beyond its economic significance, the sugar mill industry generates employment opportunities and bolsters the rural economy. Additionally, the by-products of this industry contribute to ethanol production and power generation, further enhancing its multifaceted impact on the region. While the sugar industry holds immense economic significance for Bihar, its growth has been accompanied by environmental consequences in the form of GHG emissions. A lack of consistent data has hindered our ability to quantify its environmental impact accurately. This study serves as a cornerstone, filling the void by providing a thorough GHG inventory for Bihar's sugar industry.

The findings of this study are crucial for introducing suitable technologies and policy measures that will enable the sugar industry in Bihar to harness emerging opportunities. Currently, the sugar sector is on the path to carbon neutrality, making substantial contributions to the local economy while generating clean power. This study addresses the current environmental challenges and envisions a transformative future for Bihar's sugar sector.

I hope the insights from this research will be instrumental in formulating sustainable strategies and policies aligning with the state's low-carbon development goals.

Bandana Preyashi, IAS
Secretary,
Department of Environment, Forest and Climate Change,
Government of Bihar

Dr. D.K Shukla, IFS (Retd.)
PhD, Econ., Wales, U.K.
Commonwealth Fellow
Chairman

बिहार सरकार

Bihar State Pollution Control Board

MESSAGE

As an integral component of the study conducted by Bihar State Pollution Control Board in association with UNEP and other partner organizations on *'Climate Resilient and Low Carbon Development Pathway for Bihar'* M/s Development Alternatives, New Delhi has contributed for the industrial sectors of the State like Brick Kilns, Sugar, Re-rolling Mills, *etc*.

A Low Carbon Development Strategy is pivotal for Bihar's future, striking a balance between economic prosperity and environmental conservation. By establishing clear targets, promoting cleaner energy sources, enhancing energy efficiency, and embracing technological innovations, the State can attain sustainable growth. Fast-tracking the adoption of the sugar mill industry within the State's policy framework is essential to propel Bihar towards sustainability and carbon neutrality. I sincerely hope that this detailed report on Green House Gas inventory and Low Carbon Development Pathway for Sugar Mills of the State will provide practical insights spanning short, medium and long-term strategies with policy suggestions, technical advancements and financial considerations achieving the goal of net zero.

Devendra Kumar Shukla, PhD.
Chairman,
Bihar State Pollution Control Board.

Patna,
16th November, 2023.

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Acknowledgements

Development Alternatives, in collaboration with the Bihar State Pollution Control Board (BSPCB), has conducted a pioneering study to assess the Greenhouse Gas (GHG) inventory in Bihar's industrial sector and to propose low-carbon development strategies. These collective efforts are poised to significantly contribute to Bihar's aspiration of becoming a Net-Zero State in India by 2070. This comprehensive study is integral to the *'Climate Resilient and Low Carbon Development Pathway for Bihar'* program initiated by the Bihar State Pollution Control Board.

Our deepest gratitude goes to Ms. Bandana Preyashi, IAS, Secretary, Department of Environment, Forest, and Climate Change, Government of Bihar; Dr. Devendra Kumar Shukla, Chairman, BSPCB; and Shri S. Chandrasekar, IFS, Member Secretary, BSPCB. Their unwavering support has been instrumental throughout the course of this study.

The success of this endeavor is attributed to the dedication of the project team at Development Alternatives and the invaluable contributions of expert individuals and organizations. We extend our gratitude to Shri Dipak Kumar Singh, IAS, Additional Chief Secretary, Cooperative Department, Government of Bihar; Shri Arvind Kumar Chaudhary, IAS, Principal Secretary, Department of Finance, Government of Bihar; Dr. Ashok Kumar Ghosh, Former Chairman, BSPCB; Dr. Naveen Kumar, Scientist, BSPCB; and members of the BSPCB. Without their unwavering support, this initiative would not have been possible. These individuals have taken a keen interest in the study, providing strategic guidance and support.

A special acknowledgment goes to the deep-dive partners and supporting agencies, including the Department of Industries, Department of Environment, Forest, and Climate Change (DoEF&CC), United Nations Environment Programme (UNEP), World Resources Institute – India (WRI India), Research Triangle Institute (RTI), Council on Energy, Environment and Water (CEEW), ECLEI South Asia, and the Programme Management Unit at BSPCB, for their invaluable support, provision of information, facilitation of workshops, and seamless coordination. The openness with which they shared information and ideas has been truly remarkable.

The team thanks industry owners and other stakeholders for their crucial role in the initiative's success. Their open collaboration, data sharing, and participation enriched the study with valuable insights and real-world perspectives. The contributors demonstrated transparency, cooperation, and a commitment to advancing sustainable practices in Bihar's industrial sector. The study gained a more comprehensive understanding of challenges and opportunities through their collective engagement.

Lastly, our gratitude extends to Mr. Koyel Kumar Mandal, Chief of Programmes; Shakti Sustainable Energy Foundation (SSEF); Mr. Shubhashis Dey, Director – Climate Policy & Climate Finance, SSEF; Dr. Sachin Kumar, Director - Industry, Building & Cooling Programs, SSEF; and Ms. Nidhi Madan, Associate Director - Climate Policy, SSEF. Their guidance, support, and critical inputs at every step were instrumental in the success of this study.

Contents

Abbreviations

BOD	Biological Oxygen Demand
BSPCB	Bihar State Pollution Control Board
CACP	Commission for Agricultural Costs and Prices
CAGR	Compound Annual Growth Rate
CBG	Compressed Biogas
COD	Chemical Oxygen Demand
CO_2e	Carbon Dioxide Equivalent
COP26	26th UN Climate Change Conference of the Parties
CNG	Compressed Natural Gas
CPCB	Central Pollution Control Board
DNA	Denatured Alcohol
ENA	Extra-Neutral Alcohol
FAO	Food and Agriculture Organization
FOM	Fermented Organic manure
FRP	Fair and Remunerative Prices
GAIL	Gas Authority of India Limited
GSDP	Gross State Domestic Product
GHG	Greenhouse Gas
GVW	Gross Vehicle Weight
HDV	Heavy-Duty Vehicle
INR	Indian Rupee
IPCC	Intergovernmental Panel on Climate Change
IISR	Indian Institute of Sugarcane Research
KLPD	Kilo Litres Per Day
kWH	Kilowatt-hour
LDV	Light-Duty Vehicle
MDV	Medium-Duty Vehicle
MMT	Million Metric Tonne
MWh	Megawatt-hour
MoPNG	Ministry of Petroleum and Natural Gas
OECD	Organization for Economic Co-operation and Development
ONGC	Oil and Natural Gas Company
SATAT	Sustainable Alternative Towards Affordable Transportation
S&S Sector	Sugarcane and Sugar Sector
SDG	Sustainable Development Goals
SIS	Sugarcane Information System
TCD	Tons of Cane per Day
tCO_2e	Tons of Carbon Dioxide Equivalent
UP	Uttar Pradesh

LIST OF FIGURES

LIST OF TABLES

सारांश

बिहार, जो मुख्य रूप से कृषि प्रधान राज्य है, चीनी उत्पादन में विशेष रूप से महत्वपूर्ण है। 2021-22 सीजन में, बिहार की नौ मिलों ने लगभग 475,000 टन चीनी का उत्पादन किया। इनमें से छह मिलें इन-हाउस डिस्टिलरीज के माध्यम से इथेनॉल उत्पादन में भी शामिल हैं। हालाँकि, गन्ने की घटती उपलब्धता के कारण राज्य में चीनी क्षेत्र संरचनात्मक परिवर्तनों से गुजर रहा है, जिसके परिणामस्वरूप पेराई सत्र छोटा हो गया है और मौसम की स्थिति के कारण गन्ना उत्पादकों के लिए चुनौतियाँ पैदा हो रही हैं।

भारत के चीनी क्षेत्र का आर्थिक प्रभाव महत्वपूर्ण है, चीनी फसल से सकल मूल्य 2020 में 806 अरब रुपये तक पहुंच गया है। यह देश की आर्थिक वृद्धि और कृषि समृद्धि में इसके महत्वपूर्ण योगदान को उजागर करता है। अपने घरेलू महत्व के अलावा, भारत प्रमुख चीनी उत्पादक और तीसरे सबसे बड़े निर्यातक के रूप में वैश्विक प्रभाव भी रखता है। सह-उत्पादन प्रौद्योगिकी में प्रगति और इथेनॉल और संपीड़ित बायोगैस (सीबीजी) उत्पादन में विस्तार के कारण, इस क्षेत्र ने हाल के दशकों में तेजी से विकास का अनुभव किया है।

इस रिपोर्ट का उद्देश्य बिहार में चीनी क्षेत्र में ग्रीनहाउस गैस उत्सर्जन का विश्लेषण करना है। ग्रीनहाउस गैस इन्वेंट्री विकसित करने के लिए उपयोग किया जाने वाला दृष्टिकोण जीएचजी प्रोटोकॉल का पालन करता है, जिसका उद्देश्य प्रत्यक्ष उत्सर्जन (स्कोप I), खरीदी गई उपयोगिताओं से उत्सर्जन (स्कोप II), और अप्रत्यक्ष उत्सर्जन (स्कोप III) की पहचान करना है। यह रिपोर्ट 2070 तक शुद्ध शून्य उत्सर्जन प्राप्त करने के लिए रणनीतियों और विकल्पों पर एक व्यापक परिप्रेक्ष्य प्रदान करती है। इस अध्ययन के लिए नियोजित पद्धति में सभी चीनी मिलों का साइट-आधारित सर्वेक्षण करना, उत्पादन प्रक्रियाओं का दस्तावेजीकरण करना और ऊर्जा खपत पैटर्न का मानचित्रण करना शामिल है।

ज्ञात है कि बिहार में नौ चालू चीनी मिलें हैं, जो मुख्य रूप से राज्य के पश्चिमी और उत्तर-पश्चिमी हिस्सों में स्थित हैं जहां गन्ने की उपलब्धता अधिक विश्वसनीय है। सर्वेक्षण में यह भी पाया गया कि ये मिलें मुख्य रूप से चीनी मिलों में भाप की मांग के लिए बॉयलर में गन्ने की खोई को जलाकर और फिर टर्बाइनों के माध्यम से बिजली उत्पन्न करने के लिए शेष वाष्प का उपयोग करके अपनी ऊर्जा जरूरतों को पूरा करती हैं। कुछ मिलें बिहार ग्रिड को अधिशेष बिजली निर्यात करने में भी सक्षम हैं, जिससे नवीकरणीय बिजली आपूर्ति में योगदान मिलता है। इस रिपोर्ट के लिए एकत्र की गई जानकारी वर्ष 2021-22 से संबंधित है। भारत का गन्ना और चीनी क्षेत्र देश के कृषि-आधारित उद्योगों में एक प्रमुख शक्ति है, जो कपास के बाद दूसरे स्थान पर है। 2022 में लगभग 37 मिलियन मीट्रिक टन के आश्चर्यजनक उत्पादन के साथ, भारत चीनी उत्पादन में दुनिया में अग्रणी है। यह क्षेत्र ग्रामीण गन्ना किसानों का समर्थन करने और चीनी मिलों में लगभग 500 हजार श्रमिकों को रोजगार प्रदान करने में महत्वपूर्ण भूमिका निभाता है।

अन्य ग्रीनहाउस गैसों के उत्सर्जन के संदर्भ में, अध्ययन में पाया गया कि प्रेस मड, जो गन्ने को कुचलने और स्पष्टीकरण के लिए गन्ने के रस को संसाधित करने का एक उपोत्पाद है, जब किसानों द्वारा उर्वरक के रूप में उपयोग किया जाता है, तो मीथेन उत्पन्न होता है। यह आंशिक अवायवीय अपघटन के परिणामस्वरूप हुआ। जीएचजी उत्सर्जन में कमी निर्धारित करने के लिए, अध्ययन के लिए परियोजना सीमा को गेट-टू-गेट अंतिम स्रोत, गेट-टू-डेस्टिनेशन दृष्टिकोण का उपयोग करके परिभाषित किया गया था। इस दृष्टिकोण में बिहार के चीनी क्षेत्र में सामग्रियों की आवाजाही से लेकर पूरी प्रक्रिया के दौरान होने वाले सभी जीएचजी उत्सर्जन को शामिल किया गया है, जैसे कि बागानों से चीनी कारखानों तक गन्ना और पहले गंतव्य तक संसाधित चीनी ध् इथेनॉल ध् प्रेस मड।

अध्ययन से पता चला कि चीनी मिलों की जीवाश्म ईंधन पर निर्भरता बहुत कम थी, क्योंकि वे भाप और बिजली उत्पादन के लिए मुख्य रूप से खोई से चलने वाले बॉयलर और टर्बाइन (रैंकिन चक्र) का उपयोग करते हैं। ऑफ-सीजन के दौरान आपातकालीन बिजली कटौती या रखरखाव में जब इन-हाउस बॉयलर और टर्बाइन चालू नहीं होते थे, तब उपयोग किया जाने वाला एकमात्र जीवाश्म ईंधन डीजल था। इसके अतिरिक्त, कुछ मिलों ने ग्रिड से बिजली खरीदी, खासकर ऑफ-सीजन के दौरान। सामग्रियों (गन्ना, तैयार चीनी, रसायन, आदि) के परिवहन ने भी महत्वपूर्ण जीवाश्म ईंधन के उपयोग में योगदान दिया, जिसका अध्ययन में विश्लेषण भी किया गया।अध्ययन के निष्कर्षों ने निम्नलिखित परिणामों का संकेत दिया:

- स्कोप I जीएचजी उत्सर्जनः यह डीजल और प्रेस कीचड़ से जीएचजी उत्सर्जन में विभाजित है, जैसा कि नीचे दिखाया गया हैः
  - डीजल से जीएचजी उत्सर्जनः प्रति वर्ष 547.2 टन Co_2e ।
  - प्रेस कीचड़ से जीएचजी उत्सर्जनः प्रति वर्ष 44,162.1 टन Co_2e ।
- इस प्रकार, बिहार में चीनी क्षेत्र से कुल स्कोप I जीएचजी उत्सर्जन 44,709.3 टन Co_2e प्रति वर्ष है।
- स्कोप II जीएचजी उत्सर्जनः चीनी क्षेत्र के लिए खरीदे गए जीएचजी उत्सर्जन सालाना 1,896.3 टन Co_2e थे।
- स्कोप III जीएचजी उत्सर्जनः कुल अप्रत्यक्ष जीएचजी उत्सर्जन प्रति वर्ष 10,415.7 टन Co_2e अनुमानित किया गया था।

इस प्रकार कुल क्षेत्र जीएचजी उत्सर्जन प्रति वर्ष 57,021.3 टन Co_2e अनुमानित किया गया था।

हालांकि, जैसा कि उल्लेख किया गया है, चीनी क्षेत्र बिजली ग्रिड को अधिशेष बिजली का निर्यात भी करता है, इस प्रकार स्थानीय ग्रिड को हरी बिजली (जो शून्य उत्सर्जन है) प्रदान करता है। सभी चीनी मिलों द्वारा बेची गई बिजली की मात्रा 54,500 मेगावाट होने का अनुमान है, जिसके परिणामस्वरूप वर्ष के लिए 44,690 टन $Co2_e$ का उत्पादन हुआ। नतीजतन, शुद्ध जीएचजी उत्सर्जन प्रति वर्ष लगभग 12,500 टन Co_2e या प्रति वर्ष प्रति यूनिट लगभग 1,392 टन Co_2e था। यह चीनी क्षेत्र को राज्य के सबसे स्वच्छ उद्योगों में से एक के रूप में चिह्नित करता है।

चीनी के अलावा, मिल ए) प्रेस मड और बी) स्पेंट वाश (जहां भी इथेनॉल का उत्पादन होता है) के रूप में उप-उत्पादों का उत्पादन करती है। जबकि प्रेस कीचड़ की ऊपर चर्चा की गई है, खर्च किए गए धोने को इसकी उच्च बीओडी/सीओडी सामग्री के कारण भस्म कर दिया जाता है और इसे लाल-श्रेणी के प्रवाह के रूप में वर्गीकृत किया जाता है। हालांकि, यह ध्यान देने योग्य है कि दोनों उप-उत्पादों में मीथेन वसूली की क्षमता है, और अन्य राज्यों में चीनी कंपनियां वर्तमान में प्रेस कीचड़ और खर्च किए गए धोने से मीथेन वसूली स्थापित करने के साधनों की खोज कर रही हैं।

अकेले प्रेस मड़ से मीथेन को पुनर्प्राप्त करने से इस क्षेत्र को शुद्ध कार्बन-नकारात्मक श्रेणी में पहुंचा दिया जाता है, जिससे बचने वाले उत्सर्जन में प्रति वर्ष लगभग 100,000 टन Co_2e उत्पन्न होता है। भारत सरकार की एसएटीएटी योजना का लाभ उठाते हुए टाले गए मीथेन को बायोगैस का उत्पादन करने के लिए संसाधित किया जा सकता है, संपीड़ित बायोगैस (सीबीजी) में परिवर्तित किया जा सकता है, और विपणन किया जा सकता है।

इसलिए, भविष्य को देखते हुए, परिदृश्य 2070 बिहार के चीनी क्षेत्र के लिए एक सकारात्मक दृष्टिकोण प्रस्तुत करता है। यह क्षेत्र वर्तमान समय में लगभग कार्बन तटस्थ है, स्थानीय अर्थव्यवस्था में सकारात्मक योगदान देता है, और हरित शक्ति का स्रोत है। भविष्य में, उप-उत्पादों से मीथेन निकालकर, यह क्षेत्र अपने शुद्ध सकारात्मक कार्बन उत्सर्जन को और गहरा कर सकता है और सरकार के लिए ग्रीन ट्रेडिंग योजना के तहत अन्य क्षेत्रों को ऑफसेट करने के लिए उनका उपयोग करने का मार्ग प्रशस्त कर सकता है।

इसलिए, सिफारिशें उपयुक्त प्रौद्योगिकियों और नीतिगत उपायों को शुरू करने के लिए हैं जो बिहार में चीनी उद्योग को उभरते अवसरों का उपयोग करने की अनुमति देंगे। बिहार सरकार की जैव ईंधन संवर्धन नीति 2023 इस दिशा में एक महत्वपूर्ण कदम है।

Executive summary

India's sugarcane and sugar sector is a powerhouse within the nation's agro-based industries, ranking second to cotton. India is the global pinnacle in sugar production, with a staggering output of approximately 37 million metric tons in 2022. This sector plays a dual role of paramount importance – a lifeline for rural sugarcane farmers and a significant source of employment for around 500 thousand workers in sugar mills.

The economic impact of India's sugar sector is substantial, with the gross value added from the sugar crop reaching a remarkable 806 billion INR in 2020. This underscores its pivotal role in contributing to the nation's economic growth and agricultural prosperity. Beyond its domestic significance, India extends its influence globally, serving as the world's leading sugar producer and the third-largest sugar exporter. The sector has advanced in leaps and bounds over the past few decades, with advances in cogeneration technology and, of late, from the forays into ethanol production and, looking forward, into new areas such as compressed biogas (CBG) production.

Notably, Bihar, a primarily agrarian state, hosts a key segment of the sugar sector. In the 2021-22 season, nine operational mills produced approximately 475,000 tonnes of sugar. Six of these mills also engage in ethanol production through in-house distilleries. However, structural changes are underway in the State's sugar sector due to declining cane availability, resulting in a shorter crushing season and weather-related challenges sugarcane growers face.

This report aims to analyze the greenhouse gas inventory for the sugar sector in Bihar. The approach for the development of GHG inventory development follows the GHG Protocol – which is to identify Scope I (direct GHG emissions), Scope II (purchased utility emissions), and Scope III (indirect emissions) for computation of GHG inventory. Importantly, this report provides a detailed perspective on strategies and options for achieving net zero by 2070.

The methodology adopted for the exercise was to conduct site-based surveys of all sugar mills, documenting production processes and mapping energy consumption patterns. During the survey, it was revealed that nine sugar mills were operational in Bihar; these were located around the western and northwestern parts of the State, where sugarcane availability is more reliable. The survey revealed that all sugar mills in Bihar could mostly meet their own energy needs by combustion of sugarcane bagasse in boilers (for steam demand in sugar mills), then passing residual steam through a turbine for power generation. Some units could also export surplus electricity to the Bihar grid (a renewable source of electricity). Information collected pertained to the year 2021-22, on which basis the report is developed.

To compute the GHG emission reductions, the delineation of the project boundary for the study included a last source to gate, gate to first destination approach. By definition, this also included all gate-to-gate GHG emissions as well. From the point of view of material movement, the approach included all meaningful GHG emissions involved in Bihar's sugar sector, viz., cane from plantations to sugar factory and processed sugar/ethanol/press mud or any other product from factory to first destination.

The study found very limited fossil fuel use in the sugar mills, which were driven by bagasse-fired boilers and turbines (Rankine cycle) for steam and power generation. The only fossil fuel use could be traced to diesel used in generators in case of emergency power outages or for maintenance during the off-season when the in-house boiler and turbine were offline. Some also purchased electricity from the grid, primarily during the off-season. Additionally, the other significant fossil fuel use was in transporting material (cane, finished sugar, other chemicals, and so on brought to or delivered out of the unit) that was also mapped as part of the study.

In terms of other greenhouse gas (GHG) emissions, press mud, generated in significant quantities when the cane is crushed and sugarcane juice processed for clarification, was found to generate some methane as it is usually taken by farmers for use as fertilizer in their fields, resulting in partial anaerobic decomposition.

Findings from the study indicated the following results:

- Scope I GHG emissions: This is bifurcated into GHG emissions from diesel and press mud, as shown below:
    - GHG emissions from diesel: 547.2 tons CO_2e per annum.
    - GHG emissions from press mud: 44,162.1 tons CO_2e per annum.

Thus, total Scope I GHG emissions from the sugar sector in Bihar is 44,709.3 tons CO_2e per annum.

- Scope II GHG emissions: Purchased GHG emissions for the sugar sector totaled 1,896.3 tons of CO_2e annually.
- Scope III GHG emissions: Total indirect GHG emissions were estimated at 10,415.7 tons CO_2e per annum.

The net GHG emissions for the sugar mills sector were approx **12,500** tons of CO_2e per annum, or around **1,392 tons** of CO_2e per annum per unit

However, as mentioned, the sugar sector also exports surplus power to the electricity grid, thus providing the local grid with green electricity (which is zero emission). The quantum of power sold by all the sugar mills is estimated at 54,500 MWh, which resulted in 44,690 tons CO_2e for the year.

As a result, net GHG emissions were around 12,500 tons CO_2e per annum or around 1,392 tons CO_2e per annum per unit. This marks the sugar sector as one of the cleanest industries in the State in terms of industrial GHG emissions.

In addition to sugar, the mill produces by-products in the forms of a) press mud and b) spent wash (wherever ethanol is produced). While press mud is discussed above, spent wash is incinerated due to its high BOD/COD content and is classified as a red-category effluent. It is worth noting, however, that both by-products have the potential for methane recovery, and sugar companies in other states are currently exploring means for setting up methane recovery from press mud and spent wash.

Recovering methane from press mud alone catapults the sector into a net carbon-negative category, generating nearly 100,000 tons of CO_2e per annum in avoided emissions. The avoided methane can be processed to produce biogas, converted into Compressed Bio-Gas (CBG), and marketed, taking advantage of the Government of India's SATAT scheme.

Looking into the future, therefore, ***Scenario 2070*** presents a positive outlook for Bihar's sugar sector. The sector is almost carbon neutral as of the present day, positively contributing to the local economy, and is a source of green power. In the future, by extracting methane from by-products, the sector can further deepen its net positive carbon emissions and pave the way for the government to use them to offset other sectors under a green trading scheme.

Therefore, the recommendations are for introducing suitable technologies and policy measures that would allow the sugar industry in Bihar to harness the emerging opportunities. The Government of Bihar's Biofuels Promotion Policy 2023 is a key step in this direction.

1. Introduction

1.1. Background: Status of the Sugar Sector in India and Bihar

THE SUGAR SECTOR IN INDIA

Sugarcane and sugar play an important part in India's economy, trade, and livelihood. Sugar, after cotton, is the country's second largest agro-based industry. Sugarcane and the sugar business affect the livelihoods of approximately 5 crore farmers and their dependents who cultivate sugarcane on about 50 lakh hectares. India is the world's largest user and second-largest producer of sugar.

As an agro-based rural industry, the sugar sector is key in addressing poverty and employment. About 110 countries produce sugar from either cane or beet, and eight countries produce sugar from both cane and beet. Sugarcane accounts for about 80% of global sugar production. In India, sugar is extracted from sugarcane. Globally, the sugar production during 2021 fell by 4.164 million tonnes to 165.167 million tonnes[1]. Brazil, India, the European Union, Thailand, and China are the top sugar-producing countries.

The Indian sugar industry boasts a rich historical legacy dating back to ancient times and has evolved into a major global player. It has made impressive strides through innovative technological advancements and a steadfast commitment to self-reliance, sustainability, and diversification. This industry serves as a cornerstone, supporting millions of farmers, laborers, and entrepreneurs, with sugarcane as a staple for mass consumption and a renewable energy source.

The establishment of modern sugar processing units in the early 20th century catalyzed a significant expansion in sugar factories and production. Post-independence, the sector continued its growth trajectory, marked by substantial advancements in research and development, disease and pest management, sugarcane varieties, and agro techniques. This resulted in increased sugarcane production and sugar yield. Furthermore, transformative technological innovations, including information technology and precision agriculture, have revolutionized the sector. The Indian sugar industry has evolved into multifaceted sugar complexes, producing sugar and generating bioenergy, bioethanol, bio-manure, and chemicals, thus contributing significantly to the nation's sweetener and energy needs.

1 https://www.isosugar.org/sugarsector/sugar

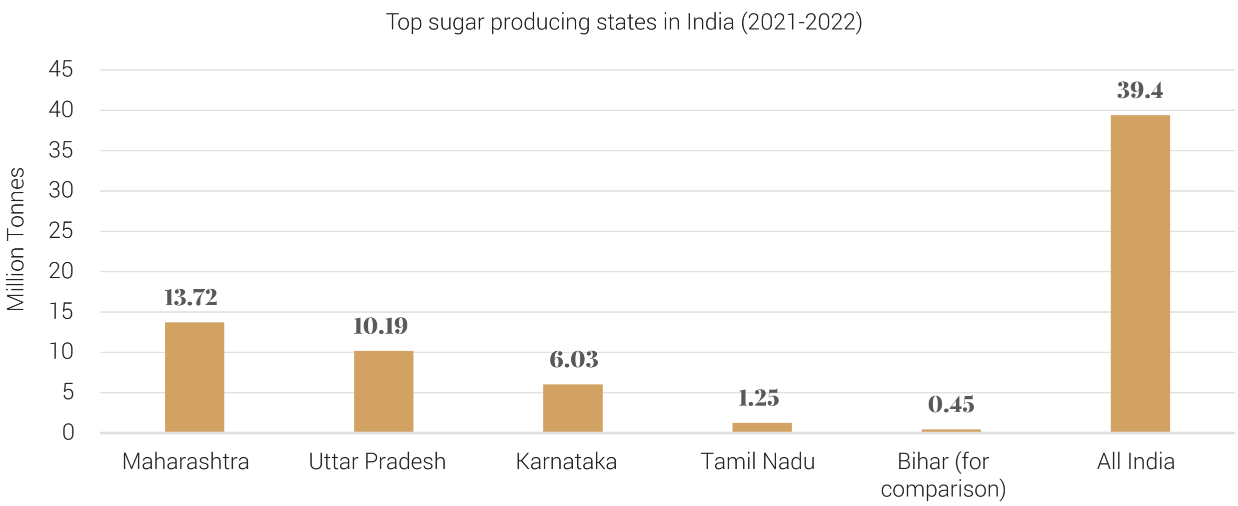
Furthermore, it has undertaken various developmental initiatives in rural areas, fostering socio-economic development, job creation, and environmental sustainability.

As the world's largest producer, consumer, and second-largest exporter of sugar, India occupies a place of pride in the global sugar landscape. As of 2021-22, sugar production in India was just under 40 million metric tonnes (around 39.4 million metric tonnes (MMT) of sugar as of the sugar crushing season, 2021-22[2]). It is also important to note that as much as 3.6 million tonnes of sugar ingredients were diverted in the same year for ethanol production. In 2022-2023, India produced over 35 million metric tons of sugar, with domestic consumption exceeding 29 million metric tons. The country had exported around 11 million tonnes, an all-time high, in the 2021-22 marketing year[3]. India has about 525 operational sugar mills as of 2021-22, although the figure keeps fluctuating over time.

Sugar is also among the earliest agro-based industries in India, with the first sugar plant established in Pratappur in the Deoria district of Uttar Pradesh in 1903.

The top sugar-producing states in India are Maharashtra, Uttar Pradesh, Karnataka, Tamil Nadu, and Gujarat, while Bihar, Andhra Pradesh, and Madhya Pradesh also feature consistently in the list of ten top states producing sugar in India. **Figure 1** provides the production figures of the top sugar producers in India in 2021-22.

Figure 1: Top sugar-producing states in India[4]



The sugar sector in India has undergone significant technological improvement over the years, especially in the ***power cycle***, in terms of boiler pressure and efficiency. The sector has also seen the introduction of energy-efficient turbines. The net result of this has been higher recovery of energy from cane. The surplus power is typically sold to the grid, fetching additional revenues. At the same time, enhancing efficiencies of juice clarification and evaporation also led to higher sugar recoveries from cane.

India primarily produces centrifuged sugar, which is known as 'White sugar.' The share of white sugar in production is over 90%, with the balance being met by jaggery and ***khandsari*** sugar, unrefined sugars traditionally consumed by Indian communities (and considered a healthy alternative to white sugar). Over the past two decades, sugar production has also been diverted to enhance the production of ethanol and (wherever applicable) Denatured Alcohol (DNA) or Extra Neutral Alcohol (ENA). Although molasses is the prime raw material, cane juice or syrup is extracted from the process to make more ethanol / ENA. This aspect is covered in more detail in Chapter 4.

India's sugar sector is poised for growth and diversification in the future. As the world's largest sugar producer, the biggest consumer of sugar, and its second-largest exporter, there are several positive, emerging aspects of India's sugar sector. Among these, diversification into ethanol and/or production of alcohol, higher value recovery for hitherto waste/by-products such as press mud and spent wash (spent wash is generated from sugar molasses-based distilleries), and finally, higher prices of value-added sugar-based items augur well for the industry at large. The Government of India's Sustainable

2 https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1892246
3 http://www.indiansugar.com/NewsDetails.aspx?nid=55794
4 https://www.chinimandi.com/statistics/statewise-sugar-production-in-india/

Alternatives Towards Affordable Transportation (SATAT) has of late laid open several options for exploiting recoverable resources from press mud, spent wash, and so on, which will further support the industry in the short run. Later sections of this report discuss this in more detail.

SUGAR SECTOR IN BIHAR

The economic landscape in Bihar is dominated by rural enterprises, especially in agricultural and allied industries (such as agro processing) and the services industry. Over the past ten years, Bihar has been one of India's fastest-growing state economies. The Gross State Domestic Product (GSDP) of Bihar in 2021-22 grew at 11%, compared to 8.7% for India for the same period[5].

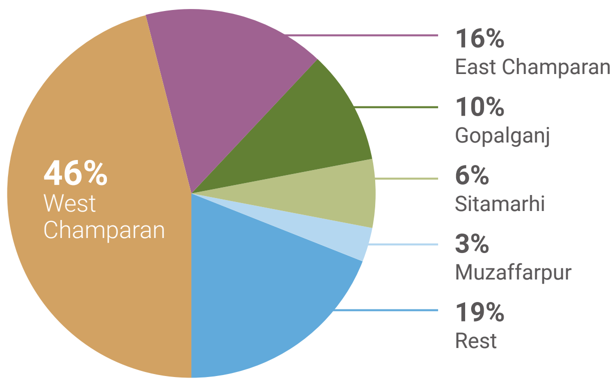
Notably, the SDG Vision document[6] shows how rural poverty levels (SDG-1) have decreased from 55.7% in 2004-5 to 34.1% as of 2011-12, which expectedly shall fall even more at the time of the next Census.

Similarly, under SDG-7 (Affordable and Clean Energy), peak power demand has risen from 2138 MW in 2011-12 to almost double, at 3769 MW, by 2016-17. This indicates the energy demand that is latent yet strongly felt in Bihar.

In Bihar, sugar is one of the key agro-based industries, with a cumulative daily crushing capacity of around 50,000 tons of cane from the nine operational sugar mills in the State.

The area under sugarcane production is 0.34 million hectares, and the State has produced 18.28 lakh tonnes of sugarcane in 2021-22. Sugarcane is cultivated in several districts of Bihar, but the top five in terms of area under cultivation are West Champaran (46.5%), East Champaran (16.4%), Gopalganj (9.8%), Sitamarhi (5.5%), and Muzaffarpur (3.1%). **Figure 2** depicts the share of cultivated land in these districts.

Figure 2: Districts of Bihar with sugarcane cultivated area.



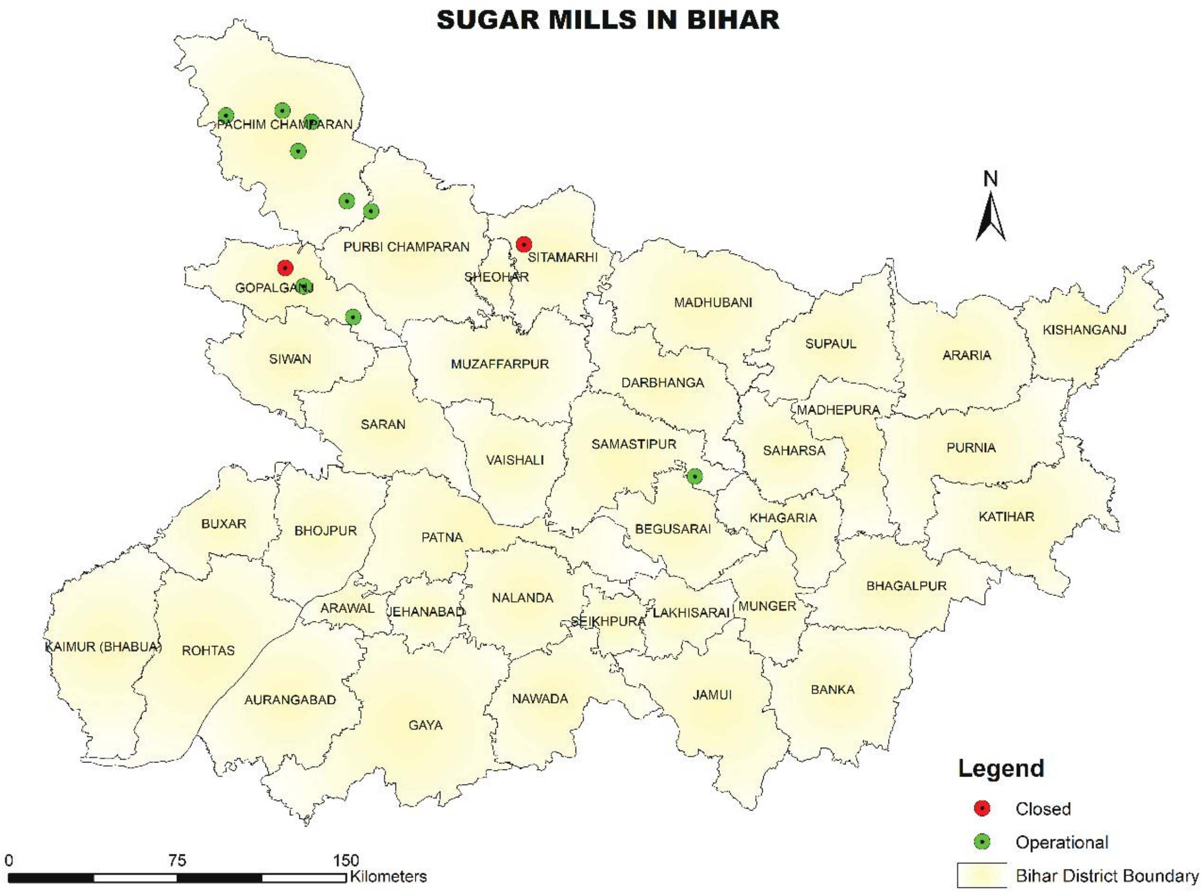
Based on cane availability, most sugar mills are in the western and northwestern parts of Bihar. However, the yield of the sugarcane farms is around 50 tons/hectare, which is lower than the national average of around 70 tons/hectare.

Further, there is a less formal process for procurement of cane for sugar production in Bihar, compared to the more sugar-intensive states such as UP and Maharashtra. As a result, sugar mills do not get the requisite quantity of cane at a proper price, and consequently, the sugar production cycle in the mills in Bihar is much smaller than in other sugar-producing states (UP, Maharashtra, Karnataka).

There are 11 sugar mills in Bihar, of which only nine are operational. All sugar mills have cogeneration facilities that utilize bagasse (residue after the cane is crushed) for steam and power generation. The boilers use ***bagasse***, the cane residue after juice extraction, as a fuel that is burnt to produce high-pressure steam. Steam is also used in the process, notably for removing moisture from sugarcane juice (carried out in juice evaporators). The steam is also used to drive a turbine, generating power that is used to meet the sugar mill's own demand and to export surplus power to the state grid.

5 https://prsindia.org/budgets/states/bihar-budget-analysis-2021-22
6 https://state.bihar.gov.in/planning/cache/8/12-Jan-23/SHOW_DOCS/SDG-Vision-Doc-2017.pdf

Figure 3: GIS map of Sugar Mills in Bihar



In addition to white (refined) sugars, which nearly all the mills manufacture, there is also added incentive from ethanol and alcohol production, which attracts better financial returns and adds to the viability of the sugar mills. **Figure 3** shows the location of sugar mills in Bihar.

At the state level, the sugar industry creates employment opportunities for more than 50,000 skilled and unskilled workers and generates more than INR 600 crores for Bihar's cane growers. Apart from being an agro-based industry, the sugar sector also provides a steady market for sugarcane growers, creates rural employment, and is a vital support to agriculture in the State.

1.2. Context: GHG Inventory of the Sugar Sector in Bihar

Bihar is one of the leading states in India in terms of action for a cleaner environment. The SDG Vision Document for the State of Bihar[7] has identified goals under each of the seventeen (17) heads of the sustainable development goals as promulgated under the 2030 Agenda of the United Nations. The comprehensive Vision Document outlines both progress to date and priorities for the future.

Also recently, at COP26 held in November 2021, Prime Minister Narendra Modi announced that India would reduce its carbon emissions intensity of GDP by 45 percent by 2030 from 2005 levels and will achieve the target of net-zero emissions by 2070.

In this context, the State government, led by the Bihar State Pollution Control Board, has undertaken several initiatives to address Greenhouse Gas (GHG) emissions and other pollutants over the years.

7 https://state.bihar.gov.in/planning/cache/8/12-Jan-23/SHOW_DOCS/SDG-Vision-Doc-2017.pdf

The Bihar State Pollution Control Board (BSPCB) has undertaken a holistic program of action to carry out detailed greenhouse gas (GHG) inventory development for major economic sectors in the State. As part of the exercise, the GHG inventory of the sugar sector in Bihar has been conducted.

The study assumes high significance in the face of commitments made by India at the national level to set a roadmap to net zero GHG emissions by 2070. Subsequently, these targets look likely to be brought forward to 2050 in the wake of renewed commitments from global peers to contain GHG emissions within a stricter time frame. As a state agency, BSPCB has taken a leadership role in seeking to contribute to the national goals by identifying key sectors within the State to account for GHG emissions and create a roadmap for their eventual transition to net zero.

This report aims to provide the Government of Bihar, members of the sugar industry in the State, and other stakeholders with a perspective on GHG emissions from the sugar sector in Bihar. The report is forward-looking, developing scenarios for 2070 in line with the Government of India's long-term goals for achieving net zero GHG emissions status. In the process, actions and enablers for the sugar sector are also analyzed.

2. Survey of Sugar Mills in Bihar

The active sugar mills collectively produce around **465,000** tons of sugar and **75,121** kilolitres of ethanol.

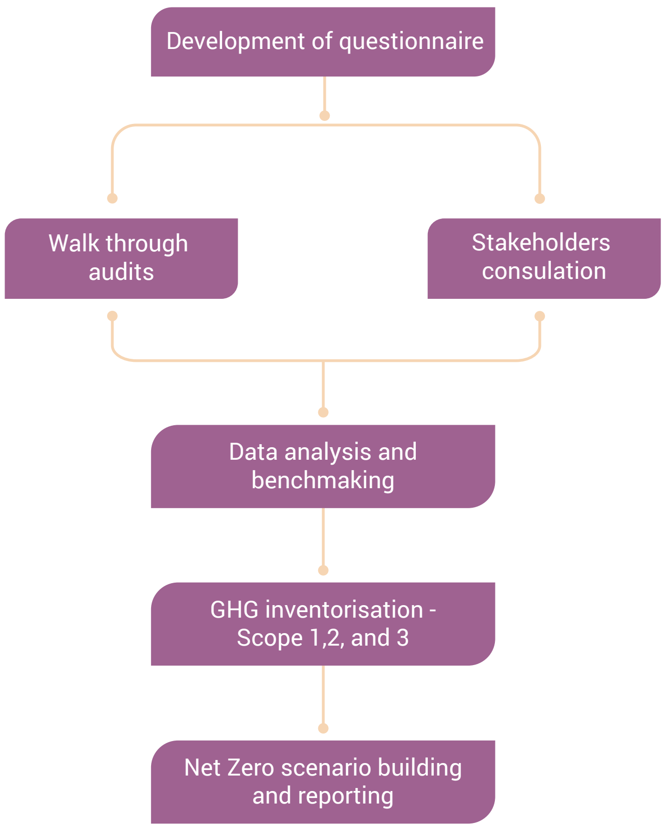
The Development Alternatives team conducted a detailed survey of all the active sugar mills in Bihar.

The overall production of sugar (and ethanol, where applicable) and other by-products in the process (such as press mud, ash, and spent wash from the distilleries) makes it one of the more complex industrial processes from an energy use efficiency perspective, as both electricity and steam are used extensively. Keeping this in mind, the survey identified key parameters relevant to developing this GHG inventory.

2.1. Survey Methodology

The overall flow of tasks adopted for conducting the study has been summarised in the **Figure 4** below.

Figure 4: Flow diagram of the methodology adopted for the study.



The study has utilized primary data collected from site surveys in all operating sugar mills.

Surveys were carried out using a questionnaire, which, however, was used as a part of other methods used by the team to unearth information relevant to the sugar sector in the State. These included detailed engagement with the management on parameters pertaining to ratings of key equipment (such as ratings of boilers and turbines), as well as technologies and processes employed by the mills (such as diffusers, clarifiers, evaporators and so on).

Each visit was also accompanied by walk-through surveys of the mill that were carried out to check facilities for material handling and disposal on the site.

2.2. Key findings of the Survey

The key findings of the site survey in 9 sugar mills in Bihar have been discussed below.

- Most sugar mills are concentrated in the Western and northwestern parts of Bihar. The main concentration is in the district of West Champaran, with other mills located in East Champaran, Gopalganj and Samastipur.
- Most sugar plants, 6 out of 9 mills in Bihar, report less than 100 days of the sugar production cycle. This is due to scarcity in procuring sugarcane from farmers in the region. This is discussed in detail in Section 4.
- All sugar mills have cogeneration facilities and sell power generated from firing bagasse to the grid during the season. Few of them also procure grid electricity. Overall, sugar mills are net sellers to the grid during the season. Sugar mills in Bihar also, on average, use diesel genset for 250-300 hours in a year.
- Most sugar mills have in-house distilleries, where molasses is converted to ethanol. Sugar mills find it more profitable to generate alcohol from molasses than sugar production since there is a higher demand for blending ethanol with petrol and alcohol (ENA).
- The average crushing capacity of sugar mills is around 5,800 tons of cane per day (TCD), with one sugar mill having the highest crushing capacity of 11,500 tons of cane per day (TCD).
- The active sugar mills collectively produce around 465,000 tons of sugar and 75,121 kilolitres of ethanol.

The DA team conducting on-site survey at a Sugar mill in Bihar.

2.3. Analysis

The key findings shown in section 2.2 above indicate wide disparities across sugar mills in the State. A ***benchmarking analysis*** was undertaken to reconcile this disparity. The benchmarking process developed weighted averages of all active sugar mills. The weights were relative to the operational parameter of a sugar mill, i.e., if a sugar mill had a larger scale of production (or output), the share of that mill in the total output of sugar would also be higher.

The benchmark values arrived at, and the analysis results were shared in a stakeholders' meeting conducted under the aegis of the Bihar State Pollution Control Board (BSPCB) in BSPCB headquarters in Patna. Representatives from sugar mills and various state departments were invited to the stakeholders' meeting, and the study results were presented.

At the same time, mill owners provided feedback on specific aspects of the study. The feedback was noted and incorporated into the present report.

Details of the analysis are presented in chapter 3.

3. GHG Inventory of Sugar Industry

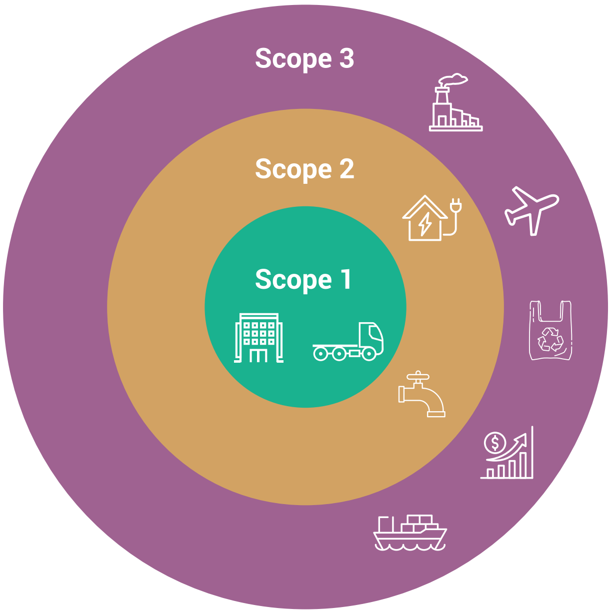
The overall context for conducting the GHG inventory of sugar production in Bihar was conducted in line with the guidance provided by the GHG Protocol, developed by the World Resources Institute[8]. The GHG Protocol has identified 3 broad areas where GHG emissions may be classified. These are termed Scope 1, Scope 2, and Scope 3 emissions.

The inventory of GHG emissions associated with sugar mills in Bihar has been evaluated under Scope 1, 2, and 3 emissions. Scope 1 emissions are defined as direct emissions released into the atmosphere as a direct result of a set of activities at a company or factory level. Scope 2 emissions are released in the atmosphere from the consumption of purchased electricity, steam, heat, and cooling. Finally, Scope 3 emissions are all indirect emissions, not included in Scope 2, but that occur in the value chain of the reporting company or sector, including both upstream and downstream emissions. **Figure 5** highlights an illustration of the emissions under each scope.

The subsequent sections discuss the sources of GHG emissions in a sugar mill, the approach for calculating them, and the results.

Figure 5: Illustration of Scope 1, Scope 2, and Scope 3 emissions

(Source: https://www.anthesisgroup.com/what-we-do/)



8 https://ghgprotocol.org/about-us

The diesel generators are used during outages of grid electricity to power

sugar mills

and offices.

3.1 GHG Emission Sources

Scope 1- Direct emissions: In sugar mills of Bihar, direct emissions are generated due to (1) the use of diesel fuel in generators and (2) fugitive emissions from the decomposition of organic waste. The diesel generators are used during outages of grid electricity to power sugar mills and offices. The sugar mills are located across the State and experience different levels of grid supply.

The sugar mills generate mainly two types of organic waste, potentially leading to methane emissions. Press mud is an organic waste stream that is generated from clarifiers in sugar mills. Mill owners generally send press mud to compost pits, following the Government of India's guidance. However, in some cases, it is often taken by farmers to be used as fertilizer in their fields. Press mud can generate methane emissions due to its partial decomposition in atmospheric conditions when it mixes with water or in other humid conditions, such as other organic waste.

Spent wash is another organic waste generated in a distillery when molasses is distilled to produce ethanol. Spent wash is generally processed through bio-methanation, evaporation-incineration, and other treatment forms stipulated by law so that no methane emission is generated. However, maintenance of such systems is vital to ensure that spent wash is not allowed to flow out, which contributes to GHG emissions when contaminated with acidic waste. The total fugitive methane emissions from spent wash are zero since sugar mills/ distillery is expected to treat the waste as per the stipulated law.

Other emissions that can be considered under Scope 1 include vehicular emissions from vehicles owned by the reporting organization, in this case, the sugar mills. However, during the survey, the team found the following:

- Companies' owned vehicles were limited to a single truck or pick-up vehicle, which is typically used to transport sugar or other materials (other than sugarcane) to and from the factory.
- In some cases, sugar mills engaged a vehicle for pick up and drop of staff, which was within a radius of 15 km from the factory (covering points such as railway stations and bus stations).
- It was found that in all such cases, total annual GHG emissions were negligible in comparison with the scale of emissions discussed in the model. As such, these emissions were not considered in our study.

Scope 2 - Indirect emissions (owned): The sugar sector primarily uses bagasse, a renewable energy source, so energy use from bagasse is zero emission. Electricity is purchased by sugar mills during the season (in case of special circumstances, such as electricity demand for the process during plant outages) and during the off-season when there is no in-house production.

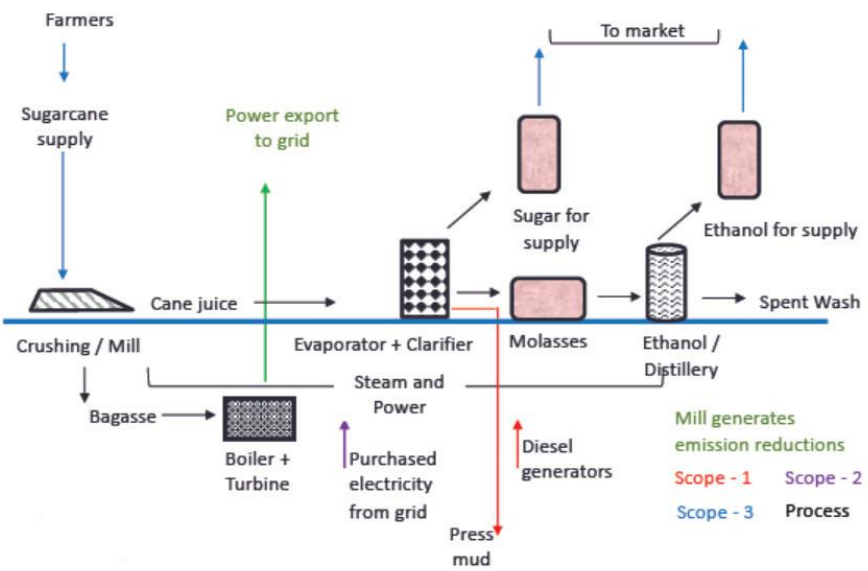
Importantly, as discussed in the previous section, the sugar mills export power to the state grid of Bihar. This power export is significant, and as it is generated from bagasse (a renewable energy source), it is classified as ***green power***. Overall, the net import of power by sugar mills is negligible compared to the net export of power produced by the mill (from bagasse). This is discussed later in **Section 4**.

Scope 3 - Indirect emissions (not owned): The Scope 3 emissions are limited to emissions from diesel use in the transportation of materials that include the following:

- Supply of sugarcane to mill.
- Transporting processed sugar for sale.
- Transporting processed ethanol for sale.
- Supply of materials such as Sulphur and lime to mill.
- Supply of maintenance chemicals.

The emissions due to diesel use in vehicular movements by vendors and employees have been ignored as these are random and negligible in terms of other emissions. Also, most employees reside in-campus or live nearby and often commute via bicycle or two-wheeler.

Figure 6: Presents the various processes in a sugar mill and sources of GHG emissions from a sugar mill in Bihar. This is further explained in section 3.2 on delineating the project boundary.



3.2 Project Boundary Conditions

For any assessment of GHG emissions, delineation of the project emissions boundary assumes key and strategic importance. This is done because upstream and downstream processes related to the project activity could also have positive and negative GHG emissions. For instance, a life cycle assessment of material GHG emissions could estimate emissions from cradle to grave for such a project as sugar.

For the purposes of this report, the approach that has been adopted is to measure emissions from the nearest source to the factory (sugar mill) gate and include emissions from the factory gate to the nearest destination. In addition, all emissions in the production process (also known as gate-to-gate, where the reception of inputs begins the process, which ends with the exit of the final product(s) from the unit). **Figure 6** illustrates the boundaries established for this project's emissions assessment.

3.3 Methodology for Estimating GHG Emissions

A benchmarking analysis was completed to determine the benchmark values (average values) for a sugar mill using the survey data. The benchmark values of the number of operational days, sugarcane used, sugar and ethanol produced, organic waste generated, electricity and diesel use, etc., have been calculated. Subsequently, these benchmark values have been used to estimate the Scope 1, 2, and 3 emissions for a sugar mill as discussed below and extrapolated to all operating mills in Bihar.

3.3.1 Scope 1 Emissions – Direct Emissions

GHG EMISSION DUE TO DIESEL USE IN GENERATORS.

The GHG emission due to diesel use in the D.G. set has been calculated considering the benchmark value of diesel-based electricity use in a sugar mill and the emission factor for diesel fuel combustion given by IPCC using the formula below.

GHG emissions from diesel use ion generators of a sugar mill

= Average diesel based electricity use * emission factor for diesel fuel combustion

METHANE EMISSIONS FROM THE DECOMPOSITION OF PRESS MUD

The methane emissions generated in the farmer's field have been estimated using the First Order Decay Model (below). The methane emissions were converted to equivalent CO_2 emissions considering the Global Warming Potential of methane. Based on the information collected from the site, it has been assumed that about 30% of press mud generated from a sugar mill is distributed to farmers.

$$= \varphi_y \cdot (1 - f_y) \cdot GWP_{CH4} \cdot (1 - OX) \cdot \frac{16}{12} \cdot F \cdot DOC_{f,y} \cdot MCF_y \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

Wj,x = Amount of solid waste type j disposed in the Solid Waste Disposal Site (SWDS) in the year x (t)

Φy = Model correction factor to account for model uncertainties for year y

Fy = Fraction of methane captured at the SWDS and flared, combusted, or used in another manner that prevents the emissions of methane to the atmosphere in year y

GWP (CH4) = Global Warming Potential of methane

O.X = Oxidation factor

F= Fraction of methane in the SWDS gas (volume fraction)

DOCf,y = Fraction of degradable organic carbon (DOC) that decomposes under the specific conditions occurring in the SWDS for year y

MCFy = Methane correction factor for year y

DOCj = Fraction of degradable organic carbon in the waste type j

Kj = Decay rate for the waste type j

Y = Year of the crediting period for which methane emissions are calculated

X = Years in the time period in which waste is disposed at the SWDS, extending from the first year in the time period (x = 1) to year y (x = y)

E = Known as Euler's number, approximately equal to 2.71828

3.3.2 Scope 2 Emissions – Purchased Electricity.

Using the benchmark electricity purchased data for a sugar mill in Bihar and the emission factor for grid electricity provided by the Central Electricity Authority (Government of India), the Scope 2 emissions have been estimated using the formula below.

Scope 2 emissions for a sugar mill

= Average electricity purchased by a sugar mill * emission factor for grid electricity

3.3.3 Scope 3 Emissions – Transportation

The sugarcane is usually transported to mills by bullock carts, tractors, and trucks from locations within a radius of up to 50 km. On the other hand, sugar and ethanol are transported by tractor or 12/14/16 wheel trucks to distributors. The emissions from diesel use in transportation have been estimated using the information on the type of vehicle used for transportation, the average distance travelled by each means of transport, and the emission factor of freight vehicles (provided below).

Table 1. Emission Factor of Freight Vehicles

Category as per GVW	Emission Factor (kg CO_2/km)
LDV (<3.5 T)	0.307
MDV (<12 T)	0.5928
HDV (> 12 T)	0.7375

The Scope 3 emissions have thus been estimated using the formula given below.

Scope 3 emissions for a sugar mill

= Average distance travelled by vehicle type (i) * emission factor for that type of vehicle

3.4 Results of GHG Inventory in Sugar Mills

Based on the above approach, the benchmark (average) values for a sugar mill in Bihar have been estimated and presented in Table 2 below. The sugar mill's operating cycle is roughly 100 days per year, which is lower than the national average. On average, a sugar mill produces around 10 metric tonnes of sugar by processing 100 metric tonnes of sugarcane annually. The amount of press mud generated is around 3.5% of the sugarcane processed annually.

Table 2: Benchmark values for a sugar mill

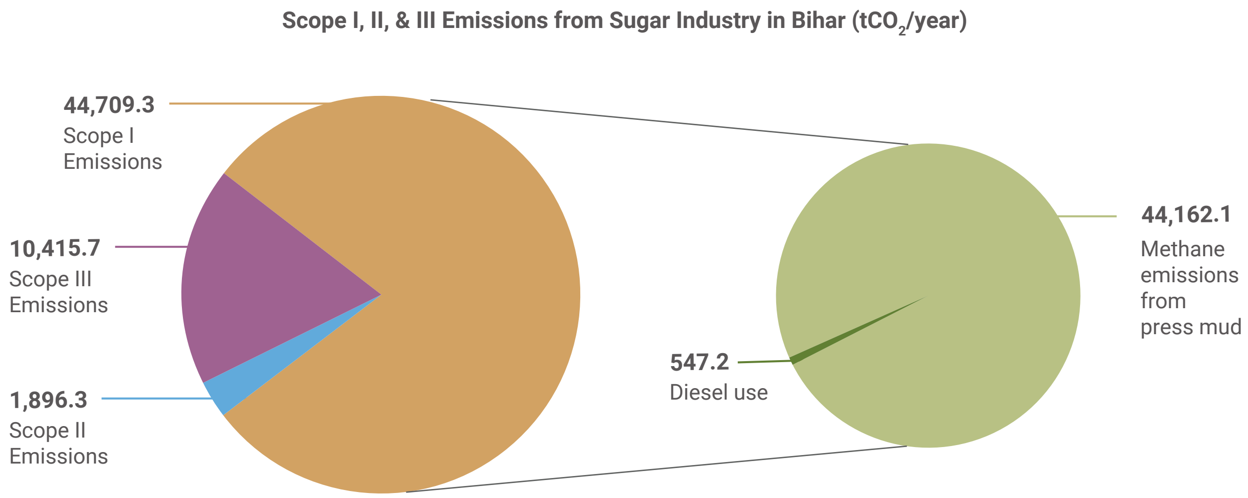
#	Parameter	Values
1.	Number of days of operation in a year	92
2.	Crushing capacity (tons of cane per day)	5,900
3.	Sugarcane used (metric tonnes)	6,90,938
4.	Sugar produced (metric tonnes)	66,527
5.	Ethanol produced (kilo liters)	13,330
6.	Ethanol production capacity (kilolitres per day)	74
7.	Press mud generated (tons)	23,843
8.	Diesel-based electricity used by sugar mill (kWh/year)	75,957
9.	Electricity purchased by sugar mill (kWh/ year)	2,56,940

Considering the benchmark values for fuel use, organic waste generation, and others, the scope 1, 2, and 3 emissions for a sugar mill and the total for all sugar mills in Bihar have been calculated based on the approach discussed above. The estimated values have been presented below in Table 3 and graphically represented in **Figure 7**.

Table 3: Estimated values of Scope 1, 2, and 3 emissions for sugar mills in Bihar

Category of GHG emission	GHG emissions - one sugar mill (tCO_2e/year)	No. of sugar mills	GHG Emission - all sugar mills (tCO_2e/year)
Diesel use	60.8	9	547.2
Emissions from press mud	4,906.9		44,162.1
Scope I Emissions	4,967.7		44,709.3
Scope II Emissions	210.7		1,896.3
Scope III Emissions	1,157.3		10,415.7
Total GHG emissions			**57,021.3**

Figure 7: Scope 1, 2, and 3 emissions for sugar mills in Bihar



4. Approaching Net Zero and Beyond

4.1 Current GHG Emissions from the Sugar Sector in Bihar

The previous section has established that the total GHG emissions from sugar mills in Bihar are 57,021 tons of CO_2 equivalent annually, as determined for 2021-2022.

However, as discussed under Scope 2 emissions in section 3, a considerable amount of electricity is exported from the sugar mills and fed into the state grid of Bihar. As this electricity is generated from bagasse, it is a renewable source of electricity, which is a zero-emission source.

Incidentally, there are emission reductions generated from ethanol production, produced from sugar mills in Bihar (and elsewhere). However, GHG emission reductions from ethanol production are classified under the GHG inventory of distilleries and not considered under the sugar sector, which primarily concerns the production of sugar and allied products such as jaggery, treacle, and so on.

The sugar mills can offset their GHG emissions by exporting this green power, as shown in **Table 4** below.

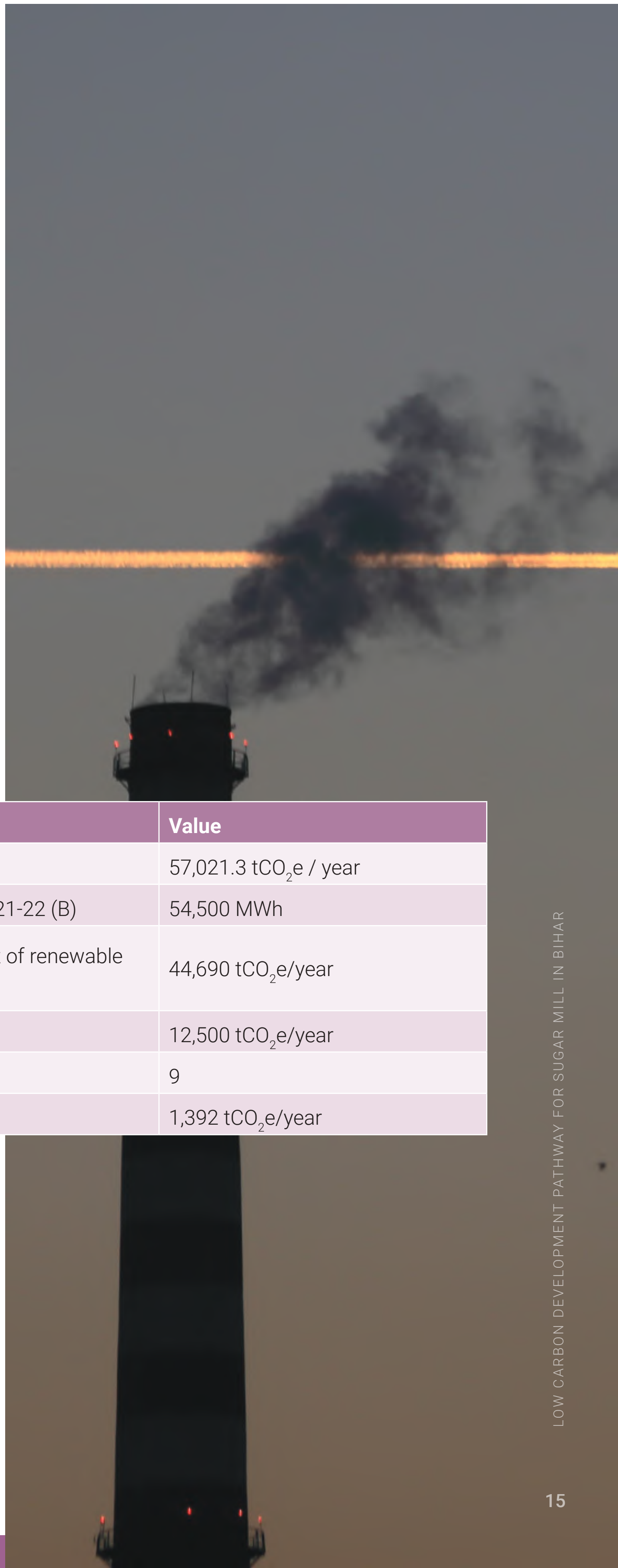


Table 4: Offsetting GHG emissions by export of green power to grid by sugar sector in Bihar

Category	Value
Total GHG emissions from all sugar mills (A)	57,021.3 tCO_2e / year
Electricity generated from bagasse that is exported to the grid in 2021-22 (B)	54,500 MWh
GHG emissions avoided by the sugar sector in Bihar from the export of renewable electricity (C)	44,690 tCO_2e/year
Net estimated GHG emissions from the sugar sector (A – C)	12,500 tCO_2e/year
Number of sugar-producing units	9
Per unit emissions from sugar sector in Bihar	1,392 tCO_2e/year

It is important to note that by virtue of the sale of green power to the grid, the sugar sector in Bihar is almost a net zero sector. However, there are further upcoming opportunities for the sugar sector in Bihar that can further propel the sector to becoming a *green leader* in the State and be a flagship industry in terms of green initiatives. These opportunities will be further explored in the following subsections.

4.2 Growth Projections for the Sugar Sector in Bihar

Projections for the growth of the sugar industry in Bihar are based on favourable factors for the growth of the sugar industry in India. However, given lower capacity utilization levels in the sugar sector in Bihar, enabling actions would be required to bring it up to speed with the growth scenario that applies to the rest of the country. These aspects are discussed below.

FUTURE OUTLOOK FOR THE SUGAR SECTOR

Looking forward, the OECD-FAO Agricultural outlook predicts global sugar demand to rise from around 85 million metric tons as of 2018-19 (before the Covid pandemic) to around 110 million metric tons by 2030[9], led by demand mostly from developing countries: developed countries' demand is expected to remain flat.

The following trends also look likely to emerge, especially among large sugar-producing countries like India and Brazil:

- Demand for sugar will be sustained, as mentioned above, with demand still rising in parts of Africa and Latin America, where living standards are projected to rise over the next few decades.
- Brazil (~ 21%) and India (~ 18%) together meet about 40% of global demand. However, sugar production is expected to stagnate, as the OECD FAO report quoted above indicates.
- A significant global development that has gained momentum in the wake of the emergent climate crisis is the demand for ethanol and Extra-Neutral Alcohol (ENA). Ethanol demand has propelled the sugar sector worldwide to ramp production and set up distilleries to produce ethanol and ENA. This has led to some diversion of cane juice (cane syrup) for additional ethanol production, substituting for sugar production, in addition to molasses that is used as primary raw material for ethanol / ENA production.
- Further, demand is rising for sugar alternatives such as brown (unrefined) sugar, cane sugar, treacle, jaggery, and other sugarcane-based products that have positive health properties with less sugar content. For instance, the demand for jaggery is growing at 2% annually, which is much higher than the demand rise for ordinary sugar[10].
- Finally, global trends also indicate that efforts are being made to enhance efficiencies in sugarcane production (farming), sugar, and by-product processing. These include improvements in agronomy and water use in cane production and better automation and control systems in cane procurement, processing, and juice extraction.
- Thus, one expects the sugar sector to increase sugar recovery from cane and for farmers to produce more sugarcane per hectare of plantation.
- In India, states such as Uttar Pradesh have a total of 2.86 million hectares under sugarcane cultivation, with an overall productivity of 83.9 quintals of cane per year. At the same time, Bihar has about 0.34 million hectares, with an overall productivity of only around 53.0 quintals of cane per hectare. With almost similar geographic and climatic conditions, Bihar has around 36% lower productivity. In addition, as the paper has shown, the mill cycle for sugar mills in Bihar is around 100 days, while for U.P., it is between 150 and 180 days for most mills.

Stakeholders' Consultation held at BSPCB, Patna

9 https://www.oecd-ilibrary.org/sites/969526b0-en/index.html?itemId=/content/component/969526b0-en

10 https://agriexchange.apeda.gov.in/Weekly_eReport/Jaggery_Report.pdf

PROJECTIONS FOR THE SUGAR SECTOR IN BIHAR

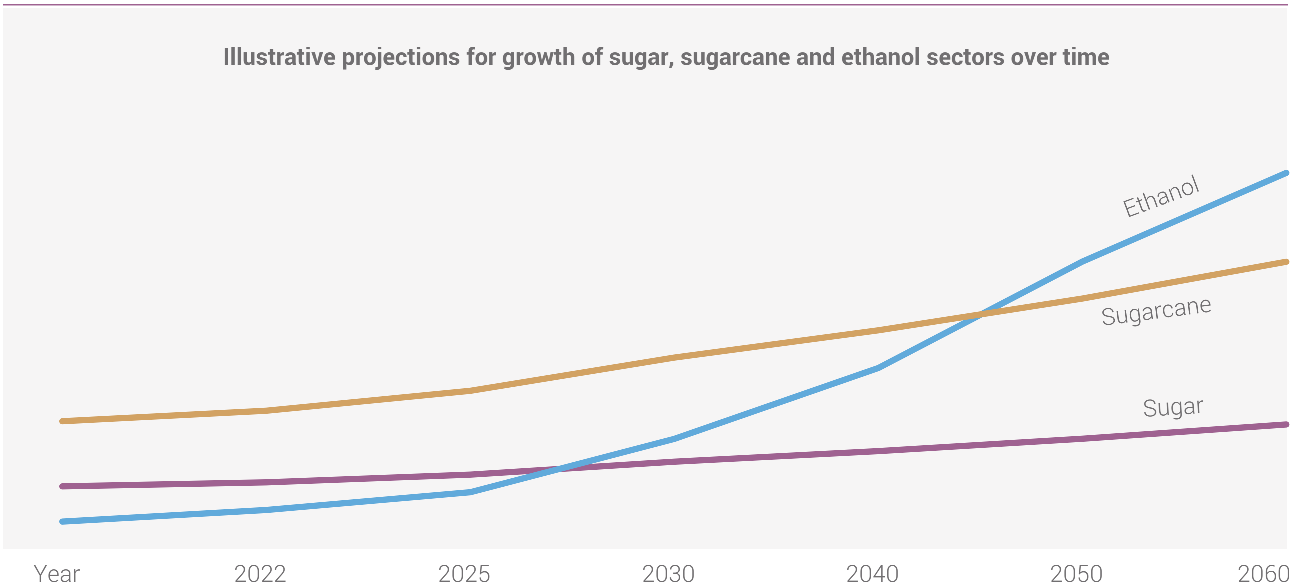
Given the above factors, growth for the sugar sector in Bihar needs to address both cane production and processing on one hand and sugar mill efficiency on the other. This means:

a. Improvement in milling cycle: Regarding sugarcane production, the drive to increase the sugar production cycle in Bihar from around 100 days to, say, a 150-day mill cycle is a key step. This would require an assured supply of cane to enable mills to increase the milling cycle and produce more sugar, jaggery, ethanol, and other by-products.

b. Optimizing production efficiencies in the sugar cycle to enhance sugar realization from a given quantity of cane.

Considering the above, one expects the sugar sector in Bihar to increase its operations by stretching the milling cycle in a graduated manner to around 140 – 160 days over time to meet the rising demand for sugar and by-products. At the same time, more output per ton of cane input will raise the overall quantity produced, whether of sugar, ethanol, or other by-products. While the results could be felt in the medium to long term (as discussed below), the net impact could be a rise of 50% in sugar production from current levels.

Figure 8: Illustrative projections for trajectories of growth of sugar, sugarcane and ethanol sectors in Bihar till 2070.



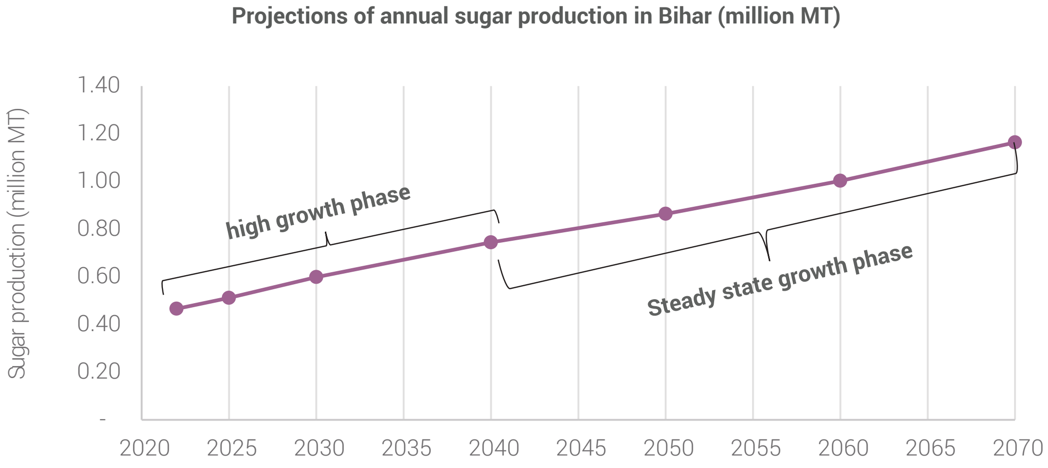
As discussed above, the future trajectory of this sector, as already being witnessed, is a gradual diversion in production, with more emphasis on by-products such as ethanol and alcohol, as well as diversification into other sugar substitutes and by-products. Of these, the market opportunity presented by ethanol demand could support the sugar industry in Bihar significantly, as is currently being witnessed. Expected trajectories of movement of demand for sugarcane, processed sugar, and ethanol are shown in **Figure 8**.

Combining the above, projections for the growth of the sugar sector in Bihar are estimated to follow the trajectory of India's recent growth in the sugar sector. It is seen that over 21 years, between 2000 and 2021, Indian sugar production grew at a compounded rate (CAGR) of 3.2% per annum, rising from 18.51 MMT in 2000 to 35.8 MMT in 2021. While this growth rate is expected to continue in the short run, the Indian Council of Agriculture Research predicts in their Vision 2050[11] document for the sugar sector that long-term growth in India would be around the 1.5% per annum mark.

Considering a similar growth rate for Bihar, one arrives at a scenario for the State, whose sugar production is similarly projected to rise at a CAGR of 3.2% till 2040. This can be termed as the high growth phase. Post 2040, the sector is expected to move gradually to a more steady-state growth trajectory of 1.5% per annum (CAGR) in the long run till 2070. The estimated projections are graphically illustrated in **Figure 9** below.

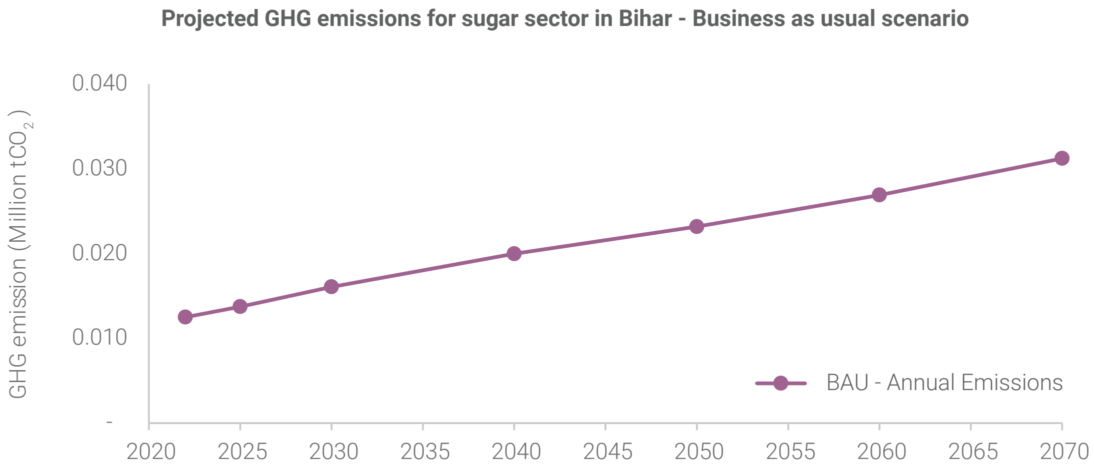
11 https://icar.org.in/files/ICAR-SBIVision2050-FinalDir-SBI.pdf

Figure 9: Projected sugar production in Bihar, scenario 2070



Along with the projected sugar output values, GHG emissions identified in this report are also mapped in **Figure 10**.

Figure 10: Projected GHG emissions for buainess as usual scenario for sugar sector in Bihar



As one can observe, emissions in the baseline (business as usual) scenario are expected to rise from 12,500 tons CO_2e/year as of the present date to around 31,200 tCO_2e/year in the year 2070.

With the projections as indicated in **Figure 9**, the following section analyses actions that could be adopted by sugar mills in the short, medium, and long terms to reduce GHG emissions and/or create additional options for the generation of green power.

4.3 Low Emissions trajectory for the Sugar Sector – Scenario 2070

This section analyses the future scenario of the sugar sector in Bihar. The analysis is done keeping 2070 in mind, which is consistent with the Government of India's target date for achieving ***net zero*** GHG emissions as set initially at the Glasgow Climate Conference (2021).

As is evident from 4.1 and 4.2 above, sugar production in Bihar not only has the potential to emerge as a net zero activity, but it also has the potential to generate net GHG emission reductions to offset emissions of other carbon-intensive industries in Bihar.

The following sections outline short-, medium-, and long-term interventions for the sugar sector in Bihar to move to a lower trajectory of GHG emissions.

4.3.1 Actions: Short term: Present - 2025

ENHANCING RESOURCE EFFICIENCY

A key enabler would be to implement Sugarcane Information Systems (SIS) in the same manner as it has been implemented in other states, such as Uttar Pradesh. The SIS was developed under the aegis of the Sugarcane Commissioner, Uttar Pradesh, and was analyzed by the Indian Institute of Sugarcane Research (IISR). The SIS focuses on eliminating the time lag between harvested cane and its reaching sugar mills through an interactive online platform.

Briefly summarised, the platform would ensure that online transactions take place between farmers and mills so that three major hurdles are overcome:

a. Cane reaches fresh to the mills, containing more moisture, leading to a higher realization of juice (syrup). It is estimated that a transit delay of 12 hours reduces recovery by 0.10%, translating to INR 1932 million (about 193.2 crores) loss in UP[12] alone. For Bihar, the potential could be higher in terms of higher juice recovery from cane, as cane procurement processes in Bihar are yet to be streamlined as in UP and Maharashtra. This step could, if and as applied in Bihar, increase juice recovery by 0.25% - 0.50% without any additional investments other than software installation.
b. This also leads to better capacity utilization of sugar mills and associated works such as ethanol production.
c. Replacing the manual, weigh, and certify system at cane purchase centers with an automated, I.T.-enabled procurement process.
d. Incidentally, the SIS is a self-sustaining model that uses a fee-based system to generate its revenues.

One expects implementing a similar, I.T.-enabled information system for the sugar sector in Bihar with immediate effect. The model could be implementable from the 2024 – 25 sugar-crushing season.

It is pertinent to note that while SIS will have a positive economic impact on the overall viability of the sector, there is no direct impact on gross GHG emissions from the sector. However, indirect effects would be felt on GHG emissions through higher ethanol production and a marginal increase in clean power production (due to higher cane input).

4.3.2 Actions: Medium term: 2025 - 2040

RESOURCE RECOVERY PHASE

In the medium term, two areas of improvement for sugar mills are in the recovery of by-products, namely, press mud and spent wash. These aspects have been introduced in earlier chapters, and this section focuses on how best to recover these resources in context.

Press Mud: Analysis has shown that the press mud recovered from the juice clarification process has sufficient methane content that can be profitably recovered. Roughly around 100 – 110 cubic meters of biogas can be generated from a ton of press mud.

Mixing the press mud with cow dung, spent wash, and other materials (rich in methane potential) in an anaerobic digester further enhances yield and reduces hydraulic retention time in the digester. A typical sugar mill with 20,000 metric tonnes of press mud can generate 2.2 million cubic meters of biogas annually.

Spent wash: Distillery spent wash is a liquid effluent with high levels of toxicity as well as a foul odour. High levels of Biological Oxygen Demand (BOD; between 45,000 – 70,000 mg/litre) and Chemical Oxygen Demand (COD; between 80,000 – 160,000 mg/litre) along with a pH value between 3.7 and 4.2, indicating an acidic nature, as indicated in a Central Pollution Control Board report[13].

Methane recovery from spent wash is an option that allows the unit to recover energy, avoid GHG emissions, and generate Fermented Organic Manure (FOM) as a saleable by-product, which could go back to ***contract farmers*** to support organically grown sugarcane. Roughly 2-3 cubic metres of biogas can be generated from one cubic meter of spent wash.

12 Report on SIS, published by Indian Institute of Sugarcane Research, Lucknow
13 https://cpcb.nic.in/ngrba/charter_distillery.pdf

From the above two possibilities, the biogas that is generated can be processed in the following ways:

a. **Enhanced generation of green electricity**. The sugar mills already sell green power to the grid, and the biogas can be fed into a generator and power generated for sale to the state grid. Typically, from a single cubic meter of biogas, around 2 – 2.2 kWh of power can be generated[14];

b. **Production of bio CNG**. There is strong demand in Bihar, as in the rest of the country, for ***green or bio CNG,*** a zero-emission fuel, to replace solid and liquid fuels. The quantity of CBG produced is explained with an example in the **Table 5** below.

It is pertinent to keep in mind that each of the above options would result in a) avoidance of any methane emissions in the baseline scenario, and therefore, the sector would be net-zero anyway, just from processing its press mud and spent wash. The prospect of using press mud and distillery spent wash is analyzed in detail below.

In the short and medium term, a significant opportunity is presented in the form of the Sustainable Alternatives Towards Affordable Transportation or SATAT scheme, launched by the Ministry of Petroleum and Natural Gas (MoPNG), Government of India[15]. SATAT seeks to develop and support compressed biogas (CBG) that can be generated from agricultural residues, municipal solid waste, and other organic waste streams, including press mud and spent wash from sugar mills. CBG projects attract subsidies on capital costs and other forms of support and incentives.

Through SATAT, sugar mill owners in Bihar can invest in their press mud and spent wash to generate biogas, which could be compressed and sold as bottled gas or injected into the national gas grid operated by ONGC and/or GAIL.

The investment has the following clear advantages:

- First, using existing by-products, such as press mud for biogas recovery, leads to methane avoidance and further reduced GHG emissions. This will lower GHG emissions arising out of press mud, thus rendering sugar mills a ***carbon-negative*** sector – with positive GHG offsets.
- Further, through bio methanation route, enhance the sale of power to the grid and/or sale of compressed biogas. This will generate a stream of green energy, which can be accounted for in favor of the mills.
- There are at least five instances of projects in India using press mud and spent wash for bio-methanation that have received support under SATAT[16]. These projects can be used as a test case for sugar mills in Bihar.

Importantly, the Bihar government has approved the Bihar Biofuel Production Promotion Policy 2023, which also extends capital subsidy for CBG producers in addition to benefits announced under the SATAT Scheme[17].

The DA team conducting on-site survey at a Sugar Mill in Bihar.

14 https://www.aqper.com/en/how-much-energy-is-there-in-biogas#:~:text=Each%20cubic%20meter%20of%20biogas,and%20applied%20to%20other%20uses.
15 https://satat.co.in/satat/technology.html
16 Some examples are provided here: https://satat.co.in/satat/commissioned-plants.html
17 http://www.indiaenvironmentportal.org.in/content/475399/bihar-biofuels-production-promotion-policy-2023/

To consider an example, seven sugar mills in Bihar have set up ethanol manufacturing units. These range from 60 kilo litres per day to 120 kilo litres per day (KLPD). Considering an average of 100 KLPD, the details for biogas recovery from spent wash alone are as follows:

	Parameter	Value	Comment
1	Ethanol production capacity	100 KLPD	Average
2	Biogas potential	38,000 CuM	
3	Compressed biogas output	15 tons per day	
4	Annual operation	330 days	Same as ethanol cycle
5	GHG emission reductions from sale of CNG / electricity (CH4 emissions not considered)	3,000 tCO_2e	Average

Table 5 shows that around 15 tons of CBG is possible from a 100 KLPD ethanol unit.

Estimation is provided for spent wash to biogas to CBG yield – the yield will rise with addition of press mud with the spent wash.

Thus, with the approved Biofuel Production Promotion Policy (2023) and taking full use of the SATAT scheme, Bihar can be expected to harness the full benefit of the potential for resource recovery from press mud and spent wash and conversion to compressed biogas.

4.3.3 Actions: Long term: 2040 – 2070

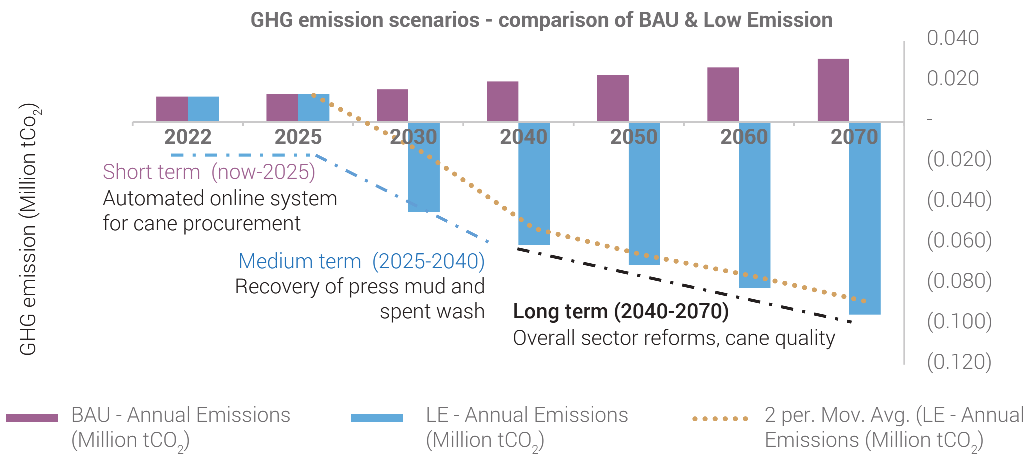
SOLUTIONS FOR LONG-RUN SUSTAINABILITY FOR THE SUGAR SECTOR

In the long run, sugar mills are expected to work closely with sugarcane growers (farmers) to ensure more lasting and long-term solutions for the sector. Some of these solutions include:

- Use of drip irrigation for sugar production: sugarcane plantations work with flood irrigation techniques, which are largely monsoon-dependent in the context of Bihar. Replacing flood irrigation with drip irrigation using modern irrigation techniques[18] can optimize production while reducing the demand for water and dependence on monsoons.
- Increase area under sugar cultivation; and
- Develop healthier varieties of sugarcane. Traditionally, cane varieties had higher diameters at the base and more juice content per unit weight. Some of these varieties need to be recovered.

At the same time, better engagement of the sugar mills with farmer communities, improved soil and irrigation techniques, and better incentive structures would also lead to a rise in the area under sugarcane plantations in Bihar, thereby giving more cane to sugar mills.

Figure 11: Business as usual and low emission GHG scenarios for sugar sector in Bihar - Projections till 2070



18 https://agritech.tnau.ac.in/agriculture/agri_irrigationmgt_sugarcane.html

These steps shall reduce water use in sugar production, which is widely recognized as a major constraint. On the other hand, such measures shall enhance the sustainable growth of cane.

Considering the above, we arrive at projected GHG emissions, which are a result of short-term and long-term actions adopted, as discussed above. The low emissions scenario is projected along with the business-as-usual scenario **Figure 10** to show the impact of the emission reduction measures mentioned. The trend of the emission reductions is depicted as the dotted line.

From the figure above, while in the B-A-U scenario, GHG emissions are around 30,000 tons of CO_2 per annum, the use of press mud and spent wash for resource recovery makes the sugar sector in Bihar carbon negative. Thus, the sugar sector in Bihar can achieve the rare distinction of reversing its status as a net emitter to a net contributor to Bihar's overall efforts to become net zero.

Under a dynamic carbon market in India (which is being designed for India as of the present date), the sugar sector can be a net exporter of GHGs over time. As a result, by 2070, the sector would have avoided as much as 95,000 tons of CO_2 equivalent per annum.

This is a conservative estimate without considering any downstream benefits on GHG emission reduction from enhanced power generation from the sugar cycle. Moreover, from the recovery of biogas, there could be more GHG emission reductions if the resultant biogas could be compressed as CBG and, taking advantage of the SATAT scheme, could be used to replace liquid fuels (petrol/diesel) or natural gas in transportation.

The overall savings of nearly 100,000 tons of CO_2e of GHG emission reductions per annum can be further enhanced by replacing fossil fuels with CBG produced by the sugar sector in Bihar.

From an impact perspective, the savings generated by the sugar sector can contribute to Bihar's overall targets for net zero. They can also be utilized to offset other, more hard-to-abate sectors, such as cement and steel in the State, or other necessary emissions, such as from paddy harvesting (which contributes to GHG emissions from methane generation).

4.4 Enabling actions to Support transition to a Low Emissions Scenario in Bihar.

The sugar sector in Bihar has tremendous potential, especially considering the Government of India's SATAT scheme, to achieve carbon neutrality and net zero targets and contribute to lowering Bihar's net GHG position.

To summarise, the following key steps are suggested to create an enabling environment for the sugar industry in Bihar to thrive.

4.4.1 Policy

The Indian states of Uttar Pradesh (UP) and Maharashtra have emerged in pole positions as far as the Indian sugar industry is concerned. As a neighbouring state with similar climatic characteristics, it is worthwhile to briefly look at the reasons for success in UP's sugar sector. These are outlined below:

Almost two decades ago, the Sugar Promotion Policy (2004) in the State of Uttar Pradesh introduced a slew of incentives, including but not limited to a 10% capital subsidy on investment made by the mill and reimbursement of transport cost of sugar for a distance up to 600 km from the UP border. There were other benefits issued to growers as well. These measures reinvigorated the sector and ushered in fresh waves of investments, and today, UP is India's leading State on sugar production[19]. The state government also imposed an export tax on ethanol to divert ethanol movement for state transport (2017). In addition, the UP government also ensured minimum price support for cane growers in the State, providing incentives for farmers[20].

In addition, to increase sugarcane production, price support incentives need to be provided to cane growers (farmers) so they are encouraged to put more land into sugarcane plantations. The current procurement rates, as determined by the Fair

19 https://www.epw.in/journal/2007/39/review-industry-and-management-review-issues-specials/sugar-industry-uttar-pradesh

20 https://timesofindia.indiatimes.com/city/lucknow/uttar-pradesh-keeps-state-advisory-price-for-cane-unchanged/articleshow/98107755.cms?from=mdr

and Remunerative Price (FRP) process of the Commission for Agricultural Costs and Prices[21], are around INR 300 per quintal (one quintal is 100 kg). The government of Bihar has recently raised support prices for all varieties of cane, with the best variety attracting a price of INR 335 per quintal[22].

Finally, as mentioned in section 4.3 above, the I.T.-enabled Sugarcane Information Systems (SIS) set up in UP can be replicated in Bihar with immediate effect. This will create an additional recovery of 1% in the sugar cycle (estimated) and improve the viability of sugar mills in the State.

The government of Bihar's Biofuel Production Promotion Policy (enacted July 2023, discussed above) is a welcome step in the direction of resource recovery and methane avoidance in the sector. It is expected to contribute to the overall sustainability of the sugar sector in Bihar.

As a result, by 2070, the sector would have avoided as much as **95,000** tons of CO_2 equivalent per annum.

4.4.2 Technology and Markets

TECHNOLOGY UPGRADATION AND MODERN PRACTICES IN BIHAR'S SUGAR SECTOR

Bihar's sugar industry stands at a pivotal point where the adoption of modern technology can significantly transform its efficiency and yield. Both the sugar mills and the sugarcane farmers play a crucial role in this transformation.

Sugar Mills: Even though many sugar mills in Bihar have incorporated high-pressure boilers to optimize their operations, there's ample room for further technological enhancement. Upgrading to superior crushing and processing technologies can lead to increased sugar recovery rates, translating to better financial returns for the mills. Such improvements not only enhance the quality of the produced sugar but also ensure a more sustainable and eco-friendly processing approach.

Sugarcane Farmers: The potential for improvement extends to the fields where the sugarcane is grown. Farmers can be motivated to invest in superior cane varieties. These varieties often have higher sugar content, are more resistant to pests and diseases, and can thus attract higher purchase prices from the mills. This would provide a dual benefit: increased earnings for the farmers and better raw material for the mills.

Another transformative approach lies in irrigation methods. Traditional flood irrigation practices for sugarcane are both water-intensive and less efficient. Encouraging farmers to adopt drip irrigation can substantially increase water use efficiency. This method ensures that water reaches the plant's roots directly, reducing wastage and enhancing sugarcane yield. Moreover, in the face of global climate change, drip

21 https://dfpd.gov.in/gen_policy.htm
22 https://www.livemint.com/news/india/bihar-govt-hikes-sugarcane-purchase-prices-for-all-varieties-details-here-11639843040628.html

irrigation emerges as a vital practice to make sugarcane cultivation more climate resilient. Reduced water usage and better resilience against erratic rainfall patterns ensure the sustainability of sugarcane production.

In conclusion, the synergy between technological advancements in sugar mills and modern agricultural practices adopted by sugarcane farmers can revolutionize Bihar's sugar sector. It's a shared journey towards profitability, sustainability, and resilience.

4.4.3 Finance

The sugar sector in Bihar is also cash-strapped in investing in low emission options. As brought out by sugar mills during stakeholder consultations, mill owners in Bihar are hamstrung by a lack of investible capital due to the low profitability of the sugar industry. Access to concessional finance will allow sugar mills to go for technology upgradation and diversification into waste recovery and bio CNG production.

In terms of financial support to be extended, the model for Uttar Pradesh may be replicated – as part of the afore-mentioned Sugar Promotion Policy, a 10% capital subsidy was extended for investments made by sugar mills. In the case of Bihar, such a scheme, complemented by access to low-interest debt access, will rejuvenate existing and may even resuscitate non-operational mills in the State. An indicative allocation for such investment in the sugar sector in Bihar can be capped at INR 2,000 crore (considering the allocation of similar schemes in other states).

Of late, the opening of the ethanol market and the ensuing demand from oil marketing companies (OMCs) have been transformative for some of the sugar mills, who can, therefore, realize better returns. Further, sugar prices have also improved. It remains to be seen whether this upturn can sustain the sugar sector in Bihar and generate higher economic returns across the value chain.

At the same time, mill owners need to be incentivized to invest in resource recovery and improve overall recovery from cane.

Higher power export to the grid would also generate cash flows, and the promise of higher offtake of ethanol by OMCs improves the mills' profitability. The State's policy on biofuel promotion has the potential to unlock financial resources for the sugar sector.

Finally, as a low GHG intensity sector, the sugar industry in Bihar stands to gain from the newly announced green credit scheme[23] and the impending domestic carbon offset regime[24], both recently announced by the Indian government. While the actual programmatic details would be revealed over time, the opportunity exists for the Bihar sugar industry to monetize green actions.

23 https://bfsi.economictimes.indiatimes.com/news/policy/green-credit-programme-who-will-be-benefitted-what-activities-it-comprises/101362371

24 https://www.business-standard.com/finance/news/india-set-to-announce-compliance-details-of-carbon-trading-market-in-june-123051200352_1.html

STAKEHOLDER COLLABORATION IN BIHAR'S SUGAR SECTOR

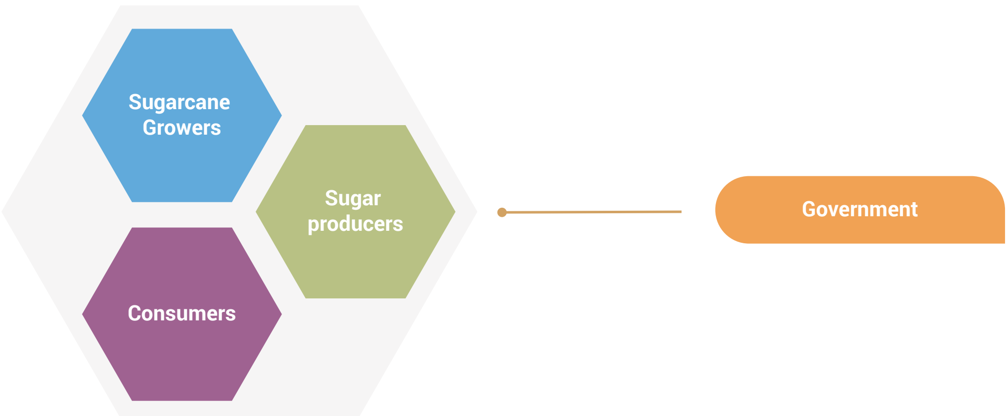
Bihar's sugar industry is a complex web of interdependent stakeholders, each playing a critical role in ensuring the sustainability and growth of the sector. Among the key players are the sugarcane farmers, who cultivate the primary raw material, the sugar mills that process it, and the consumers who are the end-users of the final product.

For the sugar sector in Bihar to flourish, it's crucial that these primary stakeholders not only coexist but actively collaborate. Sugarcane farmers, being at the base of the value chain, require adequate support in terms of access to modern farming techniques, fair pricing, and timely payments. Their well-being and productivity directly affect sugar mills, which rely on a steady supply of sugarcane to operate efficiently. An optimized operation in mills ensures that consumers receive a quality product at a reasonable price.

However, this collaboration often faces challenges due to disparate interests, lack of communication, and sometimes, systemic inefficiencies. This is where the role of the Government of Bihar becomes paramount. The government can act as a mediator and facilitator, creating policies that foster mutual trust and benefit among the stakeholders. By establishing clear regulations, offering incentives for sustainable practices, and promoting transparent communication channels, the government can ensure that all parties work towards a common goal.

In essence, for the sugar sector in Bihar to reach its full potential, a harmonious and concerted effort from farmers, mills, and consumers is necessary. The Government of Bihar has the opportunity and responsibility to foster such an enabling environment.

Figure 12: Stakeholder engagement in the sugar industry



5. Conclusion

As discussed over the previous two sections, the sugar sector in Bihar currently stands in a strategic position, both from a GHG emissions scenario and an overall sector viability point of view.

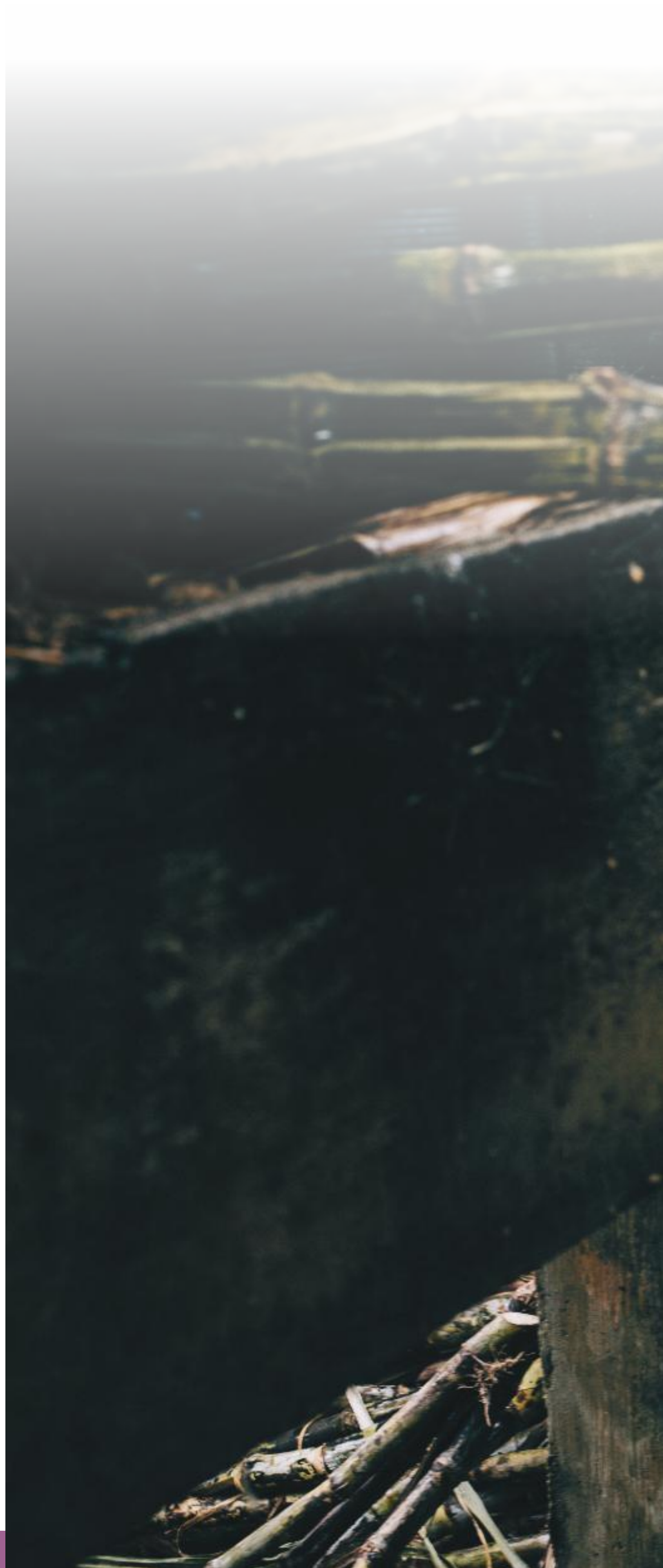
As of present, GHG emissions per mill are around 1,392 tons CO_2e per annum (about 1,400 tCO_2e per annum as of 2021-22), which can be mitigated through investment in green energy and from higher exports of bagasse-based green power to the grid.

From a viability point of view, the sugar mills are gradually recovering from their hitherto weaker sugar markets to a more vibrant sugar market coupled with higher prices for ethanol and other by-products. This demand cycle is expected to continue for some time, as discussed in Chapter 4. In the long run, though (as discussed in the 2070 scenario), the refined white sugar market is expected to stabilize. Analysts expect to see diversification of demand by-products for jaggery, brown (cane) sugar, and molasses/treacle, which carry higher nutritional values. Demand for jaggery has increased sharply over the past few years.

Ethanol, where India looks forward to a 20% fuel blend target, has been an area where sugar companies have recovered costs and improved their net position.

As vitally pointed out in Section 4, the sugar sector can leapfrog from a net emitter position to a net zero or even net positive situation in the future if they can process the press mud without letting it decompose in open fields and then sequentially process the press mud and spent wash (for molasses/juice-based distillery units) in the manner outlined in Section 4. This will enable sugar mills to capture methane (in the form of biogas) that can be converted into electricity or sold as bio CNG or compressed biogas (CBG), thereby generating more GHG emission reductions and meet the high demand for natural gas as India seeks to replace its petroleum import bill with locally produced Bio CNG. The MoPNG's SATAT scheme is a push in this direction. Finally, more fruitful engagement between mill owners and farmers growing cane and streamlining the procurement of cane using an online, automated system shall help reduce losses and augment production.

Considering the impacts of such short-, medium-, and long-term measures, the study has estimated that Bihar's sugar sector can create net GHG avoidance of nearly 100,000 tonnes annually. Implementing additional downstream actions, such as generating Compressed Biogas (CBG) and using it as a substitute for fossil fuels in transportation, can contribute to even more significant GHG emission reductions. Such actions



can self-monetize through the sale of carbon offsets in India's upcoming carbon trading regime or through the Green Credit scheme.

However, sugar mills in Bihar need to invest in technologies to harness benefits from both green energy and diversification in production. As discussed, the sugar industry in Bihar has struggled of late due to a sluggish supply of cane, weak contractual arrangements with farmers, and weak sugar markets over the past decade. This has reduced the operating cycle and shortened the crushing season. The government of Bihar has introduced increased purchase prices of cane and a policy on Biofuels (discussed in Ch-4), which could incentivize the sector. However, a few more areas need the attention of public and private sector stakeholders, outlined in Section 4.4.

The sector in Bihar requires support from accommodating policies and access to finance. These enablers can ensure that Bihar's sugar industry is able to capitalize on the opportunity to convert their waste into green wealth and become a net exporter of GHG emission reductions in Bihar in the times to come.

Annexure 1: Questionnaire

District/Block:	Village:
Name of Sugar Mill:	Date:
Name of Respondent:	Name of Sugar Mill owner:
Contact No.:	Name of surveyor:

General	
Type of Sugar Mill [What kind of products are produced]	
Number of days that mill is operational	
Batch size [tons of sugar per milling cycle]	
Annual production[tons]	
Process Description	
What is the total quantity of press mud that is generated at site per year	
What is the total production of ethanol per year	
Production capacity of ethanol in the plant	
What is the raw material used for production of ethanol	
What is the total quantity of solid waste (sediment) from ethanol production per year	
What is the total production of spent wash at the ethanol unit per year	
From the sugar mill in total, what is the quantity of solid waste that is sent for composting per year	
What is the quantity of ash that is dumped in the ash pond every year	

Scope 1: Direct Emissions ***Includes all fuels burned directly as part of activities at the mill level, including transportation by a vehicle owned by the sugar mill***	
What are the fuels are used inside the mill?	
What is the quantity of fuels used per batch/ per ton of sugar processed?	
Where is the fuel coming from?	
How fuel is transported?	
Is there any diesel generator at site?	
If yes, what is the capacity of dg sets?	
What are the hours of operation of D.G. sets [monthly]?	

Scope 2: GHG Emissions from purchased energy	
Quantity of electricity purchased for mil operations annually (*Monthly electricity bill copy needed)*	
Is there any other energy product purchased? [Such as steam, cooling, dryer etc]	
Is there any electric vehicle?	

Scope 3 Emissions	
What is the process of supply of sugarcane to the sugar mill?	
How much cane is transported per trip via tractor?	
What are the activities for which mechanized and outsourced transport is used?	
How much is the average round trip distance for each? [in km]	
What is the quantity of sugar dispatched per trip?	
[Does it require trucks, if yes, what is the average distance	
How many trips are required per month?	
Vehicle for transporting materials [Write below for more entries, specify each type of movement]	
Movement of sugar per year	
Distance travelled by trucks / tankers for supply of Sugar from Vishnu Sugar Mill	
What is the average distance travelled per vehicle?	
Is there any warehouse/ godown?	

Annexure 2: Site Data

Name of sugar mill	Number of days that mill is operational	Crushing capacity [Tons per day]	Annual quantity of sugarcane used [Tons]	Annual production of sugar [Tons]	Annual production of press mud [Tons]	Annual electricity purchased [kWh]	Production capacity of ethanol per [K.L. per day]	Annual production of ethanol [Litres]	Annual production of spent wash [Cubic Meter]
Unit 1	75	4,000	2,84,050	29,900	11,439	-	75	1,66,44,242	1,07,664
Unit 2	110	11,500	12,65,000	1,23,156	59,500	-	120	2,50,13,000	1,65,687
Unit 3	91	5,350	4,86,851	57,523	17,040	7,31,530	-	-	-
Unit 4	85	3,500	2,97,500	20,445	6,573		60	48,05,001	16,818
Unit 5	75	4,232	3,17,425	19,765	12,380	1,40,000	60	89,81,379	47,601
Unit 6	109	7,500	8,17,500	79,359	28,969	-	68	1,96,77,670	1,19,199
Unit 7	81	3,500	2,35,000	19,113	NA	2,76,132	60	48,80,000	
Unit 8	116	7,500	8,70,000	89,197	23,367	6,50,920	-	-	-
Unit 9	86	3,500	2,63,240	27,230	7,634	-	-	-	-

Name of sugar mill	Capacity of DG set -1 [kVA)	Hours of operation of D.G. set - 1 in a year [Hrs]	Capacity of D.G. set - 2 [kVA)	Hours of operation of D.G. set- 2 in a year [Hrs]	Capacity of D.G. set - 3 [kVA)	Hours of operation of D.G. set- 3 in a year [Hrs]
Unit 1	750	150	320	100	-	-
Unit 2	-	-	-	-	-	-
Unit 3	600	240	320	155	-	-
Unit 4	1,500	50	380	200	250	50
Unit 5	1,000	20	600	240	320	40
Unit 6	-	-	-	-	-	-
Unit 7	1,500	24	500	24	380	24
Unit 8	500	451	320	451	-	-
Unit 9	725	6	125	240	-	-

Annexure 3: Minutes of Meeting - Stakeholder Consultation

Minutes of the stakeholder consultation meeting on the quantification of GHG emissions from the sugar sector in Bihar held under the chairmanship of the Member Secretary BSPCB Sri. S. Chandrasekar on 4th November 2022 at Parivesh Bhawan, BSPCB, Patna.

The Board organised a stakeholder consultation meeting in association with Development Alternatives with the support from Shakti Sustainable Energy Foundation on GHG Emissions Inventory and Action Plan for the Sugar Industry in Bihar. This consultation was organized as a part of the ongoing project climate resilient and low carbon development pathways in association with UNEP. At the forum, representatives from all sugar mills in the state, Bihar Industry Association, Sugar Mill Association, Shakti Sustainable Energy Foundation, Department of Industry, UNEP, WRI India, & other relevant stakeholders were present. The following officials were in attendance at this meeting:-

1. Sri. S. Chandrasekar, Member Secretary, BSPCB;
2. Sri. Vivek Ranjan Maitry, IAS, Director (Food Processing), Department of Industries, Govt. of Bihar;
3. Dr. Naveen Kumar, Scientist BSPCB;
4. Dr. Soumen Maity, Vice President, Development Alternatives, New Delhi;
5. Sri. Abhijit Chatterjee, Consultant, Development Alternatives, New Delhi;
6. Sri. Avinash Kumar, Senior Manager, Development Alternatives, New Delhi;
7. Sri. S.N. Thakur, Regional Officer (Purnea), BSPCB;
8. Sri. Anjani Kr. Sinha, BSPCB;
9. Sri. Subhendra Sanyal, Consultant, Shakti Sustainable Energy Foundation;
10. Sri. Pappu Kumar, CPCB, New Delhi;
11. Dr. Shahidhar K. Jha, Manager WRI India;
12. Sri. Mani Bhushan Jha, Program Associate, WRI India;

The meeting began with the Member Secretary welcoming the participants and explaining to them the objectives behind this study and how necessary it is to gather data before any form of implementation. Development Alternatives has done this study with the immense support of the Shakti Sustainable Energy Foundation to create a roadmap for making Bihar a carbon-neutral State by 2070. In his opening statement, he drew the audience's focus on how essential it is to work around data as "What is measured, can be managed". With the help of such informed data, collection and analysis would help make much more informed policy decisions and would help mitigate climate change from the industry sector collectively.

Following this, Sri Vivek Ranjan Maitry, IAS Director, Food Processing, Department of Industries, addressed the gathering by applauding everyone at this meeting. Such a form of analysis enables us to have environment-friendly sustainable growth, which is the need for the hour. He also expressed that such forms of research are needed not just for sugar industries but also for other sectors to minimise pollution levels.

Post the opening remarks by the dignitaries, the presentation by Development Alternatives began with analysing GHG emissions from the sugar sector. This form of analysis is the first to be done in the country. Some of the aspects considered during the study were the transportation of raw material to the mill (sugarcane), the manufacturing process of sugarcane being crushed and the final product being sugar/ethanol and the dispatching of the final product to the market. All the sugar mills in Bihar have a cogeneration facility in their units, enabling them to generate power within the mills' premises. Bagasse is used as a fuel to generate power at the facilities. As per the IPCC guidelines, bagasse (a by-product of sugarcane) produces zero emissions when used as a fuel, therefore, minimising the emissions from this sector.

1 | Page

After the detailed presentation, the various stakeholders from the sugar mills in attendance provided their valuable feedback. For example, the distance of sugarcane procurement should be reduced from 50 KM to 30 KM. They also shared their grievances of insufficient raw material being available, due to which they were experiencing minimised crushing at the mills. Other comments shared by the sugar mill representatives were that they are experiencing water stagnation due to it being located in low-lying areas.

During the discussion, Dr. Soumen Maity drew the focus of the participant as to how the press mud must not be treated as waste. We will have to find profitable ways to deal with it effectively, ultimately enabling us to become carbon negative. He also said that the team of Development Alternatives would be preparing a report which will be circulated amongst the participants for their comments before its official release.

In the end, Dr. Soumen Maity, Vice President of Development Alternatives, gave his closing remarks where firstly he congratulated the board for taking the initiative of conducting this extensive study on GHG inventory of the sugar sector and also thanked the representatives from Sugar Mills, Department of Industries, Sugar Mill Association, Bihar Industry Association and other organisations for their participation in this event. This study was made viable because of the willingness of the sugar mills, who shared their valuable data without hesitation with the Development Alternatives team. He concluded, "This is not the end, but it is just the beginning" towards the target of net zero development pathway.

22/11

(S Chandrasekar)

Member Secretary, BSPCB

Memo No. 2527

Patna -10, Dated 23-11-22


BIHAR STATE POLLUTION CONTROL BOARD


AR STATE POLLUTION CONTROL BOARD


BIHAR STATE POLLUTION CONTROL BO

Development Alternatives

Development Alternatives (DA) is a premier social enterprise with a global presence in the fields of green economic development, social empowerment, and environmental management. It is credited with numerous innovations in clean technology and delivery systems that help create sustainable livelihoods in the developing world. DA focuses on empowering communities through strengthening people's institutions and facilitating their access to basic needs, enabling economic opportunities through skill development for green jobs and enterprise creation, and promoting low carbon pathways for development through natural resource management models and clean technology solutions. DA works to address three global challenges, namely-

Resource Efficiency and Circular Economy - Accelerating the transition to inclusive and circular modes of production and consumption by reducing carbon and material footprints across the lifecycle of economic activity while promoting local value and wealth creation.

Climate Resilience and Ecosystem Restoration - Regenerating lost biodiversity and degraded ecosystems and building resilience to climate change and extreme events in a manner that also generates prosperity.

Livelihood Security and Inclusive Entrepreneurship - Innovative business models and institutional ecosystems to empower local entrepreneurs to create businesses that generate jobs and deliver basic needs.

Our solutions in addressing these issues are focused on nine sectors - namely Waste Management, Human settlements, Decent work, Climate Response, Sustainable Enterprise, Empowering Communities, Water Solutions, Sustainable Agriculture, and Green Energy.

Since 1982, Development Alternatives has impacted approximately 20 million lives.

BIHAR

Bihar State Pollution Control Board

Bihar State Pollution Control Board (BSPCB) was constituted in the year 1974 under the provisions of the Water (Prevention and Control of pollution) Act, 1974. Enactment of the said Act and subsequently constitution of this Board was in pursuance of Clause-I of Article 252 of the Constitution of India. The Water Act, 1974 was made applicable in the first instance to the whole of 12 States and Union Territories, with Bihar being one of the said 12 States. Since its inception BSPCB, like other State Boards has been performing its functions of planning, monitoring, surveying, strengthening R&D, education and training activities in the domains of air, water, soil and noise pollution.

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