# Saroja.Earth

Saroja.Earth

# From **Pollution** to **Prosperity**

Saroja works towards pollution abatement through R&D, public problem solving and novel science-technology-society pathways across the world.

We start with Jalandhar, air pollution abatement, and stubble burning reduction.

1-pager | Linkedin | Stub the Stubble

# The First **Challenge**

# Stubble Burning causing **Air Pollution**

**20%** of PM2.5 pollution in Delhi

**1.6 mn deaths** through air pollution in India

**6.4 years** reduced life expectancy for all Indians

**1.5%** loss in GDP

Theory of Change

Ecosystem Insights

# The **Biomass** Opportunity

55,725 farm fires in Winter 2023

Agricultural waste worth $2.4 billion/year

Agricultural residue utilization in India offers a holistic solution for rural rejuvenation, energy security, and pollution abatement, benefiting farmers, villages, states, and the nation as a whole.

100MMT of material burned annually.

Opportunity of $14 billion in annual product revenues.

Research to Reality, Theory to Practice

# Who are **we**?

Saroja.Earth is the coming together of competent and conscientious **individuals and institutions** for public problem solving via state, market, society, and academia.

The Founder, Roshan Shankar is an alumnus of APJ, DPS, NSUT, Stanford and Princeton with a track record of instigating, stoking and scaling holistic systems change.

IIT Delhi

IIT Bombay

NIT Jalandhar

CSIR-IICT

NIBE Kapurthala

Punjab Agricultural University

IISc

IIM Ahmedabad

Jain University

Plaksha University

Team, Advisors, and Collaborators

# Business Model

# Revenue Model

The goal is to increase technology, manufacturing and social readiness simultaneously and scale businesses with appropriate forms of capital (equity, debt, grant, donation, CSR)

Low value goods — Pellets, Biogas, Tableware, Packaging

Rice Straw/Parali → Collection and Transportation → Landed Cost at ₹2-3/kg

- Processing at ₹3/kg → Product Sale at ₹8/kg
- Processing ₹40-150/kg → Product Sale at ₹80-400/kg

Processing and Product sale rate ranges from ₹3-40/kg from low tier to high-value products.

increased capital investment ↓

High Value Goods — High performance Carbon, Biogas, CBG, Bioethanol, SAF

| | | | | |
|---|---|---|---|---|
| Fuel/material production | Machine manufacturing | Turnkey solutions | Remote/Physical Sensing | Logistics/Supply Chain |
| Technology Licensing | Consulting for industries | Machine R&D | IT/AI/ML/DL | Warehousing |

# Journey thus far

| | FY 2023-2024 | FY 2024-2025 | | | |
|---|---|---|---|---|---|
| | Q4 | Q1 | Q2 | Q3 | Q4 |

**Market**
- Raised Rs. 1.5 crore at Rs. 30 crore valuation
- Technology Implementation
- Hybrid Rice Straw Pellet plant ordered
- Site development and plant fabrication
- Biogas/Biochar/Cutlery plant fabrication

**Non-Profit**
- Theory of Change Drafted
- Outreach and Partnerships
- Proposals for grants with IITD, IITB, IIMA and IISc

**Academia**
- Talk at IIT Bombay
- MoU with Punjab Agricultural University
- Impact partnerships with APJ Stya Unversity and Plaksha University
- Built Stub the Stubble

**State**
- Travel and meetings across GoI, GoP, GoH and CSIRs
- Work with DC Gurdaspur and DC Jalandhar
- Talk at MoP, GOI for policymakers, PSCST for technocrats

Pilot Technologies

Parali Lab

Outreach

# Why **us?**

## Network is Net Worth

- Advised Delhi Government, Punjab MPs, Haryana  and Uttarakhand IPS and GoI IAS leading to impactful politics and policy network.
- Organized political campaigns and supported non-profits across geographies leading to a rich regional social religious and non-profit network.
- Academic network includes legal, economic and technological network from APJ Sheikh Sarai, DPS RK Puram, Stanford, Princeton, IITs, IIMs, IISc etc.

## Close to Grass and Root

- Interviewed 200+ stakeholders ranging from state, market, society, farmer, banker and industry to understand the problem and frame solutions.
- Have an internally consistent and systematic theory of change.
- Founder lives and travels in Punjab and its villages for 25 days a month and the choice of geography, product, fuel and material is the foundation of a long-term business.

## Inter-multi-trans disciplinary

- Team includes creative content producers to nano-fertilizer scientists to urbanists and supported by several current and future PhD students in formal, natural, applied and social science.
- Team is from different geographies of India, disciplines of learning and diverse belief systems which allows for well-rounded, holistic, effective and innovative solutions.

# Why **this**?

## Why Rice Straw ?

- 40% of all biomass burnt
- Light but sharp material
- High silica content
- Rice straw solution solves for almost all agricultural residue
- Potential to create new industry segments in rural industrialization and bring value back to farmers
- Global and national gauntlet for prestige and social proof

## Why Punjab?

- Administratively and geographically challenging
- Low national policy support
- Adverse climate change impact
- Potential for green revolution 2.0
- All-partisan, not non-partisan
- All religions at play
- Solving for Punjab makes solving for India easier and globally faster due to easier unit economics and supportive policy

## Why frugal innovation?

- Problem solving, collaboration and research is as important and strategic as revenue and profit when building an ecosystem
- Diverse product portfolio enhances market resilience and allows for easy pivots.
- Bottom-up organizational growth helps to ensure unit financials or economics isn't broken

# I need your help with resources!

**For-Profit**
Raising Rs. 3 crore at Rs. 30 crore valuation.
(Rs. 30 lakh for 1%, RUV for smaller cheques)
(Rs. 1.5 crore in bank as of 05/06/2024)

**Research**
Rs. 7.88 crores
(Min Rs. 45 lakhs, Max Rs. 2.6 crores)

**Non-Profit**
Rs. 12.13 crores
(Min Rs. 10 lakhs, Max Rs. 3.93 crores)

**Governance Consulting**
Rs. 5.33 crore
(Min Rs. 60 lakhs, Max Rs. 3.9 crores)

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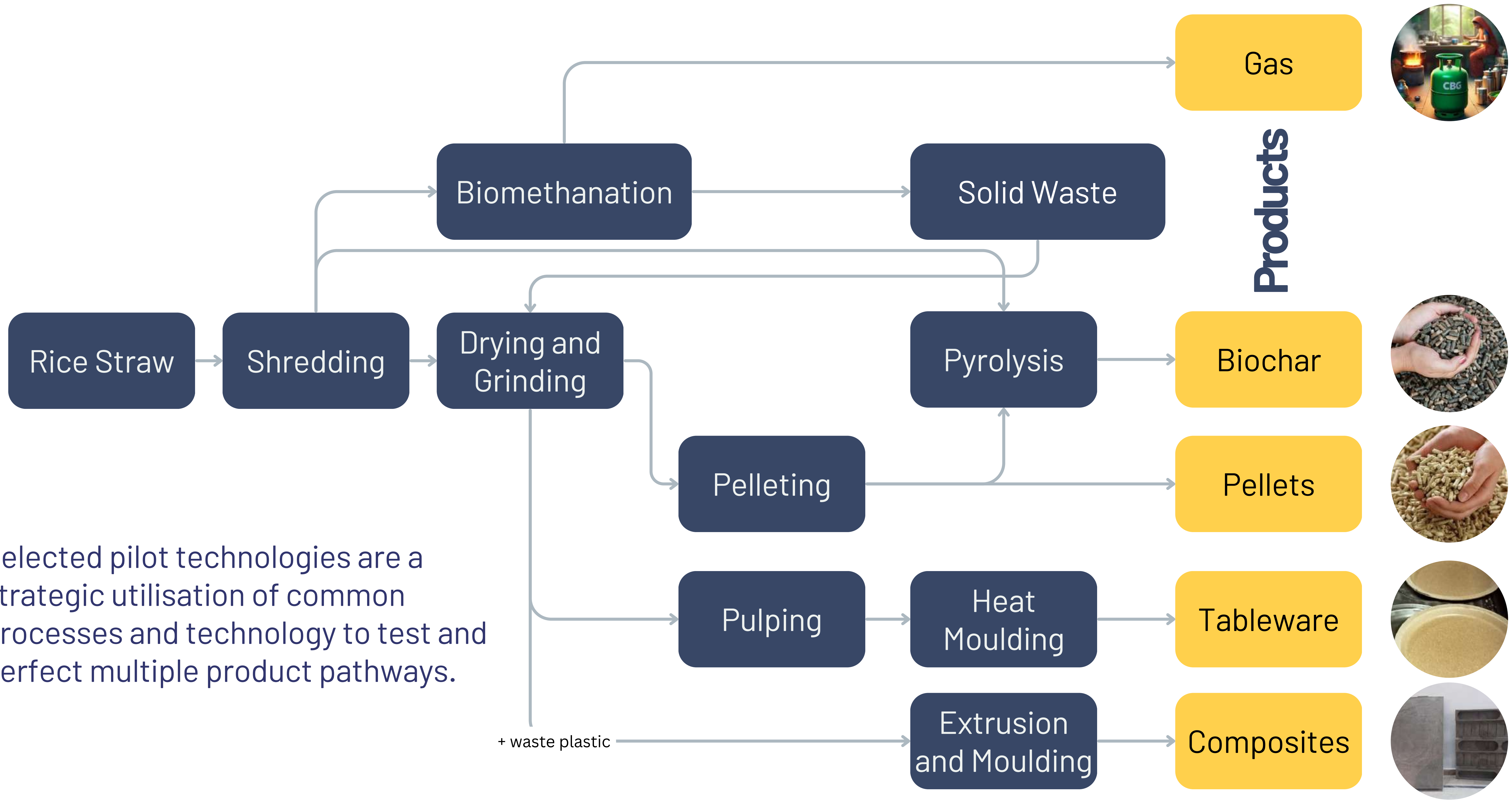
## Appendix

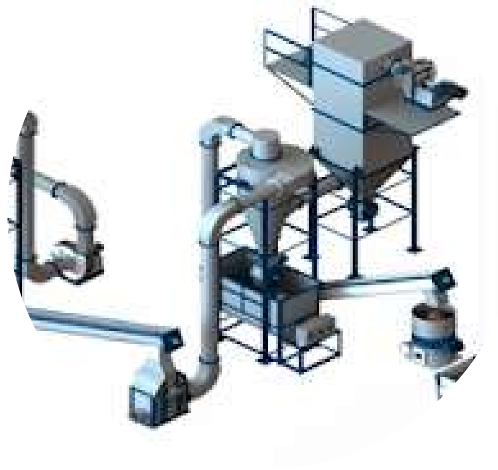
# Pilot Technologies




Selected pilot technologies are a strategic utilisation of common processes and technology to test and perfect multiple product pathways.

# Parali Lab

Pelleting Plant



Digestor

Pyrolyser

Extruder

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## Appendix

# 01. Mentorship and Team

# Team

Roshan Shankar
Convenor

Anurag Nath
Science Lead

Gunraagh Singh Talwar
Technology Lead

Vinay Nagashetti
Communications Lead

# Advisors

HS Mukunda
IISc, Jain University

Suresh Kumar
Former CPS to Punjab CM

Kalpana Balakrishnan
Professor ICMR SMRI

Sachin Maheshwari
Professor, NSUT

# Collaborators

Anupam Sobti
Plaksha University

Sachin Payannad
Jain University

Gazala Habib
IIT Delhi

Sarabjit S. Sooch
PAU

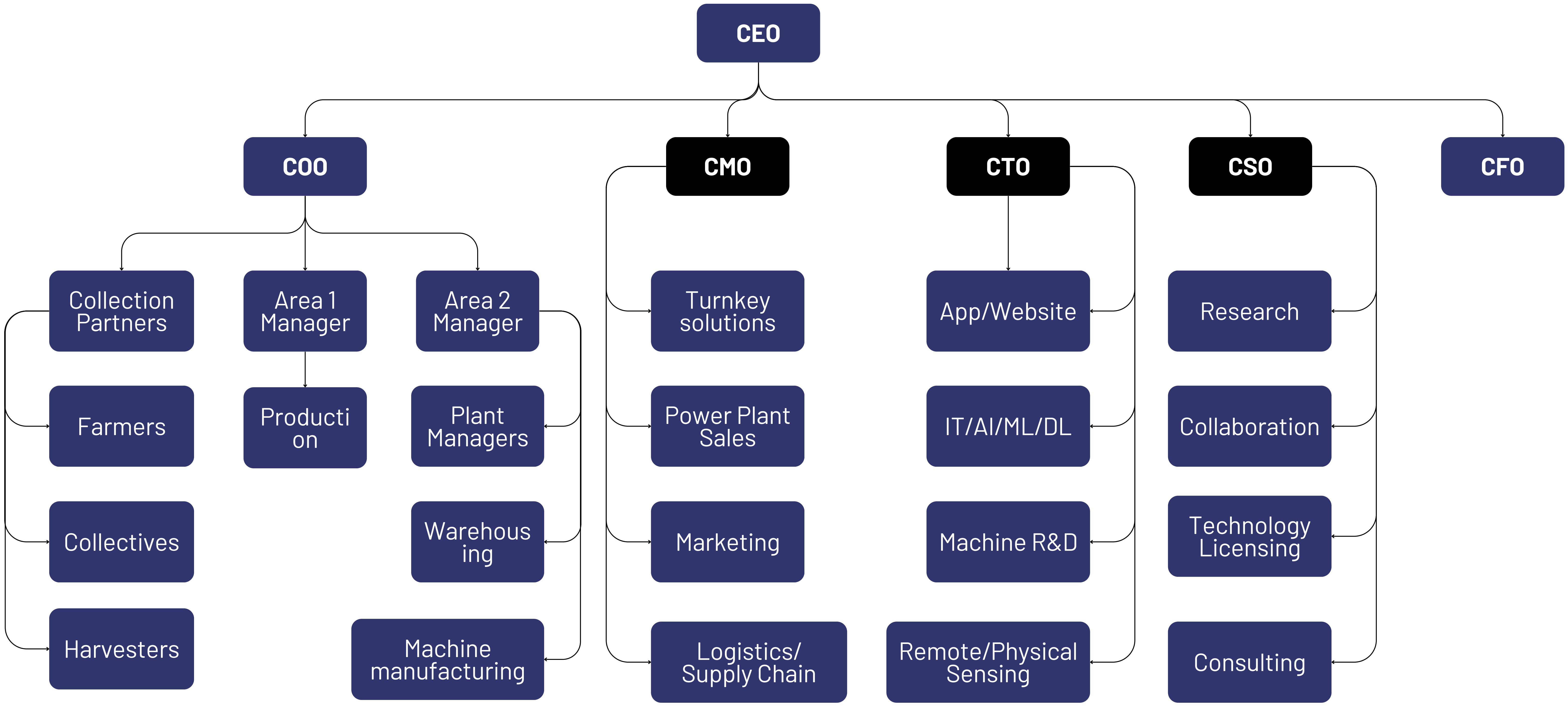
Srinivasan Ramakrishnan
IIT Bombay

Sahil Bhandari
UBC Vancouver

Anish Sugathan
IIM Ahmedabad

Shashank Tamaskar
Plaksha University

# Proposed Organizational Structure



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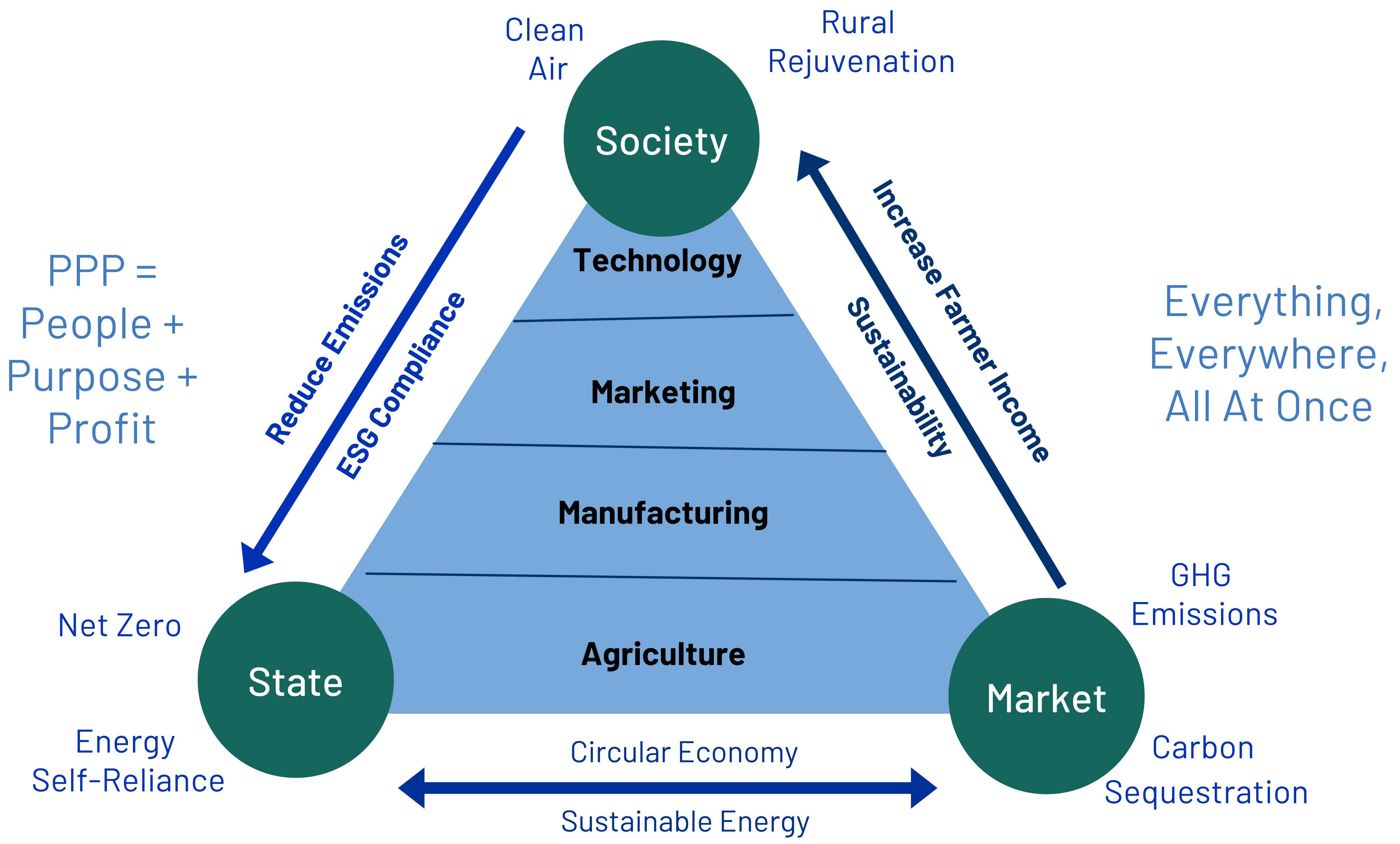
# Appendix

# Problem Solving Approach



# Stakeholder engagement and insights

| Power Plants | Captive | Small scale | Large Scale | Carbon Credits |
|---|---|---|---|---|

| All Industries<br><br>Burning Coal / Steam Boilers | Pharmaceutical | Chemical Units | Mills | Food Processing |
|---|---|---|---|---|
| | Tyre Industries | Dyeing | Textiles | Brick kilns |

*"Ensure that the cost of electricity generated does not increase"* - General Manager of Business development, Private power plant in Punjab

*"I will happily pay the same rate of Rs/KCal, this helps me meet GoI, CAQM and GoP regulation"*
DGM, Power plant in Punjab

*"Ensure that it is easy to use, doesn't generate too much waste and whatever waste is created can be utilized in some way"*
Head of Ash Procurement, Private Power Plant in Punjab

*"I want something similar to coal, do you have torrefied pellets?"*
CEO of Thermal Power Plant in Haryana

*"I already burn biomass. Just beat my existing pellets on price."*

*"What's the ash content? If its same, I am happy to do so."*

*"Can you guarantee order fulfillment on a day or two's notice?"*

*"Can you package it in modules?"*

*"Can you find a way to re-use our biomass flyash?*

# Major Sources of Pollution

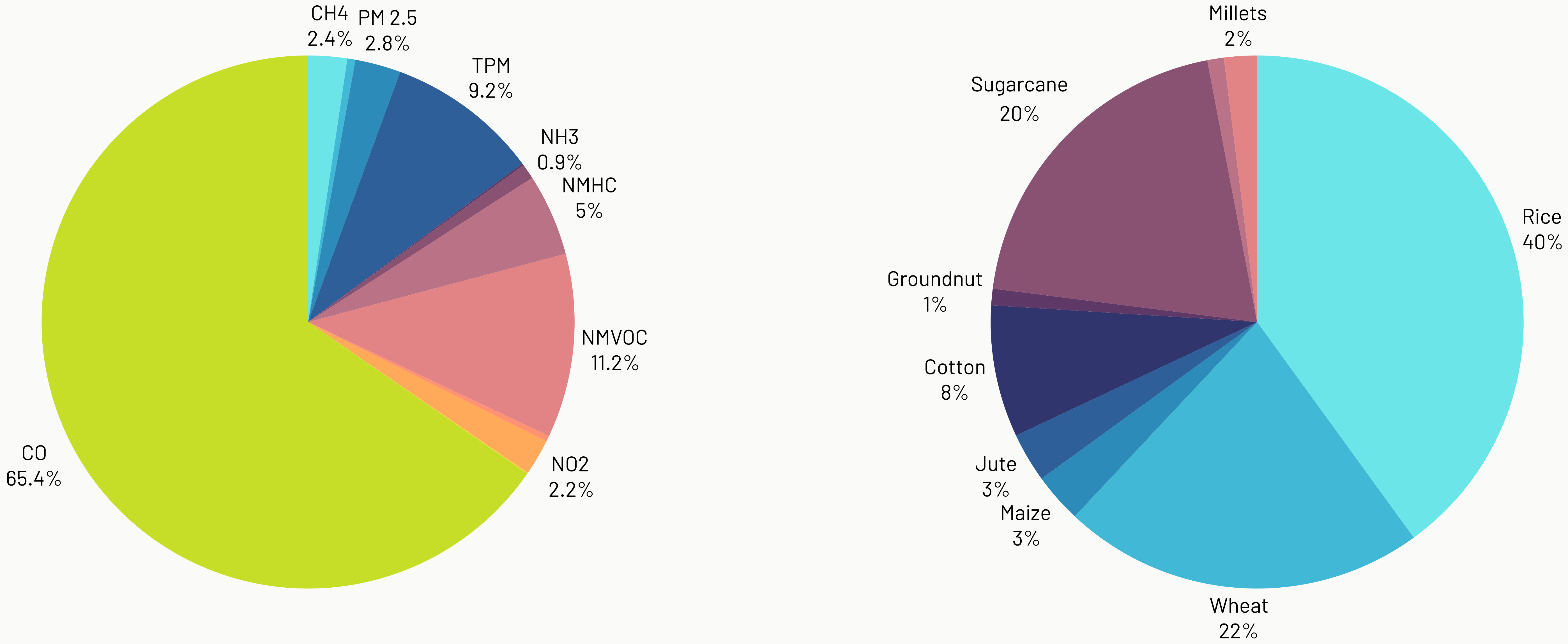



Fig. a) Emission of different pollutants and GHGs due to field burning of crop residues.
(b) Contribution of different crops in burning. Source : https://www.semanticscholar.org/

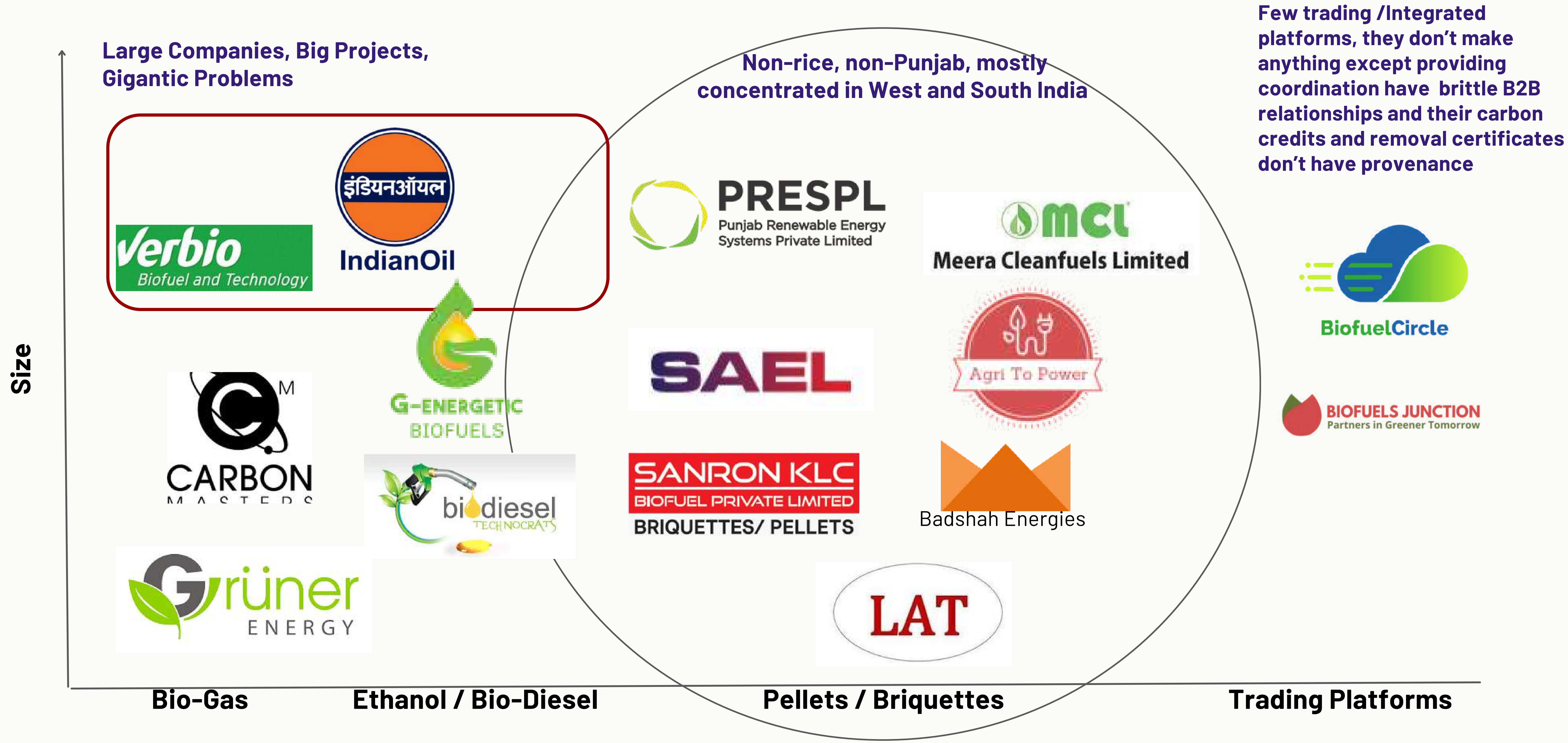
# Stakeholder Learnings

| Segment | Type | Who | People | Key Insights |
|---|---|---|---|---|
| State (Union, Delhi, Punjab, Haryana, Uttar Pradesh) | Legislature | Public representatives (MPs, MLAs, MCs) | 14 | • Low knowledge of techno-commercial aspects of biomass, boilers and flyash<br>• Penalties from government mandates for biomass on industry and farmer avoided<br>• Risk averse bureaucracy copies EU regulation without scientific localization<br>• Governance has not subsidized parali transportation like coal through railways |
| | Executive | Union/State Government Ministers/Technocrats | 12 | |
| | Judiciary | Judges and lawyers at NGT, SC and HCs | 7 | |
| | Bureaucracy | Officers at state, district, tehsil and village level | 21 | |
| Market | Businesses | Corporates, MSME and village enterprises | 36 | • 12-month working capital and labour hard to find for sole proprietors<br>• Market making and buyer interest for biofuels created by state of the world..<br>• Biomass fly ash unuseable for circular use unlike coal fly ash in cement industry<br>• Know-how for different sub-problems is expensive and dispersed in silos |
| | Industries | PSU's, Conglomerates, Manufacturers | 28 | |
| | Startups | Startups, incubators, accelerators | 19 | |
| | Financial institutions | Banks, NBFCs and money lenders | 10 | |
| Society | Farmers | Farmer Collectives and Farmer Producer Organizations | 27 | • Farmers need residue cleared in 25 days<br>• Cows won't eat hybrid rice straw due to its sharp and silica-infused nature<br>• Unpredictable yields, pricing and policy for crops that aren't rice or wheat<br>• Academia doesn't pursue industrial research to productize solutions<br>• Media uninformed, social media uninterested, NGOs ineffective |
| | NGOs and Civil Society | Charitable organizations and faith based institutions | 19 | |
| | Academia | Scientists, researchers and practitioners | 15 | |
| | Media and Digital Media | Journalists, influencers, social media experts | 9 | |
| Total | | | 210+ | |

# Technology and Innovation Roadmap

| Year1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|
| **Residue geo-tagging**<br>Farmer and customer compliance | **Product/Process Consulting**<br>Extract value for partners/clients | **Multi-modal data**<br>Fire, Emissions and Soil health through remote, social and physical sensing | **Sequestration**<br>Deep Geo-Storage by treating biomass |
| **Blockchain integration**<br>Carbon credit provenance | **Route Optimization**<br>Emission and cost minimization | **Material Innovation**<br>Extract Hydrocarbons | **Material Innovation**<br>Hard-Carbon, Bio-refinery |
| **Carbon Credits/Certificates**<br>Generation and Sales | **R&D improvements**<br>Machining, Tooling, Processing | **Fleet Management**<br>Conduct fleet management for balers, rakers, seeders etc | **Stubble Quality Metrics**<br>Computer vision |
| **Dashboard for partners**<br>Digitize collection, conversion, marketing, logistics and usage | **Mobile app for customers**<br>Track energy and money for all | **Scale Parali Lab Wins**<br>Scale viable and profitable versions with appropriate business model | **Ground Truthed Models**<br>Release AI and ML models of soil, air, water and fire quality based on remote, physical and social sensing |
| **Parali Lab Pilot**<br>Pilot biogas, biochar, cutlery and pellets | **Validation through Trials**<br>Biochar as soil additive | | **Productize plants**<br>Different plant for any crop and any form factor |
| | **Professionalize**<br>Governance Consulting and Media Advocacy | | |

# Competitive Landscape



# Our Innovative Solutions

Air Pollution

- Vehicular Emissions
- Industrial Emissions
- Power Plants
- **Stubble Burning**
- Residential sources, hotels and restaurants
- Diwali crackers
- Landfills and Crematoriums

| Product | Capital needs | Profitability | Scalability | Complexity |
|---|---|---|---|---|
| Animal Fodder | ₹ | Low | High | Low |
| Compost | ₹ | Low | High | Low |
| Mulch, Mushroom and Animal Beds | ₹ | Low | Low | Medium |
| Biochar | ₹₹ | Very High | Medium | High |
| Pellets and Briquettes | ₹₹ | High | High | Medium |
| Papers/Cartons/ Plates and Cutlery | ₹₹ | Medium | High | Medium |
| Biogas | ₹₹₹ | Medium | High | Very High |
| Particle Board | ₹₹₹ | Medium | High | High |
| Ethanol | ₹₹₹₹ | High | High | Very High |
| Ash Handling and Extraction | ₹ | Medium | Low | High |

# Unit Economics, Operational Realities

Please email **roshan@saroja.earth** if you would like to review our philosophy, program, policy, project and practice list that includes unit economics of various products and fuels that have been initiated, detailed project report for plant site and plans for Jalandhar in order to fund us through equity, grant, CSR or donation!

# Impact on Rural Economy, Industry, and Government

**For every 50 TPD Non-Torrefied Pellet plant**

Additional employment generated : **49**
Money injected into rural economy : **768 lakhs** Farmer income augmented by **284 lakhs**
**2300 Farmers** impacted! (average of 3 acre holding) **27 sqkm Land saved** from burning (7900 acres) **15,000 tons of coal saved** from burning
**17,000 tons of Parali saved** from burning in fields **22,000 tons of CO2** saved

With reference to trailing mail & meetings, we can plan teams meeting next week for further discussing your proposal.

Thanks & Regards
Vikas Sharma
Head Business Strategy
Talwandi Sabo Power Ltd. | Vill. Banawala, Mansa – Talwandi Sabo Road
Dist. Mansa | Punjab – 151302, India
www.tsplindia.co.in
Mobile : + 91 – 9501110742 T:- +91-1659-24-8112
vedanta

EEC Excellence in Power

Excellence Enhancement Centre
FOR INDIAN POWER SECTOR
(An Initiative of Indo-German Energy Cooperation)

**GOVERNING BODY**

**President**
Chairperson
Central Electricity Authority

**Vice President**
Member (Thermal)
Central Electricity Authority

**Ex-officio Member**
Director General, BEE

**Secretary**
Shri V.K. Kanjlia, Former Secretary, CBIP

**Treasurer**
Shri Manav Jain, GM- Finance, Steag India

**Honorary Members**
Dr. J.T. Verghese, Chairman, Steag India
Director (Operation), NTPC Ltd
Shri D.K. Jain, Ex-Director(Tech), NTPC Ltd
Member from VGB Germany
Dr. Winfried Damm,HOE, GIZ
Shri V.K. Kanjlia, Former Secretary, CBIP

**Elected Members**
Executive Director (Thermal), NLC
Executive Director (OS), WBPDCL
Chief Engineer I/C (Gen), GSECL
Chief Engineer (QC&I), DVC
GM -Sales & Field Services, Siemens
Executive Director, Steag India
Head Global Sales & Delivery, Uniper India

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**EEC/Webinar Invt./2023/100/146** **Dated:28th July, 2023**

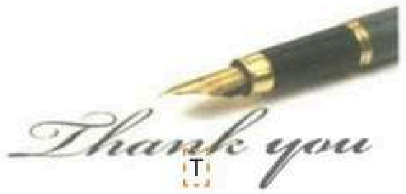
Mr. Roshan Shankar,
[redacted]

Subject: Webinar on **"Waste to Value Pathways in India: Solutions for Circular-Economy Driven Net Zero Transitions "on July 25, 2023**

Dear Sir,

I would like to personally thank you for your participation and taking session through Webinar on **"Waste to Value Pathways in India: Solutions for Circular-Economy Driven Net Zero Transitions "on July 25, 2023** judging from the response of the participants, the Webinar was very successful. The credit goes to you for making such interesting and lively presentation in this outstanding webinar and we thank you for your valuable contribution.

Thank you so much for sparing your valuable time and sharing your experiences with all those present in the Webinar. I am sure your sharing of experience will go a long way in addressing the sector challenges and would help participants to "take on" challenges in the Indian Power Industry which they are going to encounter. Hope we will have more such interactions in the days to come.




Yours Truly,

(Rakesh Chopra)
Director, EEC

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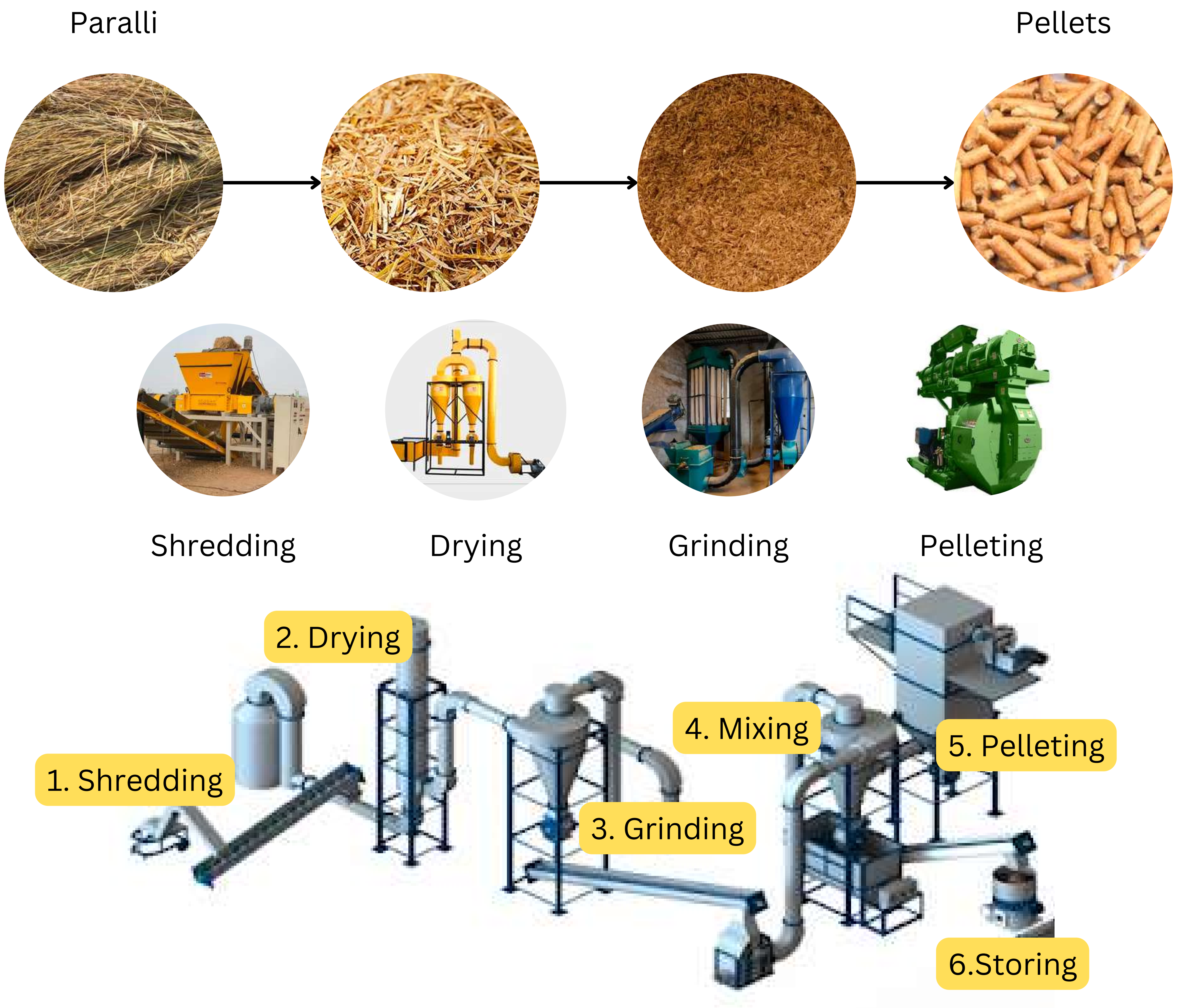
## Appendix

# Leveraging Parali for Clean Energy

Parali-derived pellets offer an innovative approach to harnessing the calorific value of rice straw. This method enables the conversion of agricultural waste into a valuable energy resource, facilitating its use in controlled combustion processes. By integrating these pellets into industrial boilers and power plants, we can significantly reduce reliance on fossil fuels, paving the way for a more sustainable and environmentally friendly energy landscape.


Paralli
Pellets
Shredding
Drying
Grinding
Pelleting
2. Drying
1. Shredding
4. Mixing
5. Pelleting
3. Grinding
6.Storing

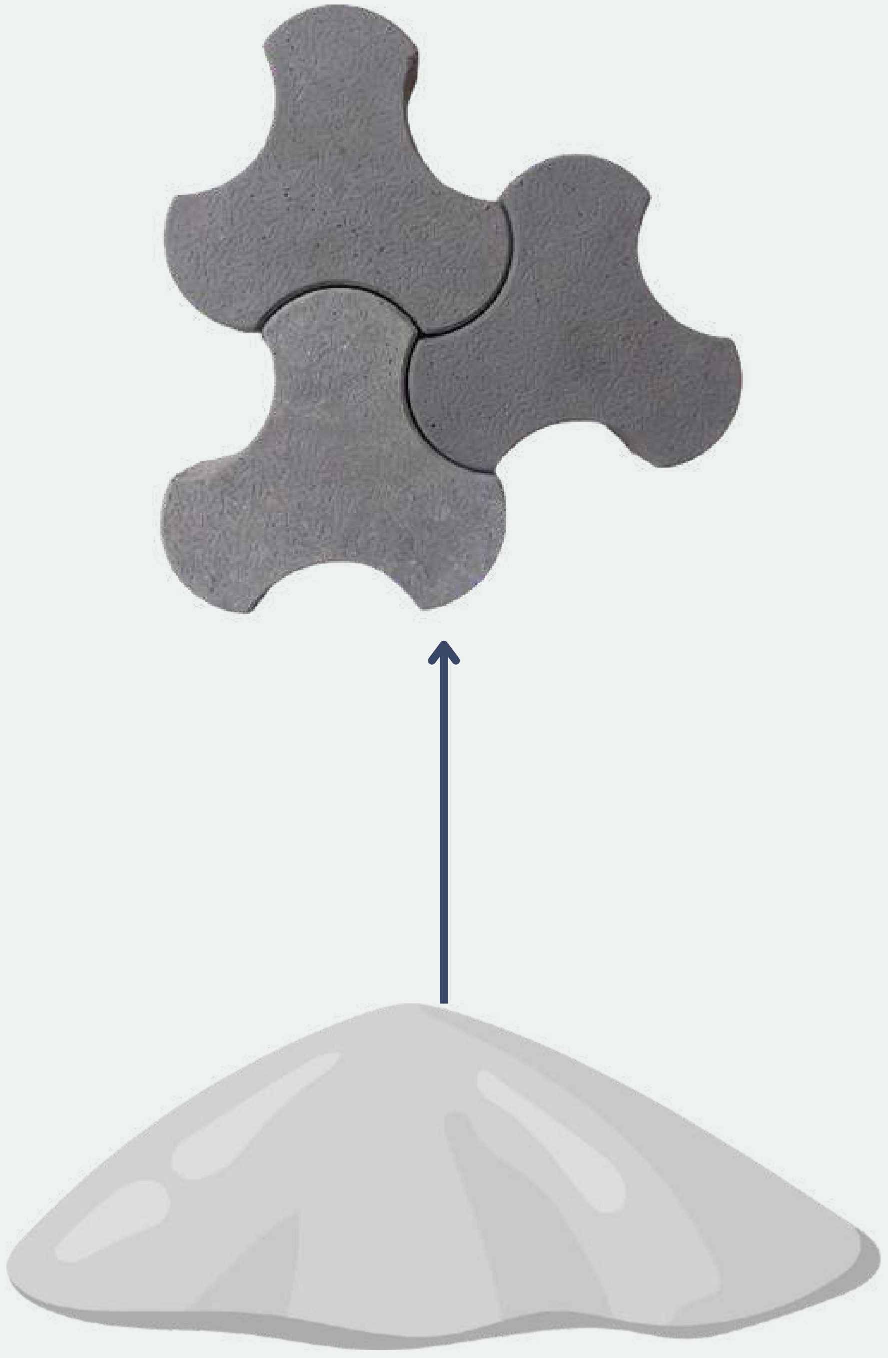
# Research Areas

**Pure Science**
Achieving high pelletization efficiency, uniform pellet size, and minimizing fines are challenges that impact the quality and combustion characteristics of the pellets.

**Natural Science**
Consistent pellet quality is a challenge due to varied moisture content, particle size and chemical composition. Studies on environmentally friendly additives and binders needed.

**Applied Science**
Rice straw has high silica content, causing wear and tear of equipment. There is a need for development of cost-effective and energy efficient drying methods of Parali.

**Social Science**
Effective policies and governance frameworks are crucial for promoting the sustainable production and use of rice straw pellets for bioenergy. Supportive policies, incentives, and regulations that encourage investment in pellet production infrastructure and promote market development.

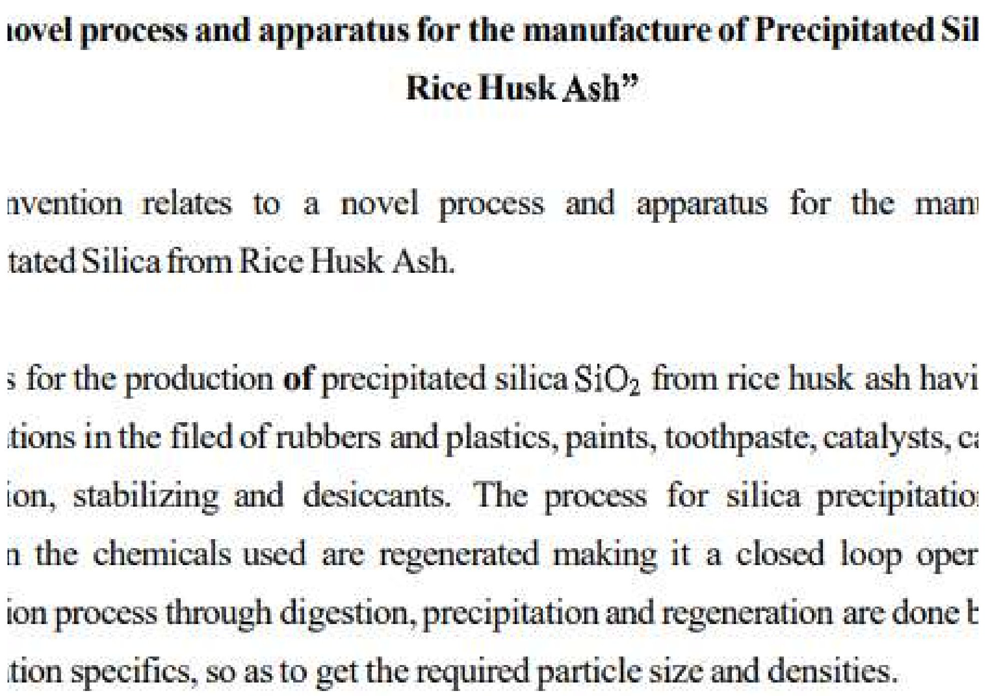


# Opportunity in Biomass Ash

Biomass ash, a byproduct of boiler operations, holds untapped potential beyond mere waste. It can be innovatively utilized in the construction industry, serving as a sustainable raw material for cement enhancement or in the crafting of ash-based bricks and concrete blocks. This approach not only addresses waste management challenges but also contributes to the circular economy by turning waste into wealth.

# Biomass Ash to Precipitate Silica

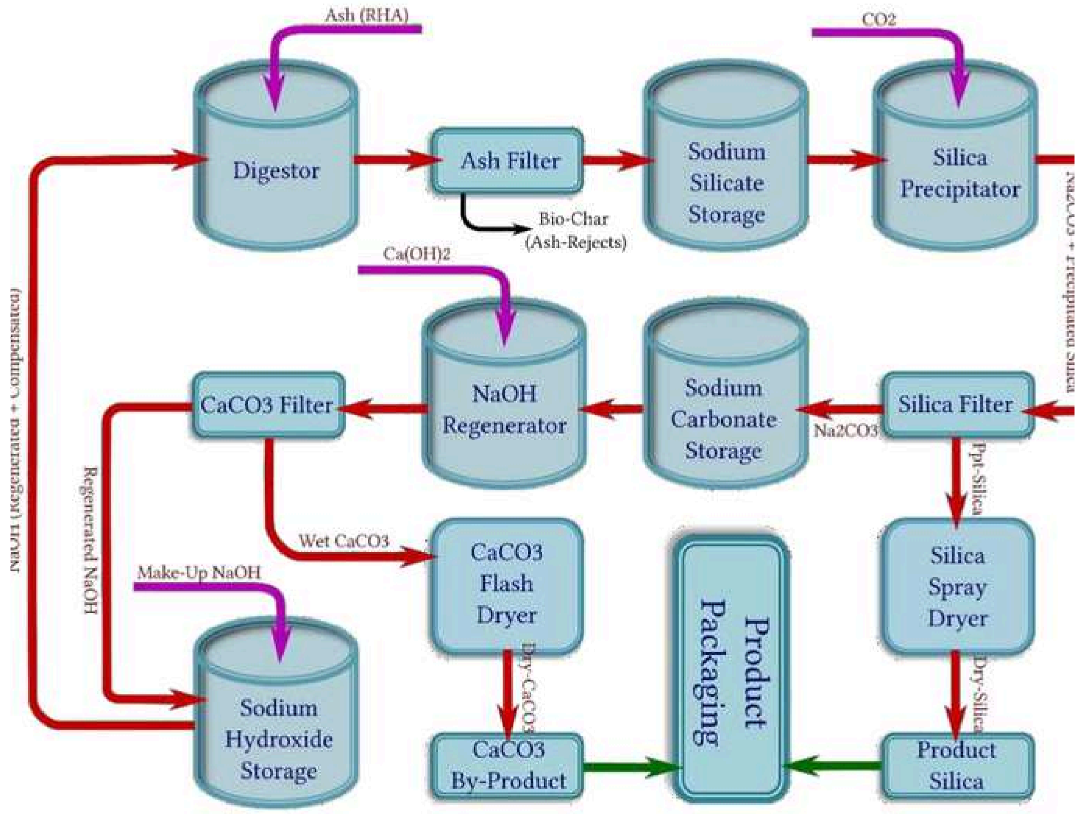
Working with IISc, we can explore production of High Quality Silica for adoption in tyre and rubber industry.


ıovel process and apparatus for the manufacture of Precipitated Sil

Rice Husk Ash"

ıvention relates to a novel process and apparatus for the manı
tated Silica from Rice Husk Ash.

s for the production **of** precipitated silica $SiO_2$ from rice husk ash havi
ıtions in the filed of rubbers and plastics, paints, toothpaste, catalysts, ca
ion, stabilizing and desiccants. The process for silica precipitatio
n the chemicals used are regenerated making it a closed loop oper
ion process through digestion, precipitation and regeneration are done b
ıtion specifics, so as to get the required particle size and densities.



# RHA to Silica Process

**01. Digestion**
Heating of RHA with Caustic Soda resulting in Sodium Silicate Solution

$xSiO_2 + 2NaOH \rightarrow Na_2O.xSiO_2 + H_2O$

**02. Precipitation**
Sodium Silicate reacts with Carbon Dioxide to form Precipitate Silica and Sodium Carbonate

$Na_2O.xSiO_2 + CO_2 \rightarrow + xSiO_2 + Na_2CO_3$

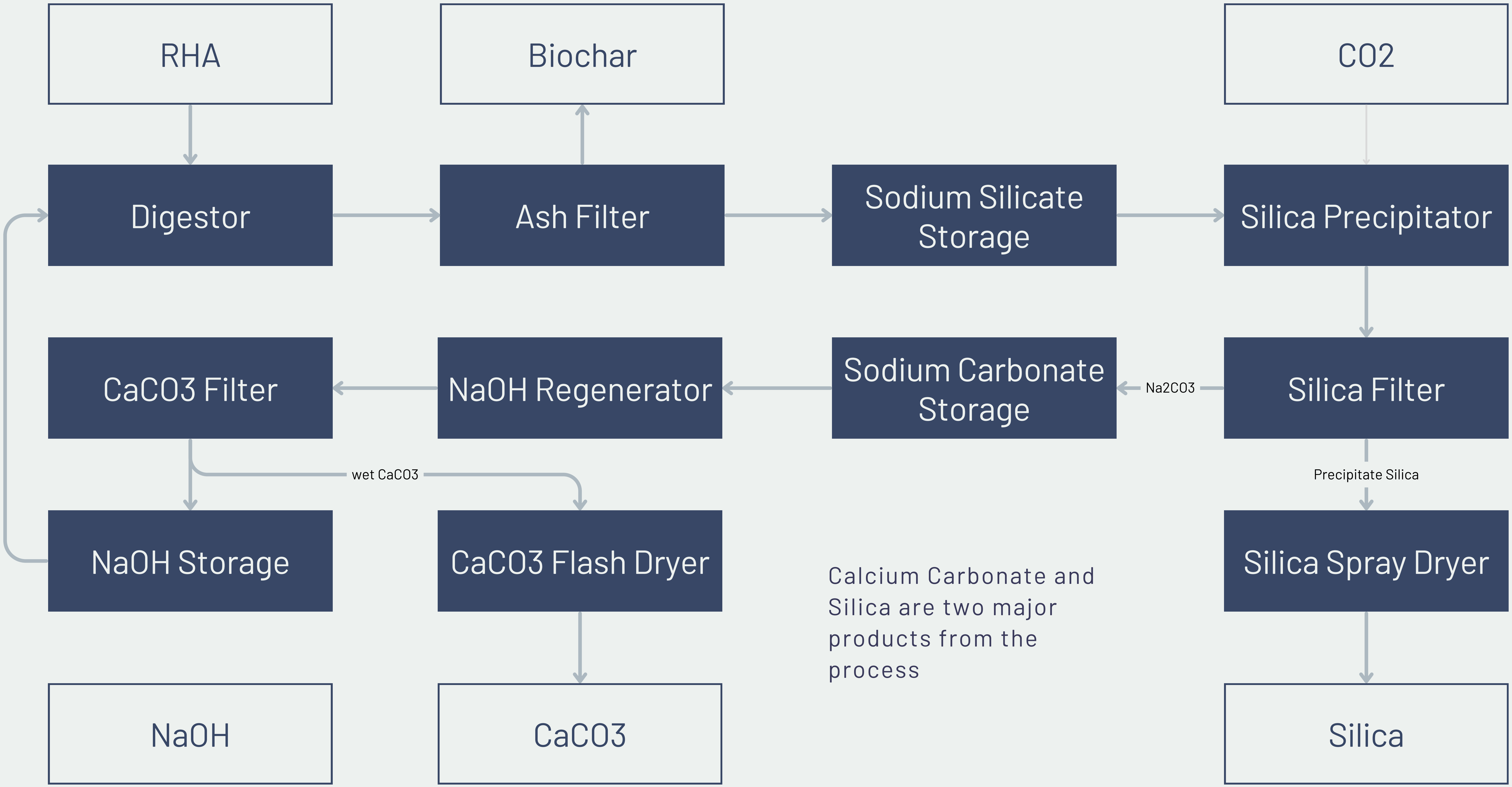
**03. Regeneration**
Caustic Soda regenerated from Sodium Carbonate with addition of Calcium Hydroxide.

$Na_2CO_3 + Ca(OH)_2 \rightarrow + 2NaOH + CaCO_3$

## 01. Digestion

## 02. Precipitation

## 03. Regeneration



RHA
Biochar
CO2
Digestor
Ash Filter
Sodium Silicate Storage
Silica Precipitator
CaCO3 Filter
NaOH Regenerator
Sodium Carbonate Storage
Na2CO3
Silica Filter
wet CaCO3
Precipitate Silica
NaOH Storage
CaCO3 Flash Dryer
Silica Spray Dryer
Calcium Carbonate and Silica are two major products from the process
NaOH
CaCO3
Silica

# Research Areas

**Pure Science**
Silica-rich structures such as phytoliths, silica bodies, and silica cells within the rice straw matrix needs research using scanning electron microscopy (SEM), X-ray diffraction (XRD), and elemental analysis. Investigations on elucidating the mechanisms and kinetics of silica extraction from rice straw.

**Natural Science**
RHA might have carbon, mineral, unburnt impurities. It needs efficient pre-treatment and purification methods. The cost of extraction and purification might make process unsustainable. Alternative energy sources need to be studied.

**Applied Science**
Cost-effectiveness of entire pre-treatment process needs to be considered before scale up. Scale up while maintaining quality, efficiency etc. needs more in-depth studies.

**Social Science**
Acceptance of silica derived from RHA might be challenging. There is a need for establishing new standards. Extracted silica must meet customer expectations and newly set standards.

# Mushroom Cultivation

Rice straw serves as substrate for mushroom cultivation. It contains nutrients such as carbohydrates, lignin, and nitrogen that serve as food sources for mushroom mycelium during the colonization and fruiting stages. It provides an affordable, sustainable, and readily available substrate option for mushroom cultivation, offering numerous benefits for both growers and the environment.

# Research Areas

**Pure Science**
Data analysis of the cultivation process, such as environmental conditions (temperature, humidity), growth rates, and contamination levels is needed to help identify patterns, correlations, and optimal conditions for mushroom growth.

**Natural Science**
Sterilization and pasteurization of rice straw to avoid contamination needs to be carefully executed. Temperature, humidity, and ventilation needs to be controlled for good yield. Adapting rice straw to cultivate different mushroom species needs research.

**Applied Science**
Sustainable and cost-effective nutrient supplementation of rice straw for mushroom growth is a challenge. Automating substrate preparation and mushroom cultivation processes for large-scale production is challenging. Developing cost-effective and efficient automation solutions is an ongoing area of research.

**Social Science**

Acceptance and understanding of this practice through training programs, peer-to-peer learning networks and workshops to allow farmers to succeed in cultivation.

# Animal Feed

Rice straw can also be used as animal feed for livestock, specifically for ruminants such as cattle and goats and also in aquaculture. It serves as a great source of dietary fibre, which promotes digestive health of ruminants.

# Research Areas

**Pure Science**
Large datasets on the nutritional composition of rice straw, animal feed intake, growth performance, and health outcomes need to be analyzed.

**Natural Science**
Improving the digestibility of rice straw through physical or chemical treatments (such as chopping, soaking, or ammoniation) needs to be studied. Not a balanced diet, protein content is low and thus augmentation must be studied.

**Applied Science**
Significant cost implications that come in due to pretreatment needs to be managed. Nutrient supplementation requirements need to be cost-effective.

**Social Science**
Rice straw is high in lignin, and animal acceptance may be low, leading to low growth rates and milk production. Farmers may be reluctant to adopt this strategy due to complex processing needed.

# Parali Based Textiles and Yarn

A foray into Parali-based textiles and yarn signifies a pivotal shift toward sustainable practices. Parali, with its eco-friendly attributes, becomes the cornerstone of a new era in textile and yarn production.


## Case Examples

**Lenzing Ecovero**

Approach: Embrace Parali as a raw material for textiles, mirroring the success of Ecovero in pioneering wood-pulp-based sustainable textiles.

Outcome: High-quality, sustainable textiles with a commitment to eco-conscious practices.

**Ikea FÖRÄNDRING**

Approach: Innovate in weaving techniques using Parali for a collection of textiles, rugs, and table-runners.

Outcome: Aesthetically unique products embodying tactile quality, showcasing Parali's versatility and artistic expression.

# Parali Based Paper and Products

Adoption of Parali for pulping brings in the potential for other paper and paper-based products such as packaging and disposables.
Upcoming initiatives include myco-stabilization through Mycelium growth.

Straw and husk based paper

Straw and husk based packaging

Rice Straw

12kg of Rice straw can be turned into 50 cups of 150-200mL


Tableware

Shredding

Pulping

Forming

Trimming

Shredding rice straw into smaller bits

Boiling at 80-100°C to form pulp

Hot Pressing in moulding machine based on die.

Machines ranging between 15-35 Lakhs depending on size of tableware.

Irregularities are trimmed pior to packaging

# Research Areas

**Pure Science**
Achieving the desired mechanical properties, such as tensile strength and flexibility, in biodegradable paper and cutlery made from rice straw is crucial.

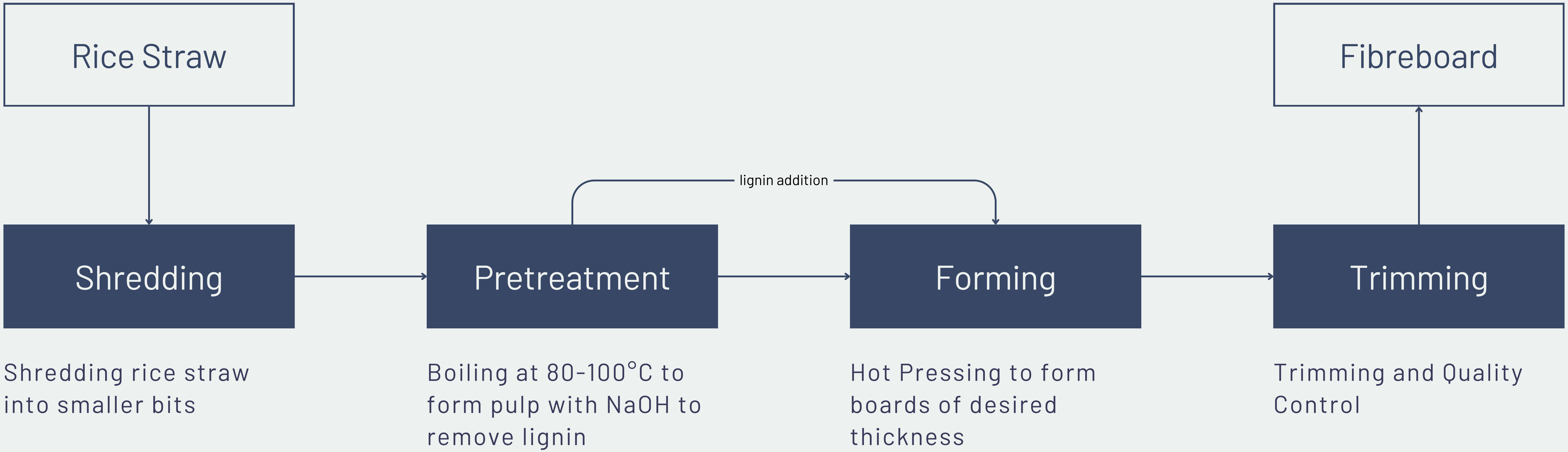
**Natural Science**
Variable composition depending on factors such as rice variety, climate, and cultivation practices. Ensuring a consistent and high-quality feedstock for biodegradable products is a requirement. Need for efficient pre-treatment methods to break down lignocellulosic structures in rice straw.

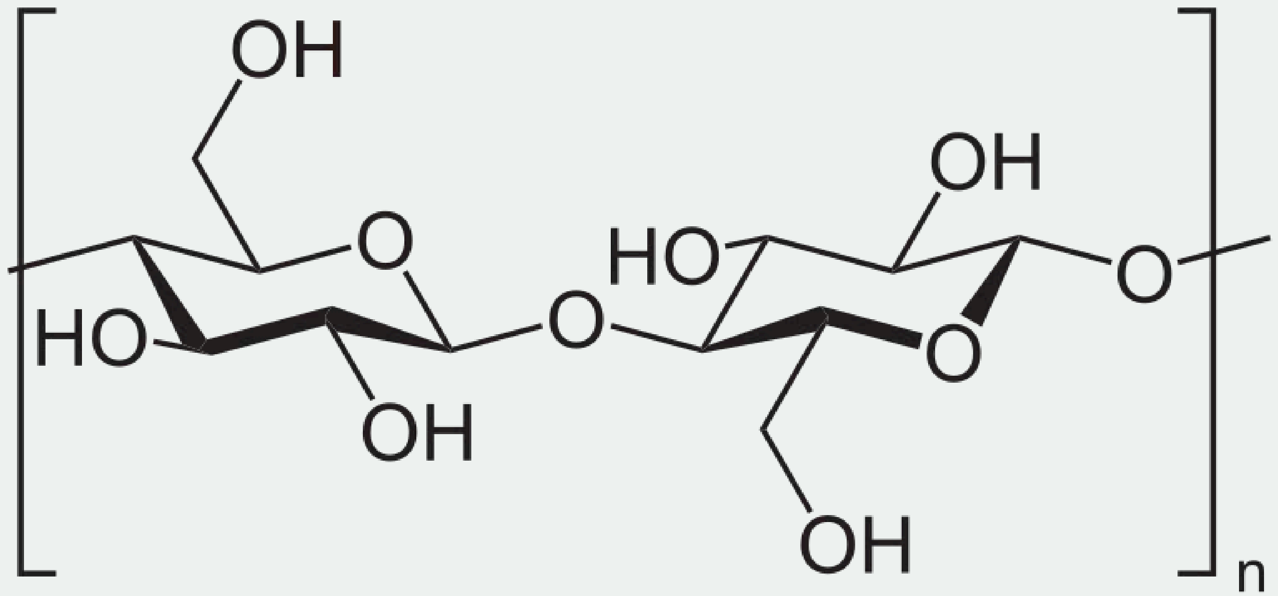
**Applied Science**
Cost-effective binders that ensure product integrity and performance requires more research.Minimizing water consumption during processing is necessary.Technologies that work well in lab set up may not work when scaled up.

**Social Science**
Meeting regulatory standards for biodegradability, safety, and environmental impact is essential for market acceptance.

# Parali based Engineered Boards

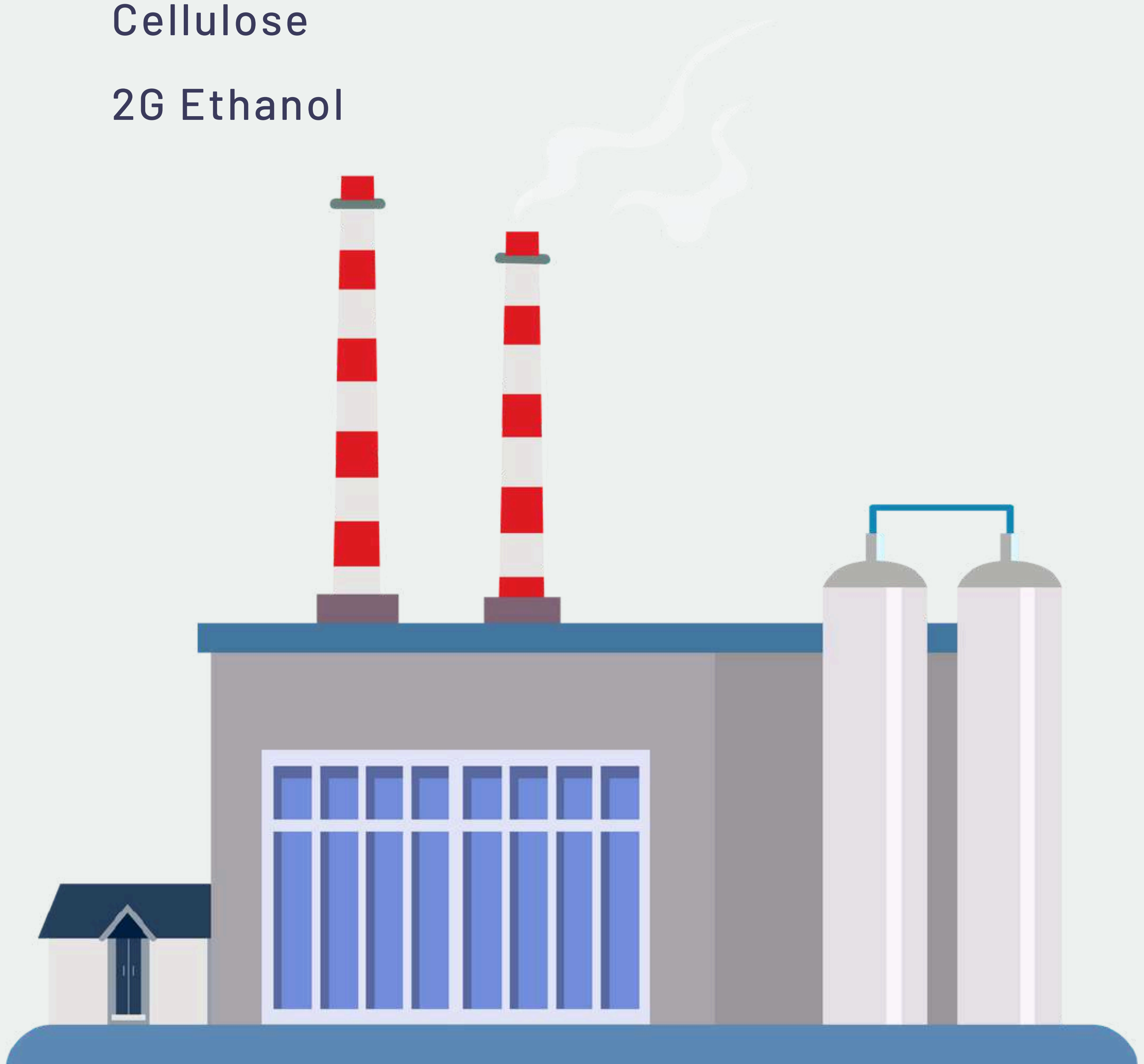
Aside from paper based products, grounded agri-residue can be compressed and bound using lignin to form engineered green boards and fibreboards that are timber-free and E0 certified. This is a sustainable edge over conventional timber based boards and has a wide adoption in market for furniture and interior applications.


Rice Straw
Fibreboard
lignin addition
Shredding
Pretreatment
Forming
Trimming
Shredding rice straw into smaller bits
Boiling at 80-100°C to form pulp with NaOH to remove lignin
Hot Pressing to form boards of desired thickness
Trimming and Quality Control




Cellulose

2G Ethanol



# Rice Straw derived Chemicals

A journey into the realm of green chemistry presents an exciting opportunity to delve into the chemical richness of rice straw. Comprising approximately 38% cellulose, 25% hemicellulose, and 12% lignin, rice straw is a goldmine of sustainable resources.

Cellulose Derived Products like Nanocellulose,Cellulose Acetate,etc., Lignin Derived Products like Adhesives, Phenols,etc., Hemicellulose Derived Products like Xylitol, Furfural,etc., Essential Oils, Extracts, Biochemicals and Organic Acids have been proposed to be developed from Rice-straw and Sugarcane based 2G Ethanol process.

# Parali to 2G Bioethanol

Bioethanol is a renewable fuel produced through the fermentation of biomass feedstocks. The second generation (2G) bioethanol refers to the advanced processes that utilize non-food feedstocks, such as agricultural residues, forestry waste, and municipal solid waste.

Processes to generate 2G Ethanol from Rice Straw have been proposed which includes enzymatic and process studies for optimisation of yield. In this case, for every ton of rice straw as input yields 220-250 litres of ethanol.

Rice Straw

Pretreatment

Mixed acid solution or steam explosion at 170°C and 10-12 bar pressure, with slurry treatment for C5 hydrolysis and recycling of steam flash water.

Pllot 2TPD to 450L Bioethanol facility can be setup in under 50 Lakhs

Enzymatic Hydrolysis

pH 5 -adjusted slurry fermentation at 50-55°C with enzyme addition,

Fermentation

Yeast mixing, cooling, and transferring to fermenters with nutrient addition for alcohol production at 30-35°C

Distillation and Dehydration

Ethanol separation through degasifying, mash, and exhaust columns, then dehydration for fuel-grade ethanol, with by-product recovery.

2G Ethanol

# Research Areas

**Pure Science**
Process optimization of the entire production process using modelling and simulation techniques is needed. Genomic data analysis to understand the metabolic pathways and enzyme systems involved engineering microbial strains for enhanced ethanol yield,

**Natural Science**
Efficiently breaking down these complex structures into fermentable sugars for ethanol production requires advanced pretreatment methods. Improving efficiency of enzymes, yeast for fermentation and optimizing  conditions for effective fermentation & enzymatic hydrolysis requires more exploration .

**Applied Science**
High ethanol yields and production rates is essential for the economic viability of 2G ethanol. Scalability might be a challenge.Engineering microbial strains to enhance ethanol yield.

**Social Science**
The associated land-use changes may have negative health impacts on nearby communities, such as occupational hazards, and exposure to agrochemicals, which needs to be considered.

# Parali to Biogas and CBG

Produced through anaerobic digestion of organic matter, providing cheap and clean energy along with valuable fertilizer and compost products.

# Research Areas

**Pure Science**
Gas flow patterns, mass transfer phenomena, and gas-liquid-solid interactions that affect biogas production, storage, and utilization need to be understood. Substrate concentration, and reactor design that influence reaction rates and gas production yields needs more study.

**Natural Science**
Consistent biogas production is a challenge due to variation in rice straw. High lignocellulosic content is hard for anaerobic bacteria to break down. Temperature, pH, and nutrient levels need to be maintained and optimized.

**Applied Science**
Operating costs, energy and resource consumption, greenhouse gas emissions, and other environmental indicators need to be considered before scale up.

**Social Science**
Upfront costs might be a challenge, and access to subsidies, microcredit or incentives in needed. Maintenance of biogas systems require technical knowledge and skills in digester design, operation, troubleshooting, and repair. Perceptions of biogas as a modern or foreign technology, concerns about odor, hygiene can influence usage patterns.

# Supporting Agriculture through Biochar

By strategically piloting and investing in biochar, the company can cultivate growth, fortify soil health, and elevate its position as an agricultural sustainability advocate.

A pilot for biochar development using rice-straw for utilisation as soil amendment is proposed.

On realizing a sustainable decentralized model, we can look towards carbon removal certificate or carbon sequestration from VERRA and Gold Standard.

# Research Areas

**Pure Science**
Optimization models needed to improve supply chain logistics. Real-time data on temperature, pressure, gas composition, and variables during biochar production needs research.

**Natural Science**
Variation in Parali needs to be controlled to ensure consistent biochar production. Important to understand how biochar interacts with different soil types. Biochar-soil-microbe interactions need to be studied to assess potential effects on soil microbial communities

**Applied Science**
Evaluating the overall environmental impact of large-scale biochar production, including energy consumption and emissions. Understanding market dynamics and price trends is crucial to  assess the economic feasibility of biochar production and identifying potential market niches

**Social Science**
Biochar products may need regulatory approval to ensure they meet safety and environmental standards. Social acceptability depends on community engagement, awareness, and perceptions of the technology's benefits and risks.

Saroja.Earth

## Appendix

# Air Pollution Concerns

## Health

Respiratory diseases

## Biodiversity

Local species dwindles

## Economic Costs

Budget allocation increases

## Poor Global Positioning

India ranks poorly in the world

## Habitat Degradation

Acidification of soil and water

## Social Inequality

Vulnerable population affected

# **Addressing** India's Air Pollution Crisis

**Current Scenario**

- Global Ranking: India ranks second as the most polluted country globally.
- Particulate Pollution Increase: 67.7% rise from 1998 to 2021.
- Life Expectancy Reduction:
- PM2.5 shortens an average Indian's life by 5.3 years.
- Delhi: Reduction of 11.9 years.
- Population Exposure:
- All 1.3 billion Indians live in areas exceeding WHO guidelines for annual average particulate pollution.

**Impact on Public Health**

- Health Risks: Significant risks, especially for children and the elderly.
- Economic Productivity: Adverse effects on productivity and environmental sustainability.

**Limitations of Current Monitoring Systems**

- Accuracy and Coverage: Existing systems lack precision and comprehensive reach.
- Need for Specificity: Greater granularity in pollutant measurement is essential for targeted mitigation.

# India's Air Pollution Crisis

- **India:** 2nd most polluted country globally.
- **Particulate Matter Increase:**
  - 1998 to 2021: 67.7% rise in average annual particulate pollution.
  - Reduced average life expectancy by 2.3 years.
- **Pollution Contribution:**
  - 2013 to 2021: India contributed 59.1% of the world's increase in pollution.

**Impact on Life Expectancy**

- PM2.5 Pollution:
  - Shortens the average Indian's life by 5.3 years relative to WHO guideline (5 μg/$m^3$).
  - In Delhi, life expectancy is shortened by 11.9 years.

**Population Exposure**

- WHO Guidelines: 100% of India's 1.3 billion people live in areas exceeding WHO's annual average particulate pollution guideline.
- National Standard: 67.4% live in areas exceeding India's national standard (40 μg/$m^3$).

- **Greatest Health Threat:** Particulate pollution reduces life expectancy by 5.3 years.
- **Comparative Impacts:**
  - Cardiovascular diseases: Reduce life expectancy by 4.5 years.
  - Child and maternal malnutrition: Reduce life expectancy by 1.8 years.

**Regional Impact**

- Northern Plains:
  - 521.2 million residents (38.9% of the population) face an 8-year reduction in life expectancy relative to WHO guidelines.
  - 4.5 years reduction relative to India's national standard if current pollution levels persist.

# Causes of Air Pollution

**Vehicular Emissions**

- Major Contributor: Millions of vehicles on Delhi's roads.
- Pollutants: Emission of carbon monoxide, nitrogen oxides, and particulate matter.

**Industrial Activities**

- Pollution Source: Factories and industries in and around the city.
- Impact: Significant release of harmful pollutants into the atmosphere.

**Construction and Urbanization**

- Dust and Particulates: Released from ongoing construction and rapid urban development.
- Effect: Further degradation of air quality.

**Inadequate Waste Management**

- Practices: Inefficient waste handling and disposal methods.
- Result: Additional release of pollutants into the air.

- **Crop Residue Burning**
- Stubble Burning: Widespread practice in neighboring states post-harvest.
- Seasonal Impact: Major contributor to "winter smog" and seasonal pollution spikes.

**Urgent Need for Action**

- Health Crisis: Air pollution requires immediate and comprehensive measures.
- Policy Making: Quick and effective policies are crucial, akin to the urgency seen during the pandemic.

# Challenges in Air Pollution Measurement

**Conceptual Challenges**

- **Outdated AQI Measure**:
  - Designed primarily for Chinese and European contexts.
  - Lacks relevance for Indian conditions.

- **Incomplete Metrics:**
  - Focus on particulate matter only.
  - Other pollutants like chlorides and methane also significantly impact health.

**Sensor and Equipment Challenges**

- **Granularity and Frequency:**
  - Pollution varies by location, time, and month.
  - Requires high-granularity measurements at regular intervals.
- **Sensor Limitations:**
  - Many sensors cap AQI reporting at 999, missing higher pollution levels.
  - Installed at heights (30 feet+), missing accurate ground-level readings.

- **Manufacturing and Cost Issues:**
  - Limited technical and financial capacity for large-scale sensor production.
  - High cost (20-25k INR per sensor) deters individual purchases.

- **Underutilized Equipment:**
  - Mobile Monitoring Systems often unused, hindering live analysis and spot verification.

- **Governmental Resource Gaps:**
  - Lack of licenses for satellite mapping.
  - Insufficient industry-grade computers and RAM.

# Transition TRL for Novel Sustainability Solutions

**Context/Background**

Collaborate with national research labs (CSIR) and Institutes of Excellence (IIT, IIM) to advance high-impact projects from TRL 3 to TRL 7.

**Potential Projects**

**Material Innovations**

- **Geopolymer Concrete**: Cement from industrial wastes.
- **Particle Board**: Made from rice husk.
- **Hybrid Composites**: Parali and industrial waste combination

**Process Improvements**

- **Treatment Systems**: For dung, fats, oil, and grease management in slaughterhouses.
- **Biochar Technology**: Convert biomass waste into nutrient-rich biochar.

**Product Development**

- **Biofilter**: Technology for industrial odor control.
- **Mobile Pyrolyser**: Convert agricultural waste into energy and fertilizer.
- **BFBR**: High-rate anaerobic reactor for complex wastewater treatment.

# AeroVigil Delhi: Multidimensional Analysis of Air Toxicity

**Context/Background**

- Innovative AQIs: Inspired by cities like Toronto developing their own AQIs.
- Data Availability: Abundance of granular data from international (satellite) and domestic weather & pollution agencies.
- Integration Potential: Combining pollution data with government operations data can address public finance and health questions, pinpointing precise targets for health and pollution interventions.

**Plan of Action**

**Data Collection:**

- Collate local data from primary clinics and transit research.
- Aggregate measurements of different pollutants from various sources.

**Advanced Analysis:**

- Apply advanced computational methods and sparse higher-dimension statistics.
- Develop improved measures of air quality and toxicity.
- Provide open API support for data accessibility.

**Customized AQI:**

- Create a New Delhi-specific AQI.
- Ensure data is open and accessible, similar to OpenAQ.

**Multifactor Analysis:**

- Leverage various sensors and metadata.
- Include meteorological factors (temperature, humidity, visibility).
- Consider local factors (greenery, industry presence, residential information).
- Use vehicular traffic congestion data to estimate local pollutant concentrations.

**Seasonal and Epidemiological Modeling:**

- Model seasonal pollution risks in combination with epidemiological data.
- Integrate waste management and traffic data into predictive models for comprehensive analysis.

# Deployment of Low-Cost Sensor Network

**Context/Background**

- Holistic Approach: Needed for urban air quality challenges in Delhi and Punjab.
- Current Limitations: Existing monitoring systems lack granularity.
- Health and Environmental Concerns: Increasing impact of air pollution in densely populated areas.

**Plan of Action**

- Sensor Network: Deploy low-cost sensors in key urban areas.
- Real-Time Data: Capture and provide hyperlocal air quality insights.
- Integrated Platform: Collect, store, and analyze data using advanced analytics and machine learning.

**Pilot Solutions:**

- **Individual**: Purifiers, masks, better chulhas, LPG substitution.
- **Building**: Road washing, mechanized sweeping, smog guns, HEPA filters.
- **Community**: Composting sites, biogas plants, smog towers.

**Expected Outcomes**

- Real-Time Insights: Hyperlocal understanding of air quality issues.
- Community Engagement: Increased awareness and participation in improvement initiatives.
- Strategic Partnerships: Effective implementation of pollution abatement solutions.
- Data-Driven Policies: Recommendations for sustainable urban air quality management.

**Policy Advocacy and Implementation**

- Advocate for evidence-based policies to address air quality concerns.
- Collaborate with policymakers to implement and enforce pollution control regulations.

# Mobile Monitoring System with IIT Delhi

- Importance of Source Apportionment: Crucial for effective air quality analysis and resource allocation.
- Complex Pollution Sources: Diverse causes of pollution in Delhi.
- Current Capabilities: Only two labs in Delhi (Raasman, IIT-D) can perform high-quality source apportionment.
- Stationary Lab Limitations: Inaccurate readings if not measured at relevant spots.
- Unutilized Resource: High-quality mobile monitoring system at IIT Delhi ($800,000) is currently unused due to financial and manpower constraints.
- Opportunity for Rapid Deployment: Utilizing existing equipment is faster than new procurement, with reduced bureaucratic hurdles.

**Plan of Action**

- Operationalize System: Activate the mobile monitoring system at IIT-D with the Centre of Excellence for Research on Clean Air.
- Resource Allocation: Hire research associates, procure consumables, fuel, and a driver.
- Utilize for Verification:
- Verify pollution complaints.
- Conduct live data analysis at hotspots.
- Perform source apportionment studies.
- Expanded Capabilities:
- Adapt for monitoring other complaints (odor, noise, water).
- Document residents' experiences.
- Support Innovation: Provide access to high-tech equipment for startups and students, fostering new opportunities in pollution abatement research.

# Software Engineering and IT Initiatives

**Objective**

Implement advanced computational methods and sparse higher-dimensional statistics for comprehensive air quality and toxicity monitoring in North India. Utilize data from diverse sources, including sensors, satellites, CCTV, and collaborate with NASA and IARI for satellite data integration.

**Plan of Action**

Advanced Computational Methods

- Develop and implement advanced algorithms for air quality and toxicity assessment.
- Use sparse higher-dimensional statistics for accurate and efficient data analysis.

**Multi-Source Data Integration**

- Gather data from sensors, satellites, and CCTV cameras.
- Implement integration strategies for a comprehensive understanding of environmental conditions.

**Satellite Data Collaboration**

- Collaborate with NASA and IARI for satellite data access.
- Monitor and ameliorate nitrates, carbon, and crop types in North Indian agriculture.

**API Development and Integration**

- Develop plug-and-play APIs for governmental, private, and academic air quality data.
- Ensure seamless access and sharing of information across diverse sources.

**Testing and Validation**

- Conduct rigorous testing of computational methods and APIs.
- Validate results against ground-truth data for accuracy and reliability.

**Capacity Building and Training**

- Provide training for stakeholders on using the developed tools and APIs.
- Enhance the capacity of entities in leveraging advanced methods for environmental monitoring.

# Air Pollution Abatement Solution: Deployment, Monitoring, and Evaluation

**Study and Deployment**

- Scope: Analyze pollution abatement solutions at assembly constituency and district levels in Delhi and Punjab.
- Pilot Projects: Deploy sensors and solutions with support from public representatives, bureaucrats, and technocrats.
- Monitoring: Conduct evaluations at district, ward, and constituency levels.

**System Creation**

- Effective Management: Develop a system to scientifically deploy, monitor, and evaluate solutions.
- Resource Abatement Curves: Produce curves to assess cost-effectiveness.
- Capital Deployment: Maximize use of government and private funds for solution implementation.

**Efficacy Evaluation**

- Individual Level: Warm clothing, heaters, purifiers, masks, improved chulhas, LPG substitution, natural abatement methods.
- Building Level: Road washing, mechanized sweeping, smog guns, water spraying, reflective paint, ESP, HEPA filters, crematorium innovations.
- Community Level: Composting sites, wind flow screens, biogas plants, smog towers, agricultural equipment utilization.
- Neighborhood Level: Efficient brick kiln designs, landfill biomethanation, industrial water scrubbers.
- District Level: Improvements in coal plant processes and materials.

# Economic Viability and Effectiveness of Solutions

**Context**

Transitioning to sustainable practices and technologies is economically challenging but crucial for long-term health and environmental benefits. Non-profits and for-profits can bridge the gap by demonstrating tangible benefits to communities and policymakers.

**Problems**

- Economic Viability: High costs of cleaner industrial processes and renewable energy.
- Implementation Challenges: Limited effectiveness due to inadequate implementation and monitoring of pollution control measures.

**Solutions**

- Cost-Effective Strategies:
  - Incentivize Renewable Energy: Subsidies and tax incentives for adoption.
  - Enhance Pollution Control Efficiency: Invest in advanced technologies.
  - Public Transport Infrastructure: Reduce reliance on personal vehicles.
- Public-Private Partnerships: Fund and deploy pollution abatement projects.

**Recommendations for Non-Profits**

- Case Studies and Pilot Projects: Showcase the success and cost-effectiveness of clean technologies.
- Advocacy and Investment: Use success stories to advocate for policy changes and attract green investment.

# Targeted Abatement at Various Levels

**Problems**

- Lack of awareness and coordination in implementing targeted solutions at individual, building, and community levels.

**Solutions**

- Individual Level:
  - Encourage masks, air purifiers, and green commuting.
  - Promote electric vehicles with government subsidies.
- Building Level:
  - Implement green building codes for energy efficiency.
- Community Level:
  - Urban planning for green belts, parks, and pedestrian zones.
  - Community programs on crop burning dangers and waste segregation.

**Refined Recommendations for Non-Profits**

- Workshops and Training: Equip individuals and communities with sustainable practice skills.
- Engage Local Governments: Integrate green building codes and urban planning for air quality improvement.
- Targeted Measurement: Focus on schools, colleges, hospitals, coal plants, brick kilns, tandoors, landfills, and crematoria across North India.

# Enhancing Awareness of Air Quality and Public Transit Effectiveness

**Problems**

- Low public awareness of air pollution health impacts and benefits of public transit.
- Preference for personal vehicles exacerbating air quality crisis.

**Solutions**

- Launch nationwide awareness campaigns about air pollution risks and benefits of public transit.
- Improve reliability, safety, and coverage of public transit systems.
- Enforce PUC norms and crackdown on overaged diesel and petrol vehicles.

**Recommendations for Non-Profits**

- Implement creative awareness campaigns using social media, community events, and collaborations with influencers.
- Partner with schools to integrate air quality education into the curriculum.
- Collaborate with government, industry, communities, and individuals for successful implementation.

# Utilization of Crop Residue in Making Value-Added Products

**Versatility and Environmental Benefits of Rice Straw Utilization**

- **Agricultural Applications:**
  - Mulching: Enriches soil nutrients and moisture.
  - In-situ Incorporation: Promotes soil health and reduces chemical fertilizer use.
- **Animal Care:**
  - Fodder: Affordable feeding solution for livestock.
  - Bedding Material: Provides a comfortable resting area for animals.
- **Mushroom Cultivation:**
  - Growth Medium: Sustainable agriculture practice turning waste into profit.
- **Energy Generation:**
  - 2G Ethanol Production: Enzymatic hydrolysis.
  - Biogas/BioCNG: Anaerobic digestion.
  - Bio-oil: Pyrolysis.
  - Biomass Pellets: Direct burning.
- **Eco-friendly Products:**
  - Biodegradable Tableware and Packaging: Reduces plastic waste.
  - Paper Pulp: Reduces deforestation.
- **Biochar Production:**
  - Carbon Sequestration: Improves soil fertility and reduces greenhouse gas emissions.
- **Silica and Activated Carbon:**
  - Rice Husk Ash: Processed into silica for various industries.
  - Activated Carbon: Aids in water purification and air filtration.
- **Construction and Manufacturing:**
  - Engineered Boards, Furniture, Pallets, Biocomposites: Sustainable alternatives to traditional materials.
- **Advanced Applications:**
  - Sodium-ion Batteries: Anode production.
  - Hydrogen Production: Gasification for clean energy.
  - Biofilms: For microbial studies.
  - Phytochemicals: Extraction for cosmetics and pharmaceuticals.

# Biomass-Derived Hard Carbon Anodes for Sodium-Ion Batteries

**Context/Background**

- Current Challenges: Lithium-ion batteries (LIBs) face supply, demand, and geopolitical uncertainties.
- Alternative: Sodium-ion batteries offer a promising, cost-effective alternative due to sodium's abundance.
- Research Needs: Significant R&D required for developing effective anode and cathode materials.
- Sustainable Source: Biomass can serve as a precursor for hard carbon in sodium-ion batteries, but standardization is challenging due to its varied properties.

**Plan of Action**

- **Sourcing and Conversion**:
  - Source various farm wastes for conversion into value-added products.
  - Subject raw materials to pre-treatments such as hydrothermal carbonization using KOH or TMAH.
- **Pre-treatment and Pyrolysis**:
  - Perform pyrolysis under reducing conditions (N2/H2 gas mixture) to obtain hard carbon.
  - Adjust reaction parameters (temperature, heating rate) to modulate physical properties (micro- and meso-porosity).
- **Surface Modification**:
  - Introduce dopants for heteroatom incorporation to enhance sodium ion storage.
- **Database and Standardization**:
  - Create a uniform database for each precursor to establish structure-performance relationships.
  - Address heterogeneity in the field by determining exact structure-performance relationships.

**Verification**:

- Use Raman Spectroscopy to thoroughly verify the hardness and quality of the final hard carbon products.

# Evaluation and Implementation of Low-Cost Sensors for Air Pollution Abatement

**Context/Background**

Assess the functionality and reliability of existing low-cost sensors, explore indigenous initiatives, and pilot high-quality laser sensors for large-scale air pollution measurement.

**Plan of Action**

**Market Survey and Evaluation**

- **Comprehensive Survey**: Identify various indigenously assembled sensors and ongoing initiatives.
- **Field Testing**: Evaluate functionality, accuracy, and reliability through testing and data analysis.

**Pilot High-Quality Laser Sensors**

- **Selection and Implementation**: Pilot high-quality laser sensors known for accuracy and reliability.
- **Data Collection**: Implement sensors in strategic locations to gather data under diverse conditions.

**Comparison with Gas Sensors**

- **Data Comparison**: Compare data from laser sensors with traditional gas sensors (industrial standard).
- **Assessment**: Evaluate accuracy, precision, and maintenance requirements of both sensor types.

**Cost Effectiveness**

- **Analysis**: Assess the potential of laser sensors to reduce the number of sensors needed.
- **Impact Evaluation**: Evaluate maintenance costs and efficiency compared to traditional gas sensors.

**Calibration and Maintenance**

- **Protocol Development**: Create a robust calibration and maintenance protocol for laser sensors.
- **Training**: Provide training for personnel responsible for sensor maintenance and calibration.

# Site Interventions for specific hotspots

**Context/Background**

Identify key urban sites contributing to air pollution: **landfills, crematoriums, and tandoors**. Aim to address air quality challenges through innovative, low-cost engineering interventions.

**Plan of Action**

**Baseline Data Collection**

- Document the number, size, and typology of landfills, crematoriums, and tandoors.
- Conduct initial assessments of air quality conditions at these sites.

**Primary Data Collection**

- Perform in-depth ambient air quality monitoring.
- Analyze emission characteristics and assess health impacts on nearby communities.

**Best Global Practices Review**

- Review global best practices in landfill, crematorium, and tandoor design and operation.
- Identify successful case studies and innovative pollution control solutions.

**Open-Source Design Development**

- Develop low-cost interventions based on global best practices.
- Create open-source design documentation for easy replication.

**Pilot Implementation in Delhi and NCR**

- Select representative sites in Delhi and NCR.
- Implement interventions and monitor effectiveness over time.

**Recommendations for Policy and Engineering Interventions**

- Compile recommendations based on pilot outcomes.
- Propose state-level policies and engineering interventions for municipal and site-scale improvements.

**Expected Outcomes**

- Reduced air pollution at targeted landfills, crematoriums, and tandoors.
- Scalable and replicable open-source designs for low-cost interventions.
- Data-driven recommendations for state policies and engineering interventions.
- Improved urban air quality management through sustainable practices.

# Public Abatement Solution Design and Deployment

**Context/Background**

- **Stubble Burning**: Major contributor to Delhi's air quality issues, accounting for 12-60% of pollution based on wind conditions.
- **Research Gaps**: Limited organized research on the economics and methods of air pollution abatement through stubble burning reduction.
- **Economic Potential**: Rural interventions can reduce pollution and boost the rural economy by harnessing the economic value of stubble.

**Plan of Action**

- **Project Reports and Videos**: Develop Detailed Project Reports (DPRs) and instructional videos to provide comprehensive information for researchers and investors.
- **AI Tools**: Create AI-aided project report generators and calculators to simplify decision-making, similar to solar calculators.

Open-Source Research: Promote adoption of stubble burning solutions through open-source research.

**Detailed Project Reports (DPRs) for Key Interventions:**

1. **Model Gauthan**: Establish five-acre plots in villages for converting agricultural waste into value-added products.
2. **Parali to BioChar**: Convert stubble to biochar by pyrolyzing at 600-700°C in low-oxygen conditions to enhance soil nutrients.
3. **Clean Tandoors**: Design and deploy clean tandoors using forced draft, pelletized biomass, and inexpensive steel fabrication.
4. **Green Crematoriums**: Implement biomass briquettes as wood replacements and optimize chimney designs to reduce pollution at crematoriums.

**Expected Outcomes**

- Reduced air pollution from stubble burning.
- Increased economic opportunities in rural areas.
- Accessible, data-driven solutions for investors and policymakers.

# Enhancing Awareness of Air Quality and Public Transit Effectiveness

**Context/Background**

- **Goal**: Increase public awareness of air quality and promote the effectiveness of public transit in Delhi.
- **Method**: Install LED screens at key bus-stops to display bus arrival times and real-time air quality data.

**Plan of Action**

**Identifying Key Bus-Stops**

- **Analysis**: Identify the top 100 bus-stops that account for 90% of traffic in Delhi.
- **Prioritization**: Focus on bus-stops based on commuter density, transit routes, and strategic importance.

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**LED Screens Installation**

- Implementation: Install LED screens at the identified bus-stops.
- Integration: Equip screens with air pollution sensors to display live air quality data.

**Public Awareness Campaign**

- **Channels**: Use social media, local newspapers, and community events.
- **Messaging**: Highlight the benefits of public transit in reducing air pollution and improving air quality

**Debate and Discussion Platforms**

- **Online Engagement**: Create platforms for public debate and discussion on air quality and transit effectiveness.
- **Participation**: Use social media forums, webinars, and community initiatives to encourage engagement.

# Utilizing Stubble as Fodder in Gaushalas and Dairies

**Context/Background**

- **Objective**: Address environmental issues caused by burning rice straw (Parali) in Punjab and enhance livestock feed quality for cows and buffaloes.

**Plan of Action**

**Awareness Drive and Education Initiatives**

- **Campaign**: Launch an extensive awareness campaign via multiple channels, including a dedicated YouTube channel.
- **Digital Outreach**: Form WhatsApp groups to inform villagers about the benefits of using Parali as livestock feed.
- **Mobile Vans**: Deploy vans with experts to educate, motivate, and assist farmers.

**Residue Management Machines**

- Provision: Provide residue management machines to farmers.
- Training: Educate farmers on proper use and maintenance for effective residue management.

**Incentivization and Subsidies**

- **Subsidies**: Subsidize transport costs for Parali, using the Pathankot model.
- **Collaboration**: Partner with dairies and leverage CSR funds to cover transport charges, making adoption economically viable.

**Procurement and Storage Centers**

- **Centers**: Establish procurement centers where the government buys Parali from farmers at Rs 1/kg.
- **Storage**: Store Parali at strategic locations like Panchayat sites, FCI sites, power plants, and dairy farms.

**District-Wide Implementation**

- **Focus**: Implement in each district, prioritizing areas with higher cattle populations.
- **Collaboration**: Work with local authorities and veterinary services for seamless execution.

# Scaling Crop Diversification in Punjab District

**Context/Background**

- Bureaucratic red tape in agriculture and air quality research.
- Resource gaps (licenses, skilled personnel, hardware).
- Stubble burning causes up to 30% of North India's winter air pollution.

**Plan of Action**

**Awareness and Capacity Building**

- Develop awareness campaigns and sensitization programs.
- Conduct workshops and training sessions for stakeholders.

**Sustainable Alternatives**

- Promote technologies like Happy Seeder, Super Seeder, Zero Drill.
- Demonstrate Rice Straw Baler, Direct Seed Rice Cultivation, PUSA Bio Decomposer.

**Soil Management and Organic Farming**

- Advocate for compost turners and soil incorporation techniques.
- Promote organic farming, including millet, cotton, and mushroom cultivation.

**Sustainable Practices**

- Encourage mulching and green energy solutions.
- Explore eco-cutlery, eco-housing, and composting.

**Policy Advocacy and Collaboration**

- Engage in policy advocacy and connect agriculture with livelihoods.
- Establish partnerships with FPOs, non-profits, cooperatives, and startups.

# Gauthans

**Context/Background**

- **Air Quality Issue**: Stubble burning significantly worsens Delhi's air quality, contributing 12-60% to pollution based on wind conditions.
- **Regional Challenge**: Predominantly occurs in Haryana and Punjab during the transition from paddy to wheat crops.
- **Current Barriers**: Existing solutions are often economically unfeasible, lack political support, and need a well-developed local industry.
- **Need for Local Solutions**: Feasible, decentralized solutions that empower local entrepreneurs are essential.

**Intervention and Plan of Action**

- **Gauthan Concept**: A five-acre plot in villages for commercial and social activities (cow rearing, composting, biofuels, handicrafts, education).
- **For-Profit Model**: Establish for-profit Gauthans to integrate agri-waste into the local circular economy, creating value from waste.
- **Pilot Project**: Set up a Gauthan in Kaithal, Haryana on rented barren land.
- **Value-Added Products**: Convert agri-waste into compost, pellets, briquettes, biogas, and sell them locally to prevent stubble burning.
- **Drone Monitoring**: Purchase a drone to monitor stubble burning in the operational village.
- **Open-Source Research**: Provide Detailed Project Reports (DPRs) for the adoption of Gauthans, including:
  - Model Gauthan setup
  - Using paddy Parali as cattle feed
  - Composting plant
  - Parali-to-briquette/pellet plant
  - Parali to biochar-based fertilizer operation (Takachar)

# Transitioning from Coal to Crop Residue in Power Plants

**Context/Background**

- **Objective**: Replace coal with crop residue (Parali) in power plants across Punjab, Haryana, and NCR.
- **Benefits**: Promote sustainable energy, reduce air pollution, and provide an economic alternative for farmers.

**Plan of Action**

**Parali Utilization Potential Assessment**

- **Evaluation**: Assess the calorific value and cost-effectiveness of Parali versus coal.

**Quantity and Logistics Planning**

- **Requirements**: Determine Parali needs for each power plant (e.g., a 500 MW plant needs 160,000 tons annually).
- **SPOC**: Establish a Single Point of Contact in each block for Parali procurement from farmer cooperatives, private enterprises, or panchayats.
- **Baling Machines**: Encourage the use of baling machines to streamline logistics

**Stubble Quality Metrics (SQMs)**

- **Standards**: Define SQMs, including calorific content, moisture, density, ash content, and crop variety.
- **Consistency**: Implement SQMs to ensure consistent Parali quality for power plants.

**Process and Technical Improvements**

- **Coal Plants**: Upgrade coal plants with scrubbers, electrostatic precipitators, and effective fly ash management.
- **Brick Kilns**: Redesign and optimize brick kiln inputs and functionality through scalable policy and engineering interventions.

**Impact**

- **Energy**: Parali has a gross calorific value comparable to domestic coal (14-15 MJ/kg) and is cheaper than imported coal.
- **Supply**: Nine power plants in Punjab, Haryana, and NCR can consume 25% of the total Parali generated.
- **Economics**: Cost of Parali delivered to power plants is comparable to domestic coal.

# Utilization of Schools for Health Measurements and STEM Education

**Background**

- **Empowerment**: Train students to use affordable ECG and PFT devices for health measurements.
- **STEM Integration**: Focus on sustainability, environment, ecology, IoT, AI, and robotics.
- **Practical Activities**: Engage in making air purifiers, masks, and air quality sensors.
- **Health Insights**: Generate regular snapshots of air quality impact on health.

**Plan of Action**

**Health Measurement Training**

- Train students in using ECG and PFT devices.
- Guide students to regularly measure cardiovascular and pulmonary health of household members.

**Air Quality Monitoring**

- Equip schools with indoor and outdoor air quality monitoring tools.
- Train students to conduct and report regular measurements.

**STEM Learning Programs**

- Develop and implement STEM modules for K-12 students.
- Focus on sustainability, environment, ecology, IoT, AI, robotics, and health assessment.

**Hands-On Activities**

- Organize workshops for making air purifiers, masks, and air quality sensors.
- Involve students, parents, and neighbors to enhance skills and awareness.

**Health Impact Assessment**

- Collect and analyze data on cardiovascular and respiratory health.
- Create regular snapshots to correlate air quality with health impacts.

**Community Engagement and Awareness**

- Conduct awareness campaigns in schools and communities.
- Foster responsibility towards health and environmental sustainability.

# Interventions at Coal plants and Brick Kilns

- **Replacing coal with crop residue in power plants**
  - Parali has gross calorific value like domestic coal at 14-15 MJ/kg.
  - Landed cost of parali delivered to power plant is comparable to domestic coal and far cheaper than imported coal
  - 9 power plants in Punjab, Haryana and NCR can consume 25% of total parali generated.
  - 500 MW plant can burn up to 160,000 tons of parali each year. For this target of 3.2 Lakh kg of parali per year per MW is needed.
  - Needs SPOC (Single Point of Contact) in each block for the power plant for parali purchase like farmer cooperatives, private Enterprises or panchayats.
  - SPOC to maximize use of baling machines to ease logistics at Rs 450 per ton.
  - Industry-defined Stubble Quality Metrics (SQMs) to be defined including but not limited to calorific content, moisture, density, ash content and crop variety for smooth processing.
- **Process and technical improvements at coal plants and brick kilns**
  - Operationalize scrubbers, run electrostatic precipitators and manage fly ash at coal plants
  - Redesign and optimize utilization of inputs and functioning of brick kilns through policy and engineering interventions that can be scale.

# Community Engagement and Awareness Programs

**Context/Background**

Enhance public awareness of air quality and promote public transit effectiveness in Delhi by installing LED screens at key bus stops, displaying bus arrival times and air quality data.

**Plan of Action**

**Identifying Key Bus-Stops**

- Analyze and identify the top 100 bus stops that handle 90% of Delhi's traffic.
- Prioritize stops based on commuter density, transit routes, and strategic importance.

**LED Screens Installation**

- Install LED screens at the identified bus stops.
- Integrate air pollution sensors to provide real-time air quality data alongside bus arrival times.

**Public Awareness Campaign**

- Launch targeted campaigns via social media, local newspapers, and community events.
- Educate the public on the benefits of using public transit to reduce air pollution and improve air quality.

**Debate and Discussion Platforms**

- Create online platforms for public discussions on air quality and public transit.
- Encourage participation through social media forums, webinars, and community initiatives.

# Information and Knowledge Dissemination

**Context/Background**
Establish a multi-disciplinary hub to generate and disseminate knowledge on environment and sustainability.

**Plan of Action**

**Multi-Disciplinary Hub**

- **Team Composition**: 10 fellows from architecture, engineering, law, and communication.
- **Roles**: Creation, coordination, collaboration, and translation of impactful research.

**Agenda**

- **Information Dissemination**: Target policymakers, quasi-judicial, and judicial bodies.
- **Open-Source Content**: Provide free-to-use, white-labeled content.
- **Digital Media Hub**: Support creators with low-cost communication tools.
- **Public Relations**: Create links with media for wider content dissemination.
- **Focus Areas**: Work across sustainability and air quality ecosystems.

**Stakeholders**

- **Government and Policy**: MPs, MLAs, bureaucrats, and public policy officials.
- **Legal Bodies**: National and State Commissions, Supreme Court, High Courts, National Green Tribunal.

# Future Directions

**Strengthen Collaborations**

- Partner with diverse stakeholders to pool knowledge, skills, and resources for innovative environmental solutions.

**Innovate and Scale**

- Focus on pioneering and expanding sustainable technologies such as advanced sensors, waste management, and green energy to achieve broader impact.

**Enhanced Policy Engagement**

- Advocate for stricter environmental regulations through active policy dialogues, ensuring effective air pollution control and sustainable practices.

**Elevate Public Health**

- Integrate public health into strategies, expand monitoring and awareness of pollution's health impacts, and promote preventive measures.

**Broaden Educational Outreach**

- Enhance STEM education with environmental themes to build an informed, eco-conscious generation.

**Align with Sustainable Growth**

- Tie projects to sustainable economic models, promoting eco-friendly agri-businesses and sustainable agricultural practices for economic and environmental resilience.

**Invest in Data-Driven Solutions**

- Support research and open data initiatives to fill knowledge gaps in air quality monitoring and pollution reduction effectiveness.

**Forge Global Partnerships**

- Actively participate in global environmental dialogues to incorporate best practices into domestic strategies, fostering unified action against air pollution.

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## Appendix



# 05. TLDR

# Ending Stubble Burning in Punjab

| Stakeholder | Type + Scope + Scale | Canvas of Solutions |
|---|---|---|
| Legislature | Public representatives (MPs, MLAs, MCs) | Implement Happy Seeder, Cow Fodder, Super Seeder, Compost, Mulch, Mushroom, Animal Beds with taxes/donations/IEC |
| Executive | Union/State Government Ministers/Technocrats | Deploy Pellet, Briquette, Torrefied Pellet, Biochar, Biofertilizer, Biogas, Syngas, Particle Board, Direct Burning, Bioethanol |
| Judiciary | Judges and lawyers at NGT, SC and HCs | Multi-scalar multi-dimensional research inputs for amicus curiae and help civil society organizations sue the state with specifics |
| Bureaucracy | Officers at state, district, tehsil and village | Enable fleet management of government ag-machines and project monitoring matching each acre of stubble to solution |
| Businesses | Corporates, MSME and village enterprises | Encourage new products like paper, packaging, plates, cutlery and novel fuels like straw-ethanol and dry digestion biogas |
| Industries | PSUs, Conglomerates, Manufacturers | Scientific research portability and technology transfer assistance |
| Startups | Startups, incubators, accelerators | Technology readiness level augmentation for 20+ solutions |
| Finance | Banks, NBFCs and money lenders | Treat parali as commodity (12-month working capital upfront) |
| Farmers | Farmer Producer Organizations | Creating Gauthans and Self-Help Group-led cottage industries |
| Civil Society | Charitable and faith-based institutions | Work with grassroot non-profits for best practice deployment |
| Academia | Scientists, researchers and practitioners | Create collaboratives and collectives for equipment and data |
| Media | Journalists, influencers, social media | Spread white-labelled solution information for content creation |

**Public Communication**

Citizen-lead AQI measurement

Collaborative state for public problem solving

Organized response for stubble burning

Powering thermal power plants through rice straw

**Government Writings and Documents**

Air pollution abatement (2016)*

Solid waste management (2016)*

Delhi Water Plan (2015-2025)*

Delhi air pollution solutions (2017, Firstpost)

C40 Clean Air Plan 2020 and updates*

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## Appendix



# 06. Technical Note

# Glossary

- Biomass co-firing: Burning biomass with coal in boilers to reduce the carbon footprint.
- G-16 coal: Internationally sourced coal used in Thermal Power Plants.
- Gross Calorific Value (GCV): Total energy in a fuel when completely combusted.
- Hybrid-rice: High-yield rice strain with high silica, not suitable as fuel.
- Pelletization: Compressing material into pellet shapes.
- Binders: Substances that help pellets stick together.
- Pellet: Cylindrical object made through pelletization.
- Torrefaction: Mild pyrolysis to improve biomass as fuel.
- Pyrolysis: Decomposition of organic materials by heating without oxygen.
- Pyrolysis: Decomposition of organic materials by heating without oxygen.
- Briquettes: Compressed blocks of biomass used as fuel.
- Boiler: Device that heats fluids to produce steam or hot fluid.
- Biochar: Charcoal from biomass used for soil amendment.
- Biogas: Biofuel from organic waste decomposition.
- Brick kilns: Furnaces for baking bricks, fueled by coal or biomass.
- $CO_2$ sequestration: Capturing and storing $CO_2$ to mitigate climate change.
- LCA models: Life Cycle Assessment models for environmental impact.
- Phenol, furan, toluene: Chemical compounds from biomass or coal combustion.

# Technology Development and Description

**Pelletization Technology**

- Prevalent for biomass like coconut, sugarcane, and mustard.
- Customized process for hybrid-rice straw.
- Energy-efficient silica extraction and fly ash upselling.
- Patentable process.

**Non-Torrefied Pellets**

- Shredded and compressed biomass; binders improve properties.
- Process optimization reduces costs, enables multi-crop usage.
- Burnt in industries and thermal power plants as coal replacement.

**Co-Firing Mandates for Power Plants**

- 2024-25: 5% biomass pellets blend.
- 2025-26: 7% biomass pellets blend.
- Specific mandates for different mill types.

**Torrefied Pellets**

- Mild pyrolysis (200-320 °C) reduces volatile material, increases carbon.
- Higher energy density, improved fuel quality.
- Suitable for thermal power plants with higher input temperature.

# Chemical Properties of Rice Straw

| Property | Rice Straw | Mustard Stalk |
|---|---|---|
| GCV (kcal/kg) | 3200 | 3700 |
| Fixed Carbon (%) | 11% | 14% |
| Volatile Material (%) | 72% | 73% |
| Ash (%) | 18% | 13% |
| Moisture (%) | 8-10% | 8-10% |
| Sand (%) | 2% | 2% |
| Size | 90 mm Logs, 18 mm Pellets | 90 mm Logs, 18 mm Pellets |
| Area | Punjab, Rajasthan, Haryana, Western UP, MP | - |
| Usage | Boilers, furnaces, power plants, brick kilns | - |

# Research and Development

**Waste-to-Value Extraction**

- Projects with universities and industries on silica extraction, ash handling, and by-products from parali burning.
- Collaboration on Biomass Derived Hard Carbon Anodes for Sodium Ion Batteries.

**Multi-Scalar Applied Industrial Research**

- Government lab partnerships to scale pellet plants across India and South East Asia.
- Optimizing models for other biomass materials.

**Hardware Improvements**

- Ongoing optimization of drying, machining, and tooling.

**IT & Technology**

- Digitization of operations for efficiency.
- Geotagging and satellite data for compliance and carbon credit documentation.

**Proprietary Data, Indices, and Models**

- Developing image recognition models for stubble and pellet quality.
- Utilizing LCA models to minimize emissions.

**Satellite-Based Data Science**

- High-resolution satellite images for monitoring and biomass yield estimation.
- Collaboration with VegaMX for accurate data.

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## Appendix



# 07. Preventing Stubble Burning

# Preventing Stubble Burning

**Aim**
- Identify solutions to reduce, eliminate, and eradicate stubble burning in Punjab
- Improve Delhi-NCR air quality

**Approach**
- Solutions derived from extensive discussions with experts and practitioners

**Stakeholders**
- Government of Punjab
- Government of India
- Government of Delhi
- Private market players (Punjab and NCR)
- Civil society actors (district and village levels in Punjab)
- Academic experts (Delhi, India, global)
- Media and social media (print, electronic, digital)
- Courts (NGT, SC, HC)

# Why Address Stubble Burning?

Unclean air affects 600 million people in North India

Stubble burning in Punjab is a significant contributor

# Delhi world's most polluted city

**TOXIC** India slips to 155 among 178 countries on environment performance index, Capital pips Beijing to be city with dirtiest air

Chetan Chauhan

NEW DELHI: It's no surprise that pollution is a perpetual problem in India. But it's definitely disheartening to hear that India has slipped 32 ranks in the global Environment Performance Index (EPI) 2014 to rank a lowly 155 and its capital Delhi has earned the dubious tag of being the world's most polluted city.

A comparative study of 178 countries on nine environmental parameters released earlier this month by the US-based Yale University shows that one of the world's fastest growing economies is a disaster on the environmental front.

What's worse, India's pollution levels could be playing havoc with the health of its citizens. "A bottom performer on nearly every policy issue included in the 2014 EPI, with and water resources, India's performance lags most notably in the protection of human health from environmental harm," said a statement issued by Yale.

The study described India's air pollution as the worst in the world, tying with China in terms of the proportion of population exposed to average air pollution levels exceeding World Health Organisation (WHO) thresholds.

A deeper look at the data gathered by a Nasa satellite showed that Delhi had the highest particulate matter (PM) 2.5 pollution levels followed by Beijing. Delhi, with 8.10 million registered vehicles, has repeatedly beaten the Chinese capital on particulate matter pollution.

The high PM2.5 pollution caused by high vehicle density and industrial emissions is the reason for the dense smog that has been engulfing Delhi during the winter months in the health implications. And while Beijing's infamous smog has hogged headlines and prompted government action, even led to the announcement of rewards for cutting back on pollution, the dangers in Delhi have been largely ignored.

According to a study by the Harvard International Review, every two in five persons in Delhi suffer from respiratory ailments. The Lancet's Global Health Burden 2013 report termed air pollution the sixth biggest human killer in India. The WHO last year termed air pollution carcinogenic.

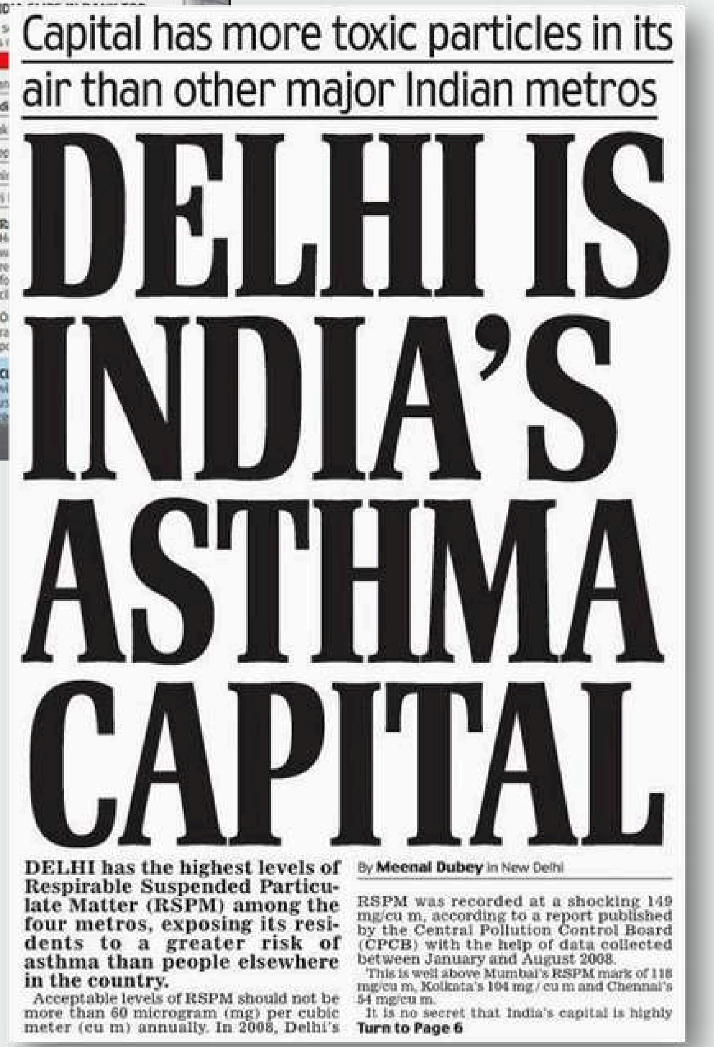
Particles smaller than 2.5 microns in diameter (PM2.5 in shorthand) are fine enough to lodge deep in human lung and blood tissue and cause diseases ranging from stroke to lung cancer, the Yale study said.

CONTINUED ON PAGE 8 » BREATHING POISON

**CAPITAL BREATHES UNEASY**

Tops global cities with worst air pollution

1. NEW DELHI, INDIA
2. BEIJING, CHINA
3. CAIRO, EGYPT
4. SANTIAGO, CHILE
5. MEXICO CITY, MEXICO



Capital has more toxic particles in its air than other major Indian metros

# DELHI IS INDIA'S ASTHMA CAPITAL

**DELHI has the highest levels of Respirable Suspended Particulate Matter (RSPM) among the four metros, exposing its residents to a greater risk of asthma than people elsewhere in the country.**

Acceptable levels of RSPM should not be more than 60 microgram (mg) per cubic meter (cu m) annually. In 2008, Delhi's

By Meenal Dubey in New Delhi

RSPM was recorded at a shocking 149 mg/cu m, according to a report published by the Central Pollution Control Board (CPCB) with the help of data collected between January and August 2008.

This is well above Mumbai's RSPM mark of 118 mg/cu m, Kolkata's 104 mg / cu m and Chennai's 54 mg/cu m.

It is no secret that India's capital is highly

Turn to Page 6

# Variability and Impact of Pollution

Pollution varies by location, month, and time

Lack of continuous, rigorous source apportionment

Hyperlocal insights show significant variations in pollution levels


The Times of India New Delhi,08,May-2014

Delhi air worst in the world

Packed With Fine Particles That Damage Heart, Lungs: WHO

SUBCONTINENT'S DIRTY AIR

Hold your breath, smog is here early

HOW SAFE ARE WE?

CAUSE FOR CONCERN

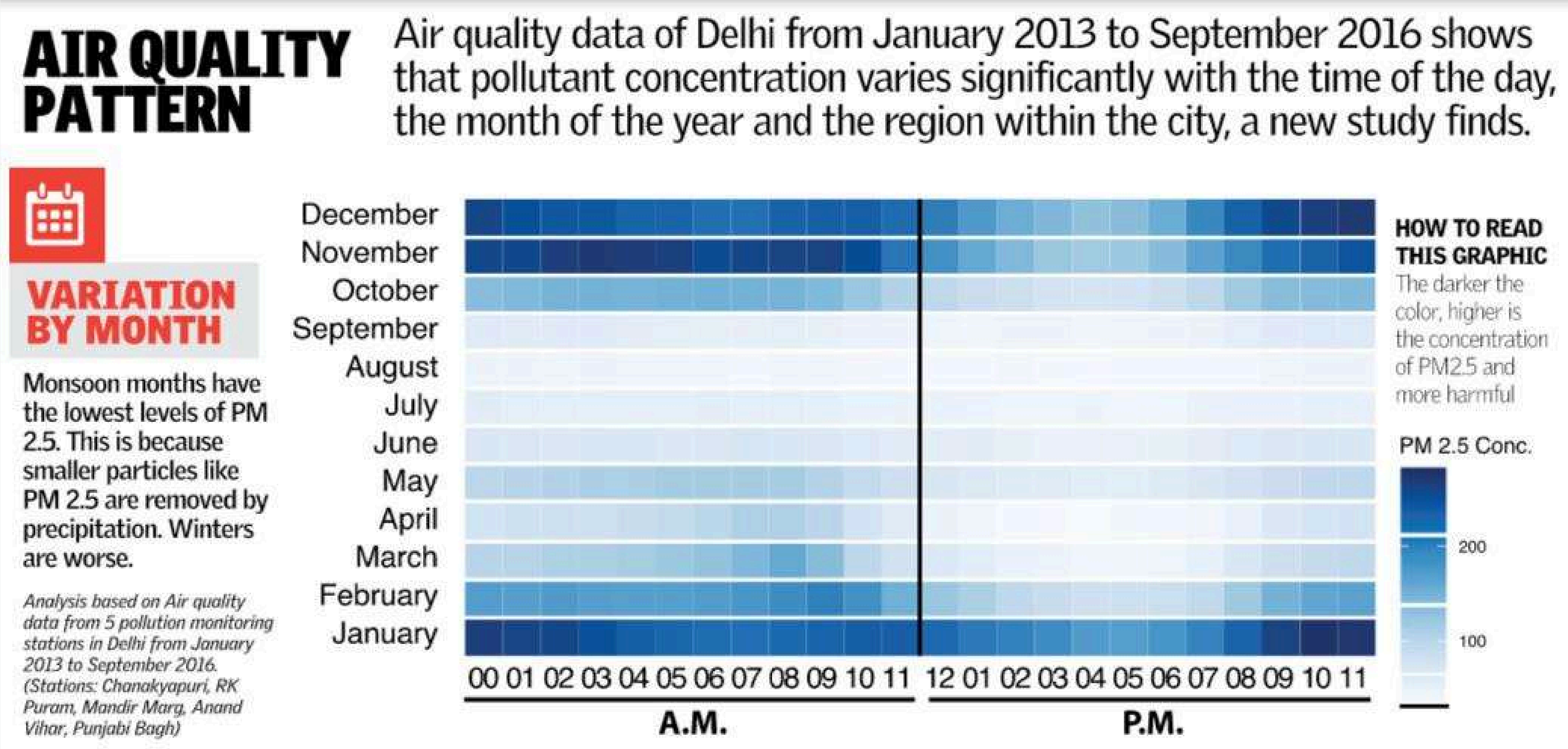
Air at public places badly polluted

TOI Ties Up With CSE For Reality Check At School, Hospital & Mall With Shocking Results

CHECKING IT OUT

# Winter Effects and Meteorology

Stubble burning impacts are exacerbated by winter meteorological conditions



# Scale of the Problem

30 lakh hectares under rice in Punjab

222 lakh tons of Parali generated annually

90% burned, burning Rs 4000 Crores of value

Sustainable management could increase farmer revenue by 10%

# Challenges and Improvements

Information
knowledge
resource
administrative
voter rationality

**many constraints** → **some solutions**

Good heuristics
Use pilots
Take and use feedback
Participate, communicate, go slow

# Identifying Failures and Solutions

**Market Failures:**
Externalities, asymmetric information, market power, public goods

**Policy Failures:**
Inaction, wrong politics, poor design, implementation issues

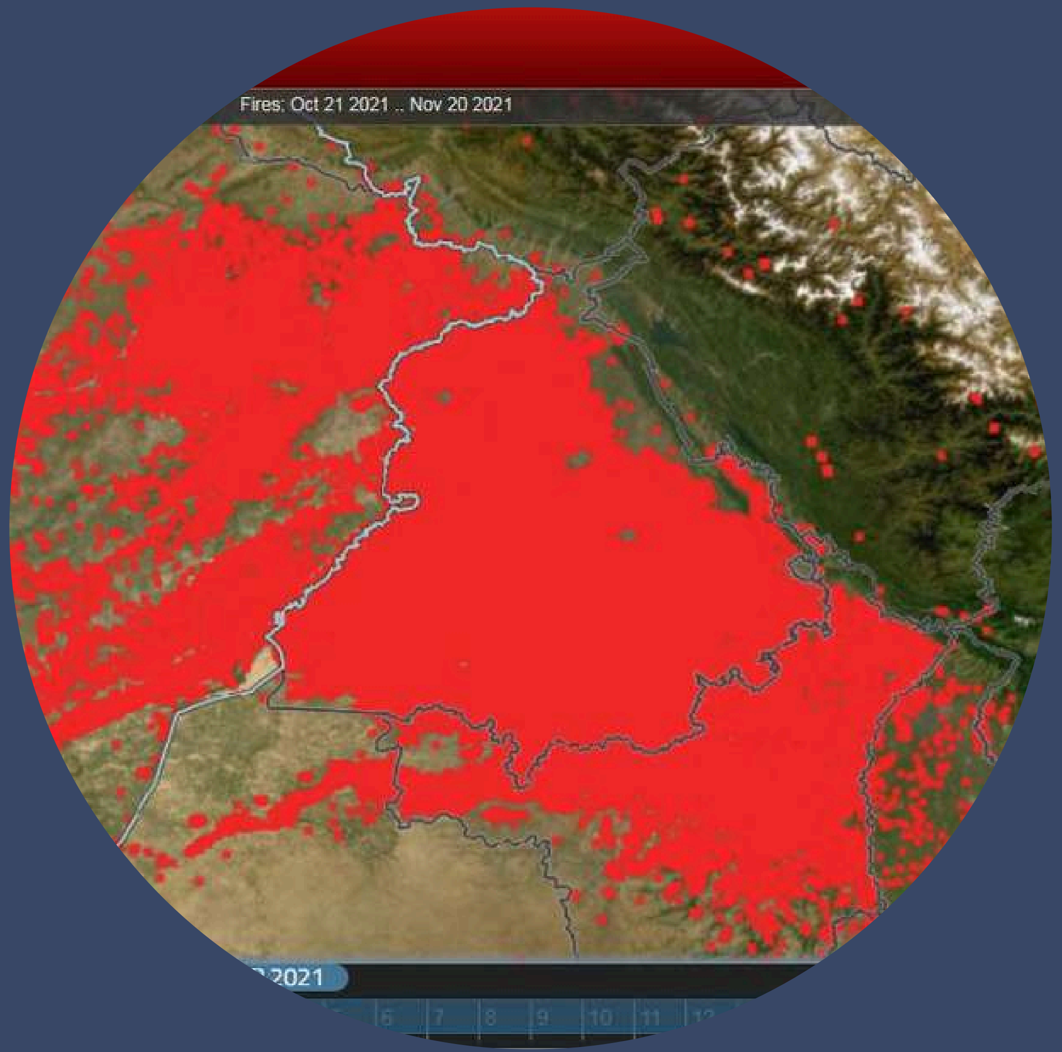
**Policy thinking**
Is there a market failure?
Does proposed intervention address market failure?
Can we effectively implement proposed intervention?

# Origins of the Problem

Green revolution, MSP, free electricity leading to groundwater depletion

Government bans through laws on subsoil water and on early paddy transplant shift harvest times

Burning seen as easy solution by farmers



# Guiding Principles

Freedom, prosperity, sustainability

Economic growth and sustainable development

Governance revolution, societal evolution

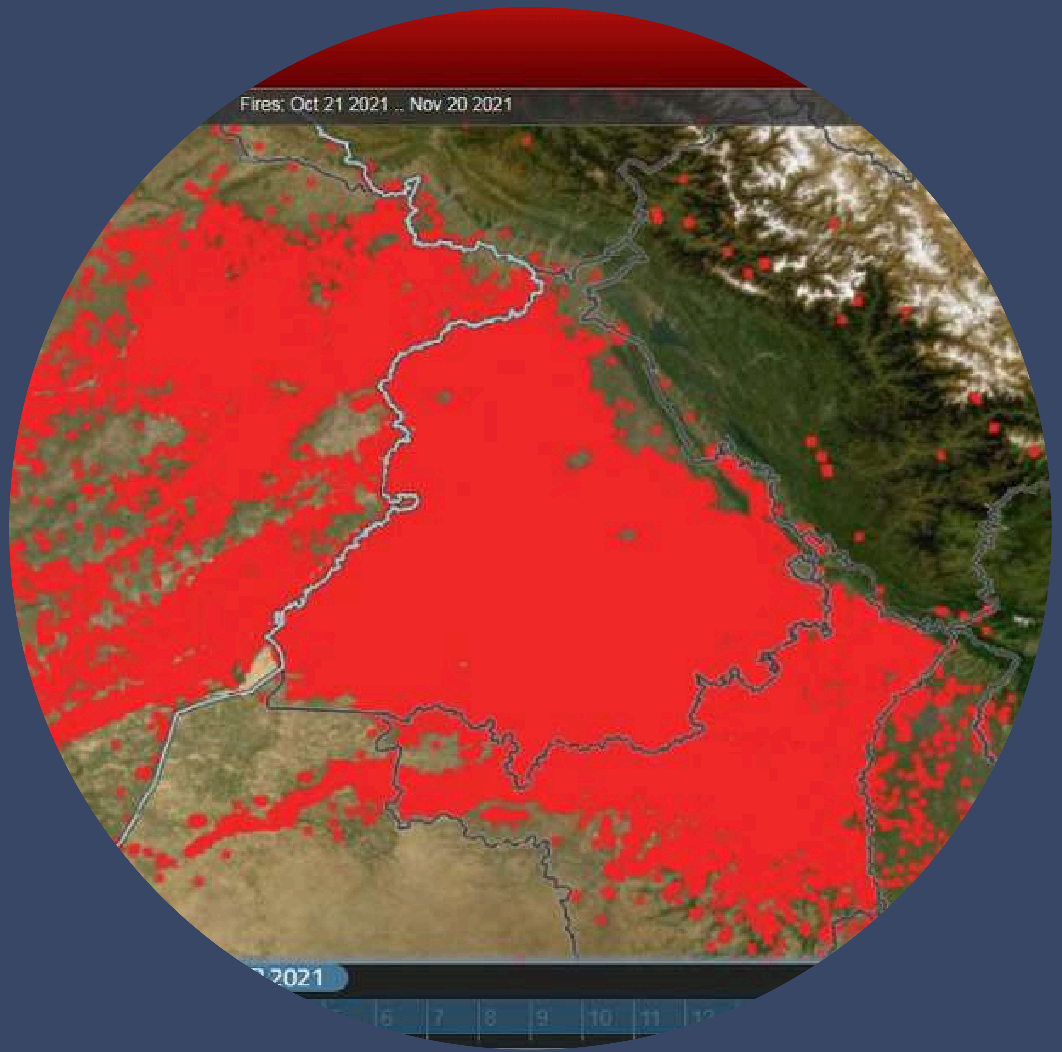
# Dimensions of the Problem

Income risk reduction through paddy

Lack of knowledge on stubble management

Dairy farms' reluctance to use paddy straw

Absence of market-based, self-sustaining ecosystem



# Multi-Dimensional Solutions

Market-based solutions

Favourable unit economics for farmers

Simultaneous implementation of solutions

Area-specific approaches

# Detailed Solution Approaches

**Farmer Education and Outreach:**

Massive media presence

Educate on ecological and economic alternatives

**Monitoring and Prevention:**

Air quality monitoring

Satellite data based burning at district level

Local level for ground truthing

**Prevent Field Burning**

Field-level teams to prevent burning

Civil penalties, not criminal

Engage fire brigades to extinguish farm fires

# Sustainable Alternatives to Burning

Happy Seeders, Super Seeder, Zero Drill, in-situ planting

**In-situ** as Animal Feed, Compost and Mulch

**Ex-situ** as pellets for burning, products such as paper, packaging

Government Incentives such as buy-back, no-burning additional MSP

# In-situ management

**Happy Seeders**
Cost: Rs 1.50 to 1.60 lakh
Function: Ploughs standing paddy residue
Requirement: High horsepower tractor

**Subsidies**
80% subsidy for farmer groups
50% subsidy for individual farmers

**Super Seeders**
Cost: Rs 2 lakhs (introduced in 2018)
Function: Ploughs residue and sows seeds in one operation
Requirement: 65 hp tractor
Technologically superior to Happy Seeder

**Farmer Concerns**
Limited time availability
High cost of machines
Machines idle for most of the year

**Recommendations**
- Maintain Agri-farm equipment subsidies
- Extend subsidy application deadline to end of November

**Farmer Education**
Cost savings on fertilizers and weed killers (Rs 1500-2500/acre)
Increased wheat yield (up to 10%)
Investment worthwhile for 25-30 days of use, covering 200 acres

# Composting and Mulching

**Pusa Microbial Solution**
Developed by Indian Agricultural Research Institute (IARI)
Decomposes crop residue into manure in 15-20 days
Capsules contain 8 strains of fungi
Enhances soil fertility, reduces fertilizer use
Cost: Rs 20 per pack

**Challenges**
Farmer pushback on-site composting
Method complexity
Longer composting time in winter

**Composting Technologies**
Use Pusa decomposer
Vermicompost
Other composting methods

**Sustainable Cycle**
Sell back fertilizer to farmers at Rs 6-8/kg
Aim for a self-sustaining cycle with long-lasting results

**Implementation Needs**
Media amplification
Stakeholder dialogue
No-cost distribution to farmers and collectives

**Government Support for Composting**
Establish 5-acre composting sites in each Panchayat
Form Gauthans/farmer cooperatives or allow entrepreneurs
Provide access to barren government land
Buy Parali from farmers at Rs 2/kg (including transport)

# Government Incentives

**MSP for Rice (2021)**
MSP: Rs 1888/quintal (Rs 18.88/kg)
Total Procurement: 162.33 lakh metric tons
Nominal Value: Rs 29,787 Crores

**Incentive Plan**
Additional Incentive: Rs 100/quintal for no-burning at village level
Over Existing Benefit: Rs 2/kg for sustainable disposal of parali
Monitoring: Use satellite data and ground teams
Condition: Entire village loses incentive if any burning occurs
Impact:
Strong incentive to avoid burning
Societal pressure to enforce compliance
Govt Outlay: Rs 812 Crores if 50% villages comply
Govt Outlay: Rs 1624 Crores if 100% villages comply

**Additional Buyback Plan**
Buyback Rate: Rs 1/kg for unsold parali
Storage: Govt sites, power plants, FCI godowns, barren lands
Condition: Buy at half market cost to prioritize other uses first
Distribution: Sell at cost to market forces after two months
Purpose: Allow market players to manage storage and purchase logistics for composting, fodder, power plants, industry, briquetting, etc.

# Farmer Education and Outreach

Tell farmers about the ills of burning fields

Burning seems cheaper, but increases other farming costs

Educate them about existence of Ecological, Nature-Centric and Farmer-Friendly alternatives

Give alternatives which have favourable Unit economics

# Multi-Level Approach

**Village Level**

Panchayats passing anti-stubble burning resolutions
Examples: Pathankot (325/421), Nawanshahr (341/467)
Monitoring and action at:

- Region
- District
- Zila Parishad
- Block
- Village

**District Level**
Utilize stubble as fodder in gaushalas
Encourage use of Happy Seeders, mulching, and redesigned harvesters
Promote in-house composting, waste-to-energy, restart Bhalswa composting plant
Use agricultural residue as industrial fuel (e.g., 10% biomass in thermal power)
Address transport and storage issues
Support startups converting stubble to energy (e.g., Farm2Energy)
Develop ecosystem for bio-pellets, biochar, torrefied pallets

**State Level**
Emphasize persuasion over coercion in air governance
Repeal 2009 water conservation laws (Punjab/Haryana)
Delhi should fund positive initiatives in Punjab/Haryana
Civil penalties for edge-case polluters
Prioritize cost-effective air quality monitoring and source apportionment
Create and deploy fertilizers using agricultural residue
Develop markets for alternative products (plates, fabrics, paper)

# Long Term Aspects

## Break Rice/ Wheat duopoly

Promote crop diversification
Disseminate information on alternative crops
Support farmers in growing vegetables, fruits, flowers
Provide subsidies for agro-forestry
Conduct info sessions on perma-forest concepts

## Address Free Electricity

Follow Gujarat Model:

- Two lines per village: one for 24-hour village electricity, one for agri pumps
- No agri pumps on village line to ensure uninterrupted village supply

2 hours of electricity on agri pump line

## Better design of Agri Machinery

Collaborate with agri machinery companies to:
Reduce crop residue in fields
Manage stubble better
Develop bailing machines
Design machines for harvesting and processing millets

## Promote Millets, Dalhan, Oilseeds

Ensure MSP for these crops
Develop drought and pest-resistant seeds
Focus on higher yield varieties
Foster a market for these crops
Encourage consumption of millets (e.g., promote millets as 1 meal per week)

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## Appendix

01. Mentorship and Team
02. Ecosystem Insights
03. Product Development
04. Air Pollution Abatement Proposals
05. TLDR
06. Technical Note
07. Preventing Stubble Burning

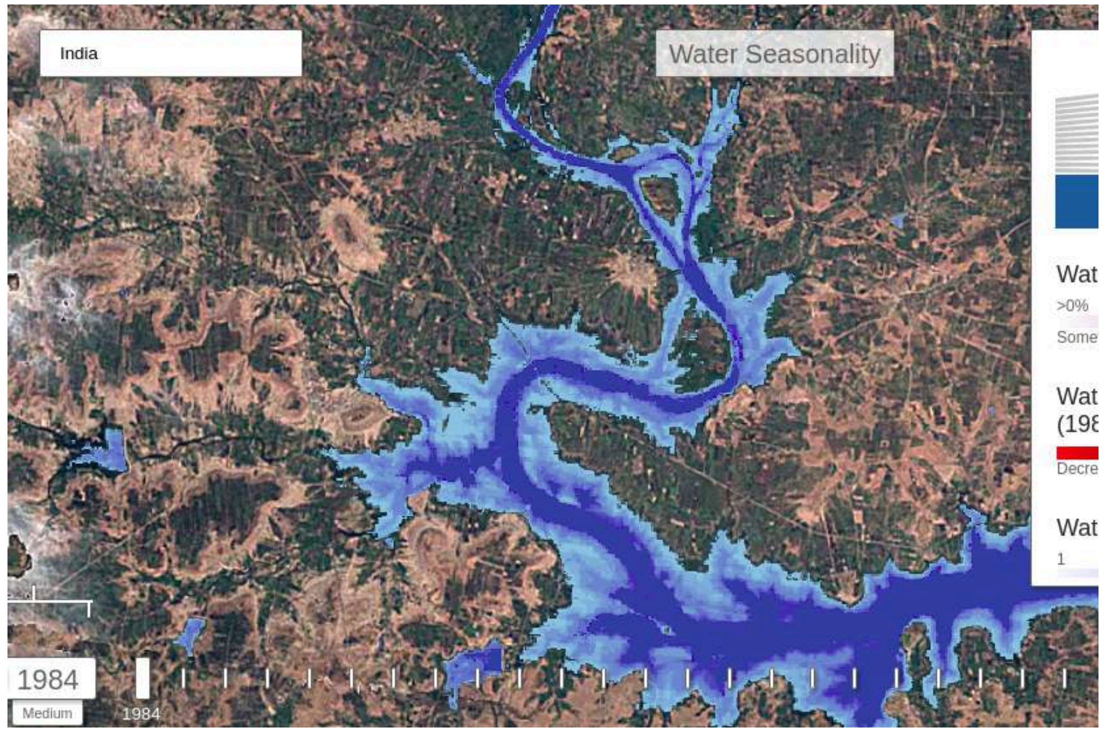
# 08. Data/ML/AI

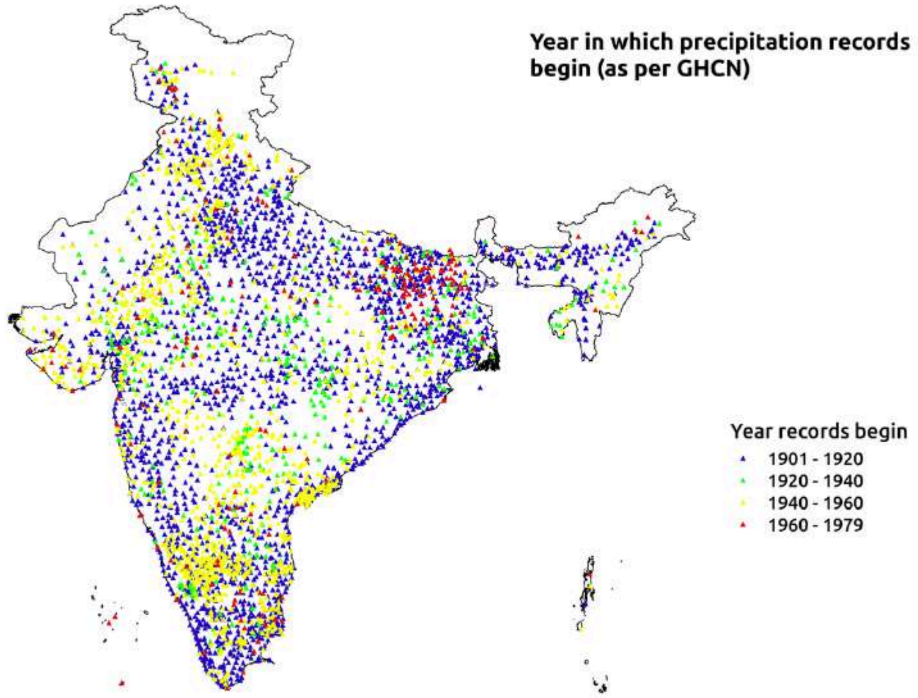
09. Professional Learnings
10. Outreach

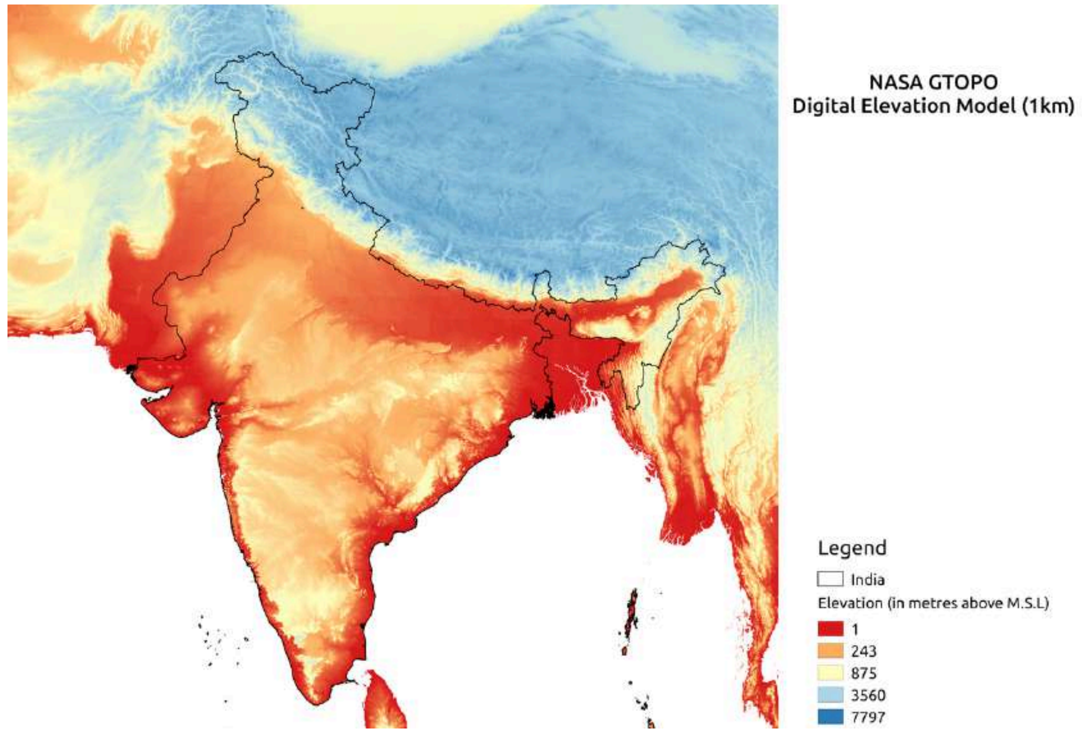
# Strategic Open Data (Remote Sensing)

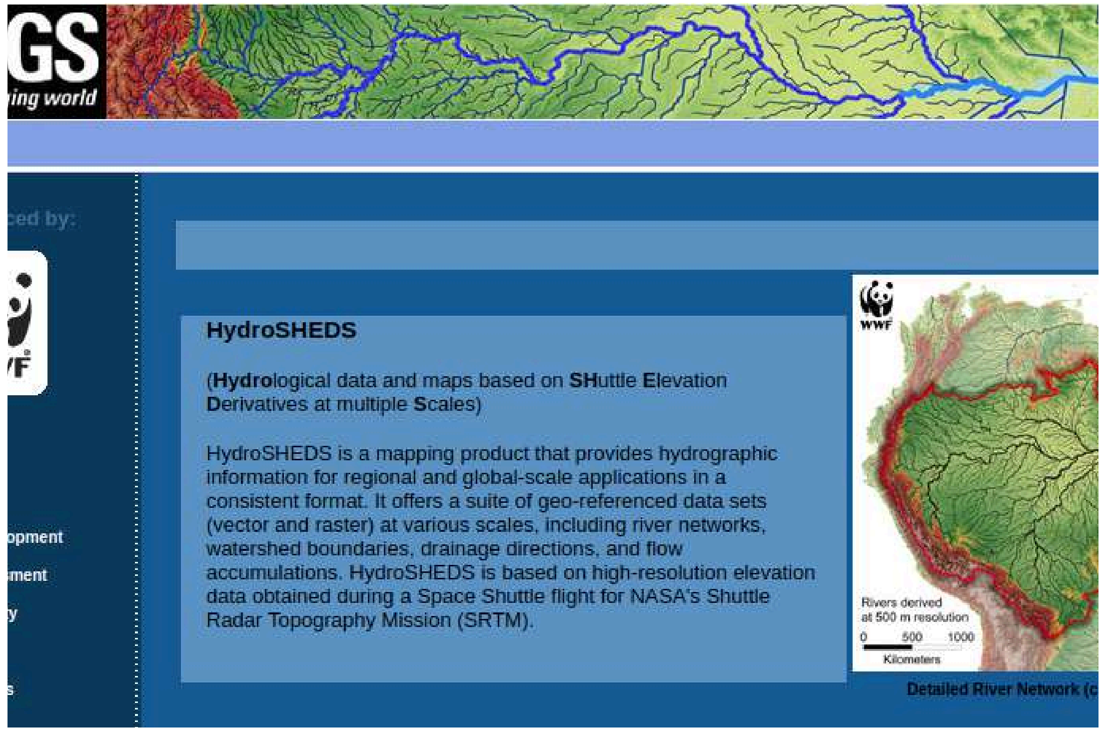
## State (Open Data)

- Data Segmentation
- Data Demand
- APIs
- Trusted Intermediaries
- Example
  - International agencies
  - National governments
  - Space companies



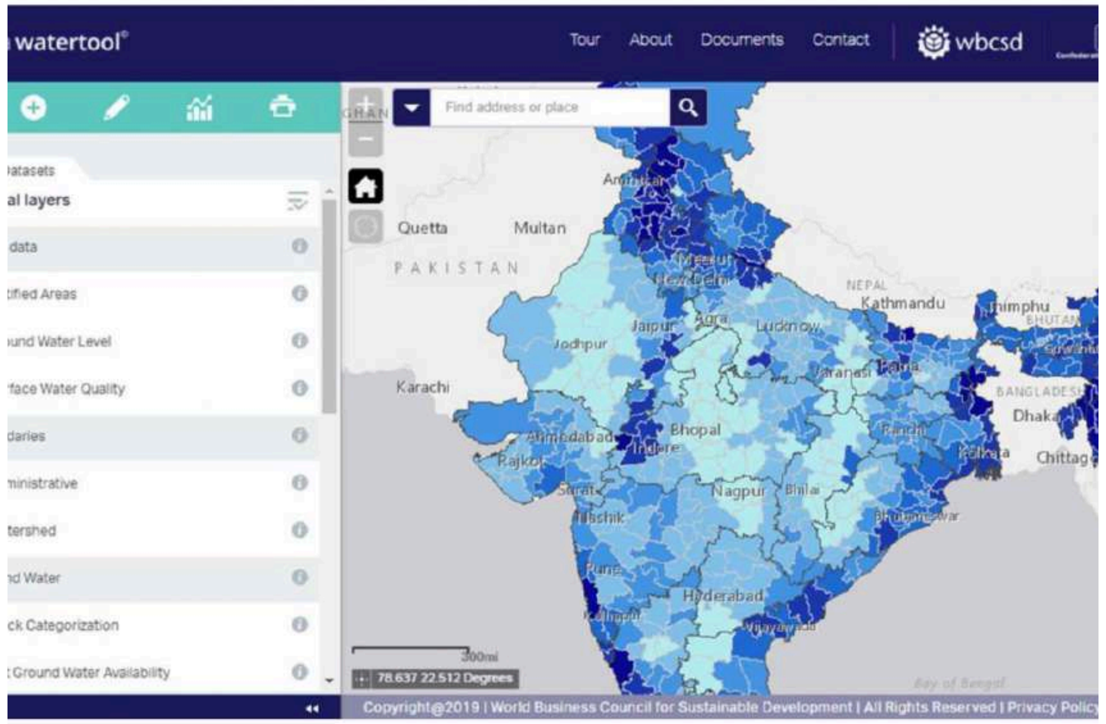



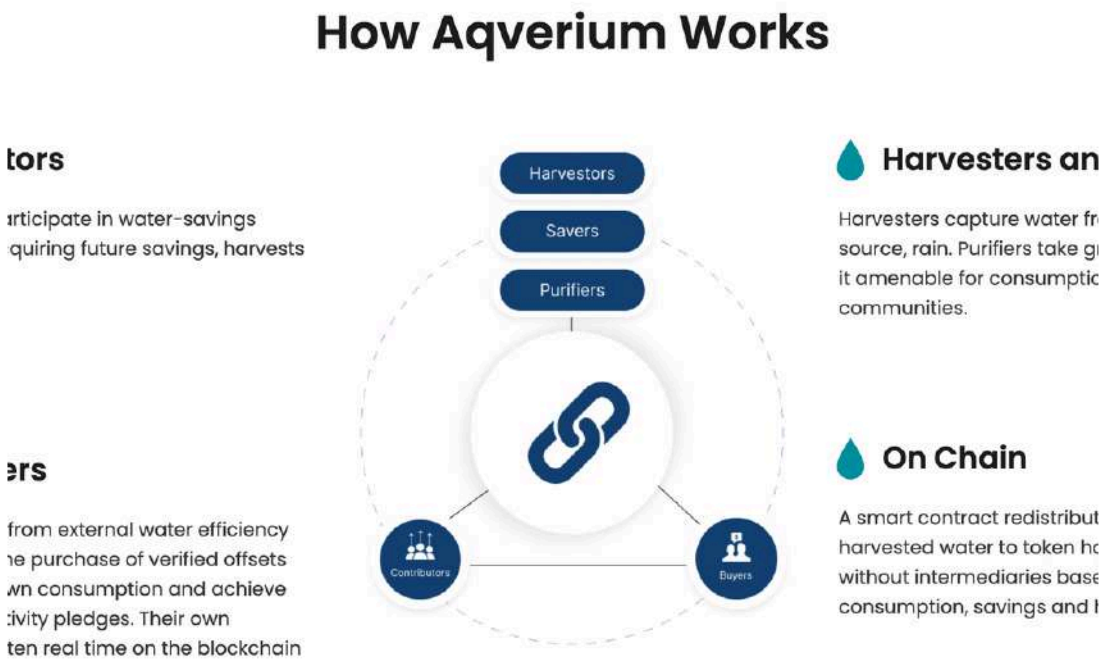



# Strategic Open Data (Physical Sensing)

## Market (Smart City)

- Data Collaborative
- Data Stewardship
- Prizes and Challenges
- Corporate Social Responsibility
- Example
  - City governments
  - Water companies working with states
  - Non-profits and multi-lateral agencies

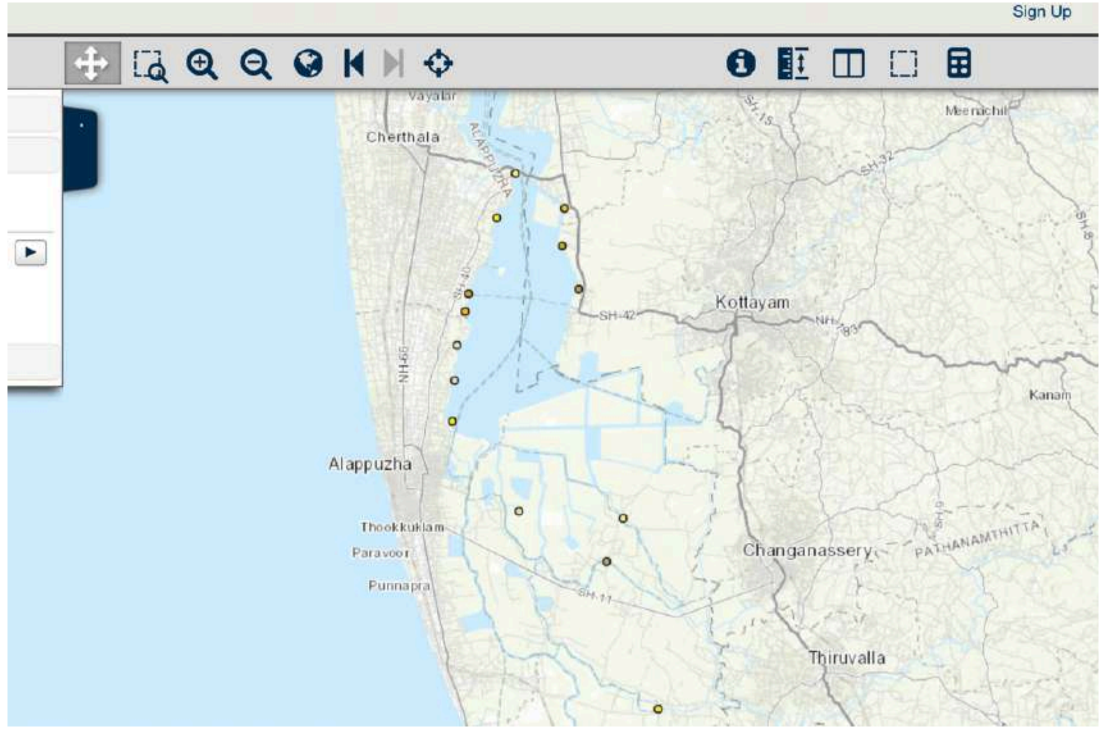



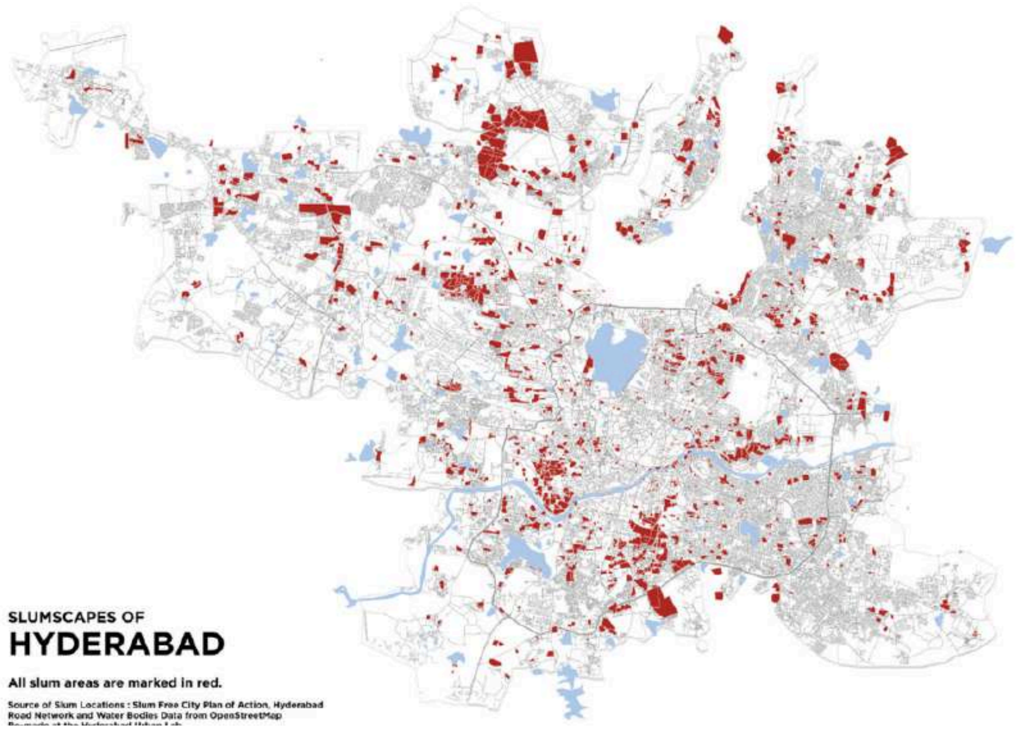



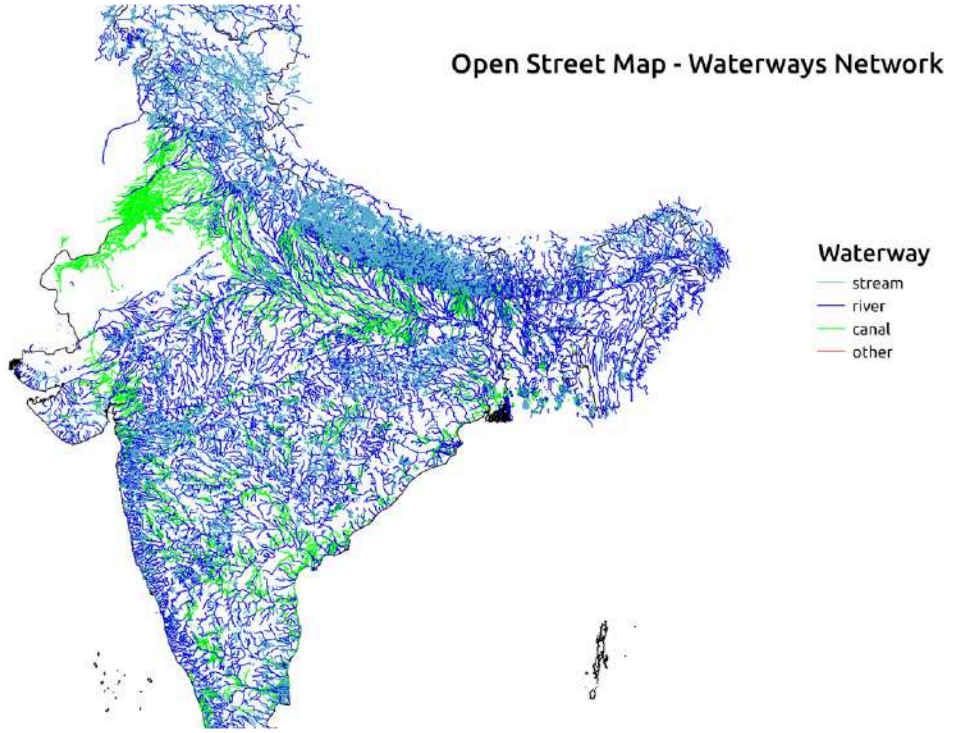
# Strategic Open Data (Social Sensing)

## Society (Hackable City)

- Data Cooperatives
- Research Partnerships
- Communities and Movements
- Example
  - Open Street Mapping
  - Community Water Mapping
  - Academic and research collaborative



Home (All Data) Punjab Haryana Insights Resources

# Stub The Stubble

Stub the Stubble is a platform to understand the problems and solutions related to stubble burning in India.

** The current Kharif season started on 15th September 2023. New data is added to the system as soon as it is available to us. Last updated at 11:11 PM, 28 Dec 2023.*

## PUNJAB

| Today | Yesterday | This Week | This Month | This Season |
|---|---|---|---|---|
| 0 | 2 | 9 | 264 | 38228 |

## HARYANA

| Today | Yesterday | This Week | This Month | This Season |
|---|---|---|---|---|
| 0 | 5 | 17 | 309 | 3116 |



[Stub The Stubble](#)

( Public interest Project of Saroja.Earth )

# Different Satellite Platforms

| | Planet | Sentinel | Aqua & Terra (MODIS instrument) | Suomi NPP & NOAA-20 (AVIIRS instrument) |
|---|---|---|---|---|
| Resolution | 3 m | 10m for visible and 20 m for Short Wave IR which is an indicator for burn event | 1km | 375 m |
| Revisit Time | 1 day | 5-6 days | 4 times a day | 4 times a day |
| Spectral bands | 8 spectral bands | 12 spectral bands (Sentinel has an advantage here) | Contain special spectral bands which detect active fires. Near real time data available | Contain special spectral bands which detect active fires. Near real time data available |
| Cost | INR 600 per sq km (Commercial) INR 0.0001 per sq km (Academic Research) | Free | Free | Free |

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## Appendix

# Collaboration and Problem Solving

## Gowers's Weblog

Mathematics related discussions

« A Tricki issue | Background to a Polymath project »

### Is massively collaborative mathematics possible?

Of course, one might say, there are certain kinds of problems that lend themselves to huge collaborations. One has only to think of the proof of the classification of finite simple groups, or of a rather different kind of example such as a search for a new largest prime carried out during the downtime of thousands of PCs around the world. But my question is a different one. What about the solving of a problem that does not naturally split up into a vast number of subtasks? Are such problems best tackled by $n$ people for some $n$ that belongs to the set $\{1, 2, 3\}$? (Examples of famous papers with four authors do not count as an interesting answer to this question.)

## Doing science online

by Michael Nielsen on January 26, 2009

*This post is the text for an invited after-dinner talk about doing science online, given at the banquet for the* ***Quantum Information Processing 2009*** *conference, held in Santa Fe, New Mexico, January 12-16, 2009.*

Good evening.

Let me start with a few questions. How many people here tonight know what a blog is?

How many people read blogs, say once every week or so, or more often?

How many people actually run a blog themselves, or have contributed to one?

How many people read blogs, but won't admit it in polite company?

Let me show you an example of a blog. It's a blog called **What's New**, run by UCLA mathematician **Terence Tao**. Tao, as many of you are probably aware, is a Fields-Medal winning mathematician. He's known for solving many important mathematical problems, but is perhaps best known as the co-discover of the **Green-Tao theorem**, which proved the existence of arbitrarily long arithmetic progressions of primes.

## Theory of Change

I am increasingly convinced that the difference between effective and ineffective people is their skill at developing a theory of change. Theory of change is a funny phrase — I first heard it in the nonprofit community, but it's also widespread in politics and really applies to just about everything. Unfortunately, very few people seem to be very good at it.

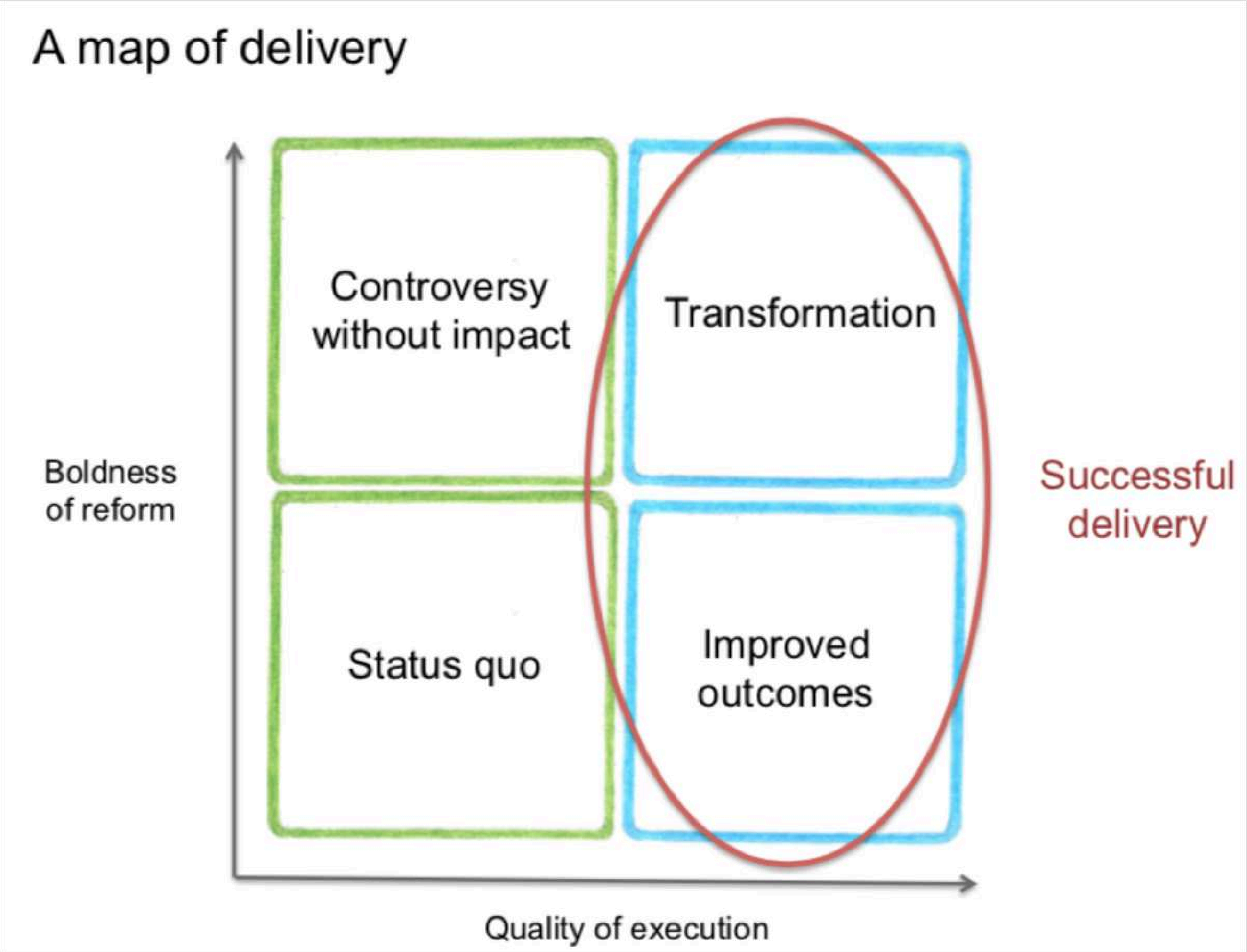
Let's take a concrete example. Imagine you want to decrease the size of the defense budget. The typical way you might approach this is to look around at the things you know how to do and do them on the issue of decreasing the defense budget. So, if you have a blog, you might write a blog post about why the defense budget should be decreased and tell your friends about it on Facebook and Twitter. If you're a professional writer, you might write a book on the subject. If you're an academic, you might publish some papers. Let's call this strategy a "theory of action": you work *forwards* from what you know how to do to try to find things you can do that will accomplish your goal.

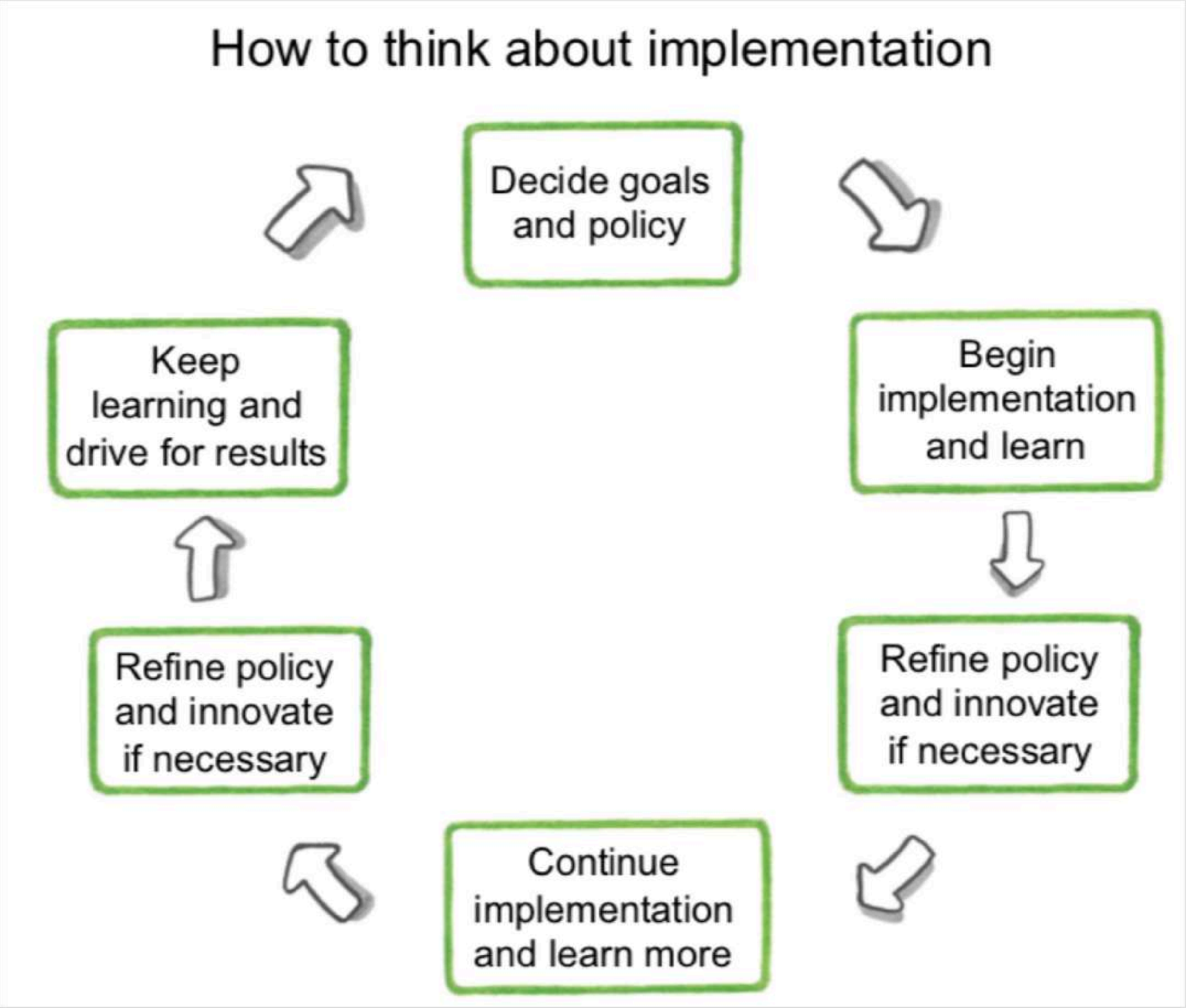
A theory of change is the opposite of a theory of action — it works backwards from the goal, in concrete steps, to figure out what you can do to achieve it. To develop a theory of change, you need to start at the end and repeatedly ask yourself, "Concretely, how does one achieve that?" A decrease in the defense budget: how does one achieve that? Yes, you.

# Technology as Ideology


# Innovation as Stack

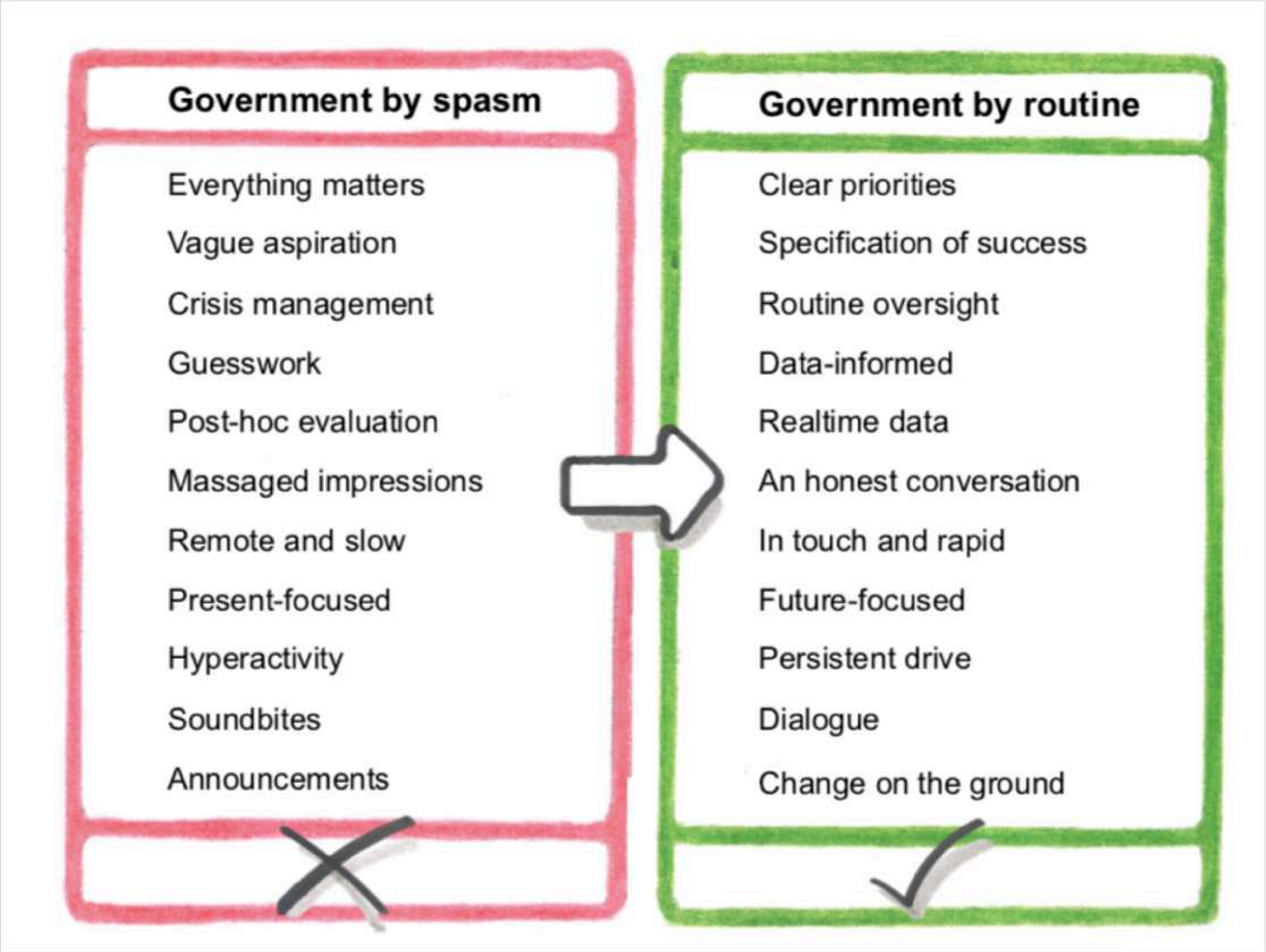
# Learning


A map of delivery
Controversy without impact
Transformation
Status quo
Improved outcomes
Boldness of reform
Quality of execution
Successful delivery

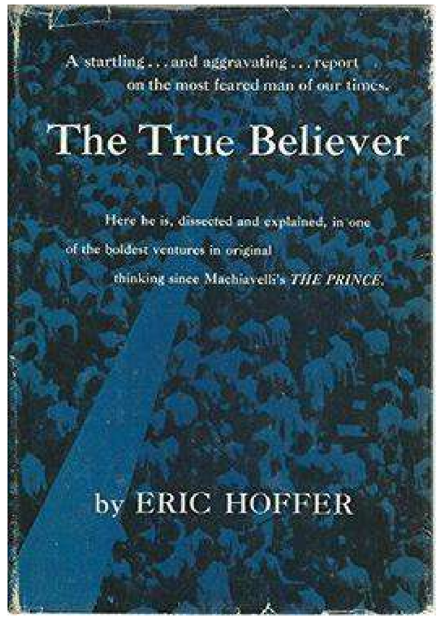

How to think about implementation
Decide goals and policy
Begin implementation and learn
Refine policy and innovate if necessary
Continue implementation and learn more
Refine policy and innovate if necessary
Keep learning and drive for results

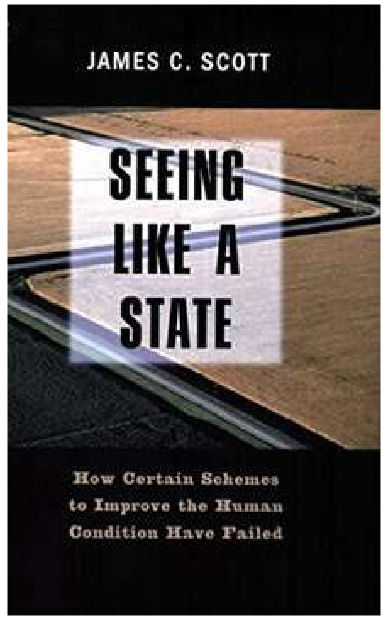
# Preaching

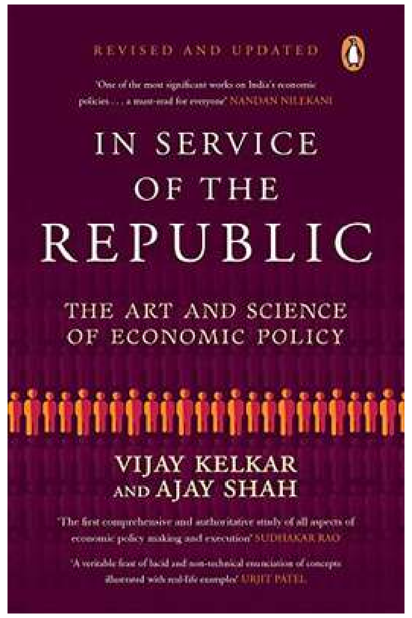

Five paradigms of system reform
Trust and altruism
Hierarchy and targets
Choice and competition
Devolution and transparency
Privatisation
Capability, Capacity and Culture
Performance Management
Strategic Direction
Community engagement and mobilization

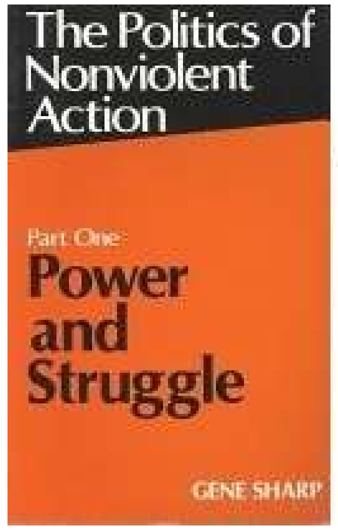

Government by spasm
Everything matters
Vague aspiration
Crisis management
Guesswork
Post-hoc evaluation
Massaged impressions
Remote and slow
Present-focused
Hyperactivity
Soundbites
Announcements
Government by routine
Clear priorities
Specification of success
Routine oversight
Data-informed
Realtime data
An honest conversation
In touch and rapid
Future-focused
Persistent drive
Dialogue
Change on the ground

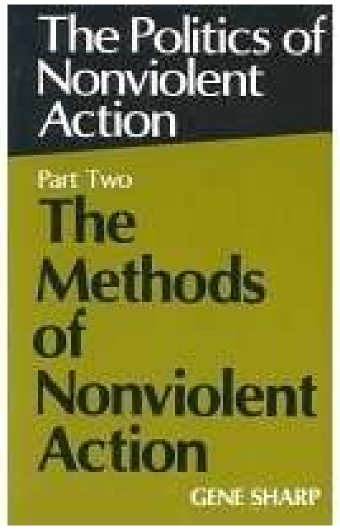
# Some interesting books, people and ideas

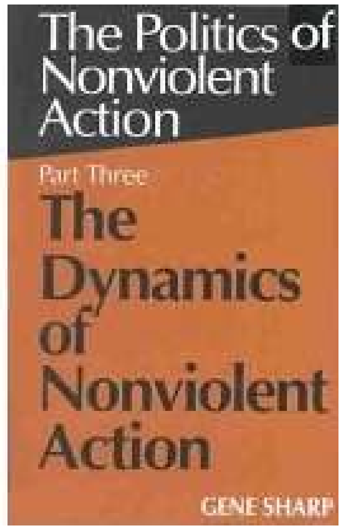


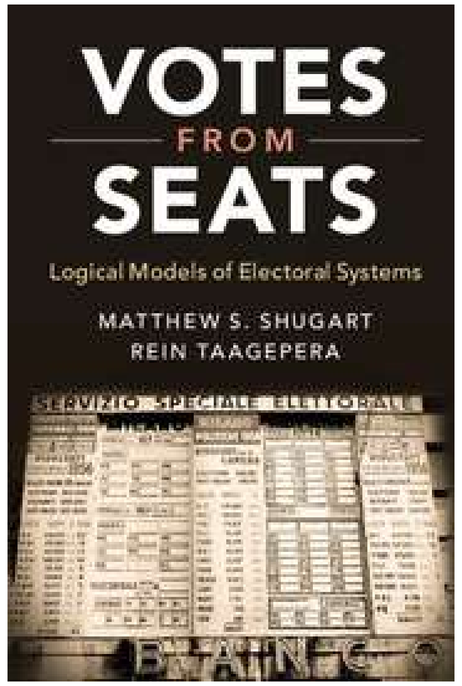



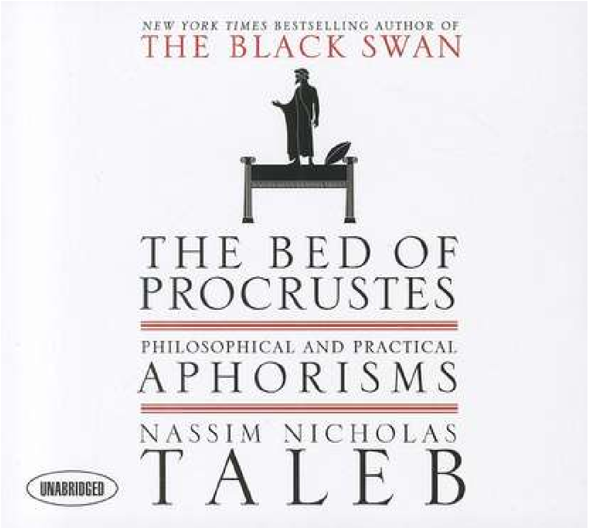



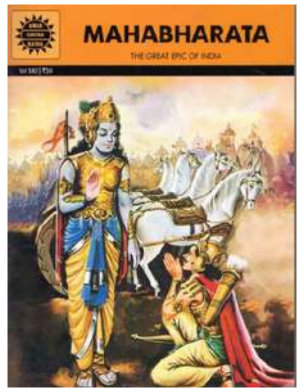



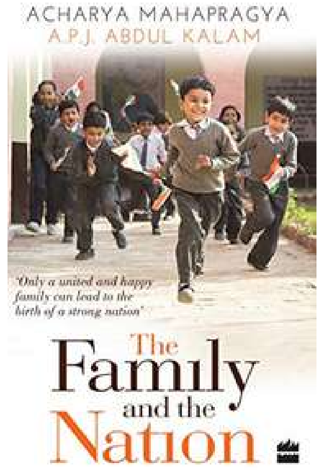







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## Appendix



# 10. Outreach

# Academia


Talk at IIT Bombay


Making Biochar with pyrolysis machine at Princeton


Cosyslab Symposium on Computational Gastronomy, IIIT Delhi


Stanford MBA Global Study Tour

SSS-NIBE Conference March, 2024

Biomass to Hydrogen Car and facility with Princeton professor

# State


WRI-Jalandhar DC coordination


Indo-Israel Accelerator

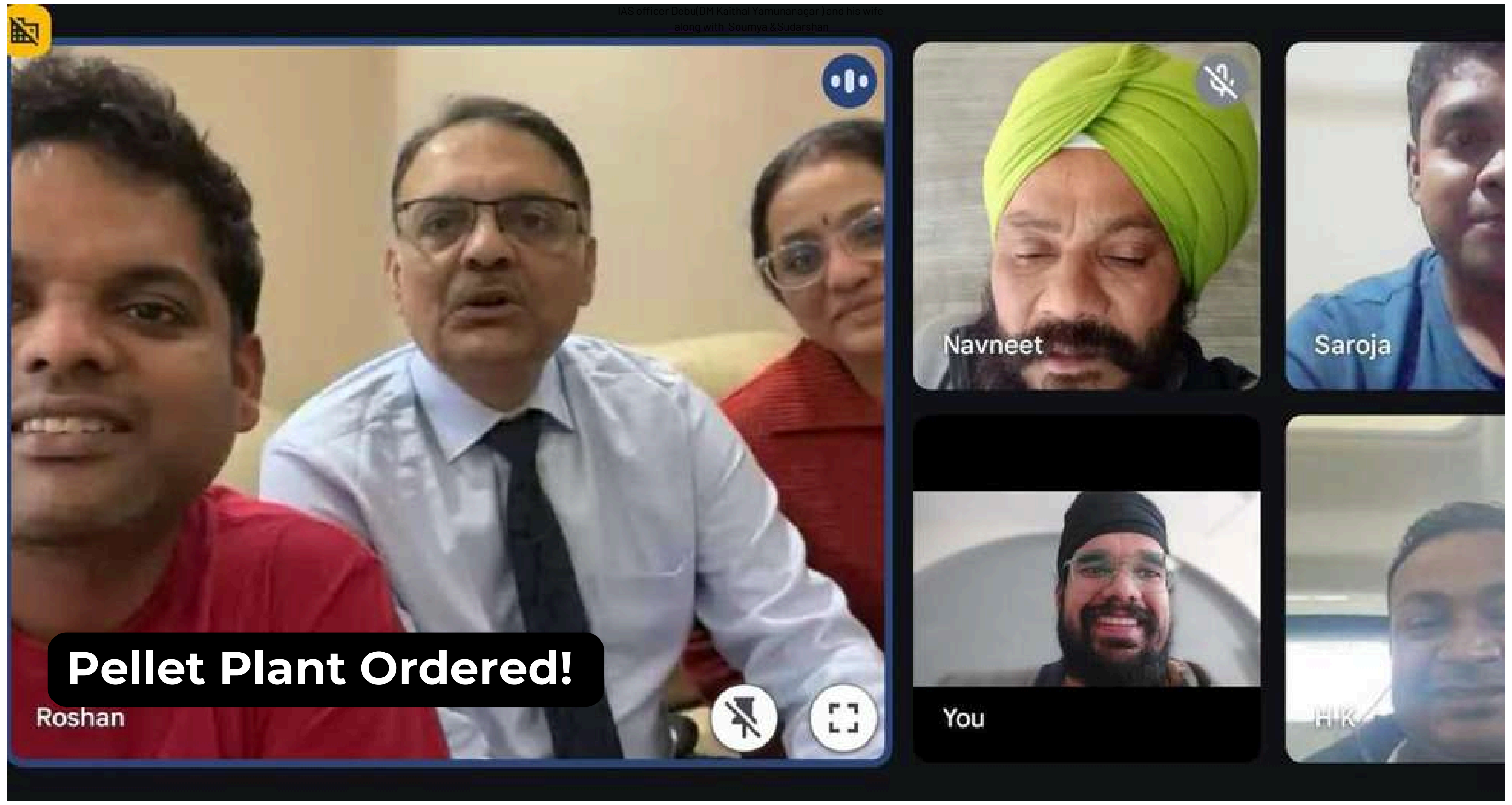

Talk with Smart City Jalandhar


Stanford University Saroja.Earth event

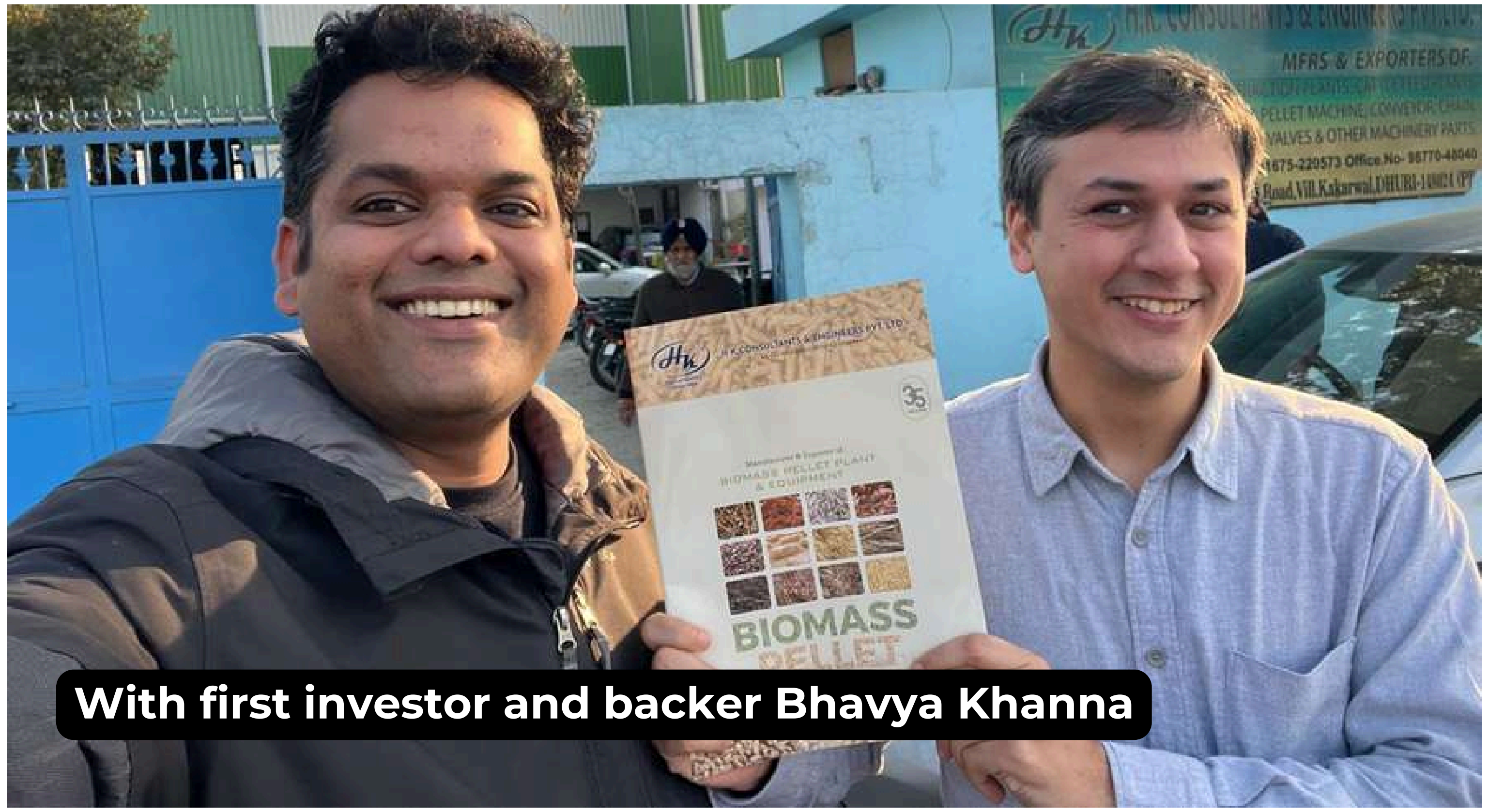
# Market


PHD: Punjab, Haryana, Delhi


With well-wishers, mentors and brothers!



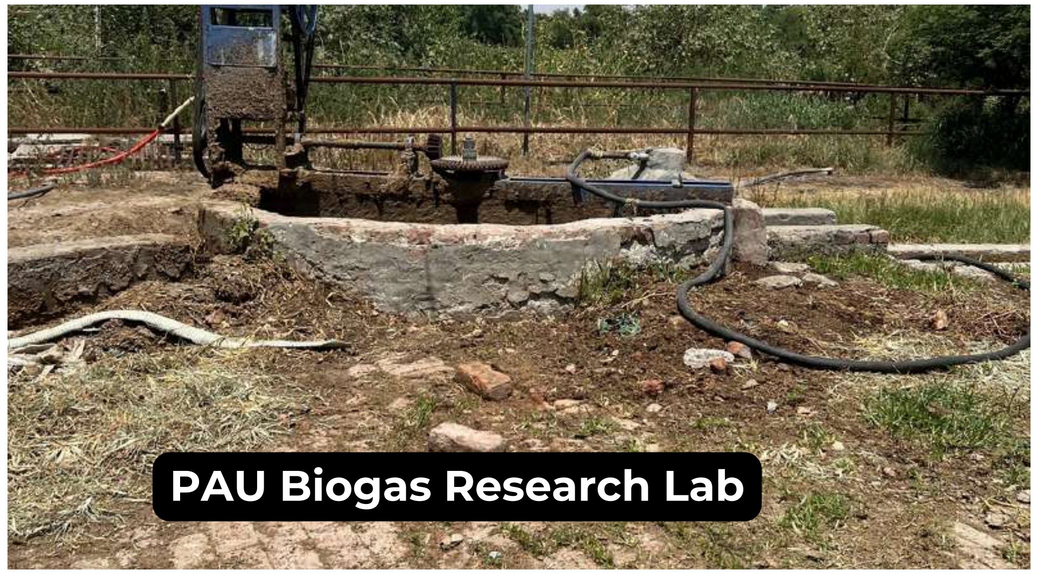
Pellet Plant Ordered!



With first investor and backer Bhavya Khanna

# Makers

Continuous Pyrolysis Plant



PAU Biogas Research Lab

RHA to Silica Plant

Pellet mould fabrication in process

# Society


With friend, scholar and historian Haripal


Sanjhi Sikhiya Collective


Team: Happy, Anurag, Seerat, Gunraagh!

To the Punjabis outside Punjab, see you back soon!