Ending Stubble Burning through Societal Interventions

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Why

- Work on pollution abatement (sustainability, resilience and health)
- Focus on air pollution caused by stubble burning in North India
- Move to all sources and forms of pollution (air, water, energy and earth)
- Value conscious India requires value creating solutions

What

- Process patentable net-zero circular rice-based waste-to-value creation
- Collect hybrid-rice straw → Make biofuel → Sell to industrial boilers
- Extract silica from biomass fly ash to close loop
- Create new product lines (torrefied pellets, biochar, paper, cutlery)
- Research pathways to extract hard carbon for sodium-ion batteries
- Open data/software creation and public problem solving to build rice waste-to-value industry using LCA, satellite and government data

Who, Where, When & How

- Princeton, Stanford and NSIT Alumnus with a mesh network of collaborators
- Start in October 2023 in Punjab, scale across India and then SE Asia/Europe
- Socially innovative technology process pilot with farmers, academia and industry
- Capitalise regulatory opportunity with district, state and national government
- Strategic technology and IT deployment for media, PR and publicity
- Grant-funded or collaborative industrial R&D for new product-line creation
- Implement with partners for scale

OUR THEORY OF CHANGE

Foster collaboration
between diverse individuals and institutions with useful specialized knowledge and canvases of impact to create strategic and open data, information, products and services.

Design and implement
do a pilot, proof of concept and proof of stake projects as a social or technical innovation that has a high probability of scale through government, private sector or civil society.

Large Scale impact
through targeted manufacturing/management, research/governance and design/operations to create novel air quality measurement and abatement solutions currently at low technological or social readiness.

Stress-test, monitor, evaluate and refine
the aforementioned process to run research and deliver results that wouldn’t be possible otherwise!

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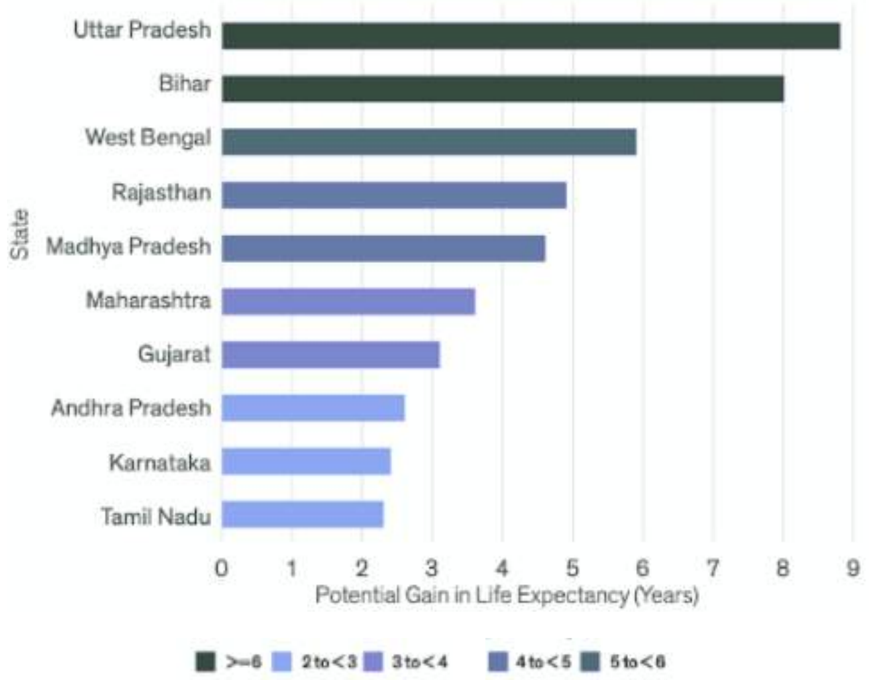
AIR POLLUTION IN INDIA

- Ranks second globally in pollution.
- Annual particulate pollution increased by 67.7% (1998-2021).
- PM2.5 pollution reduces life expectancy by 5.3 years on average.
- Delhi's pollution shortens lives by 11.9 years.
- All 1.3 billion Indians exceed WHO pollution guidelines.
- 67.4% live in areas exceeding India's own air quality standard.
- Particulate pollution poses the greatest health threat, reducing life expectancy by 5.3 years.



Potential gain in life expectancy from reducing PM2.5 concentrations from 2021 levels to the WHO guidelines in the 10 most populous Indian states

AIR POLLUTION MEASUREMENT PROBLEMS

- **Sensor Limit: does not measure beyond 999**
- **Height of Sensors: Placed 30 ft above ground level.**
- **Use of Foreign Technology: most sensors use Chinese technology which increases costs.**
- **Variation in Pollution: varies by location, time, month and season.**
- **Outdated AQI: AQI is fine-tuned for Chinese and European contexts.**
- **Lack of Facilities: lack of licensing, computers etc.**

AIR POLLUTION ABATEMENT

- **Air Pollution Abatement: Problems and Solutions**
  - **Air pollution is a major challenge in India.**
  - **Non-profit organisations play a crucial role.**
  - **Economic viability and effectiveness of solutions are vital.**
  - **High costs hinder implementation of pollution control technologies.**
  - **India needs cost-effective solutions and public-private partnerships.**

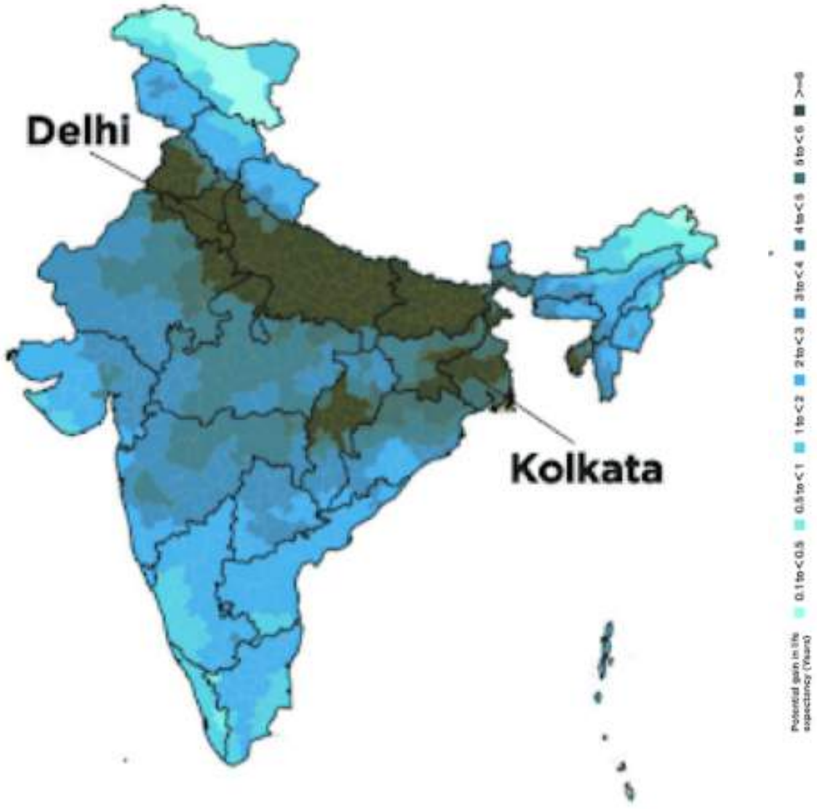
- **Targeted Abatement at Various Levels**
  - **Individual, city, and community-level initiatives are crucial.**
  - **Lack of awareness and coordination is a challenge.**
  - **Encourage green commuting options and urban planning.**
  - **Facilitate workshops for sustainable practices.**

AIR POLLUTION ABATEMENT

- **Enhancing Awareness of Air Quality**
  - **Public awareness campaigns are essential.**
  - **Public transit promotion can reduce air pollution.**
  - **Collaboration among stakeholders is crucial.**
  - **Implement creative awareness campaigns using social media.**
  - **Partner with schools for air quality education.**

AIR POLLUTION IN NORTH INDIA

- Northern India faces severe air pollution issues.
- Particulate matter (PM2.5) levels exceed WHO guidelines.
- Average life expectancy shortened by 8 years.
- 38.9% of India's population resides in this region.
- PM2.5 pollution reduces life expectancy by 5.3 years.
- Residents experience a 4.5-year reduction compared to national standards.
- Air pollution surpasses other health threats like cardiovascular diseases.
- Pollution-related deaths and health impacts are significant.



Potential gain in life expectancy from permanently reducing PM2.5 from 2021 concentrations to WHO guidelines

STUBBLE BURNING

- **Stubble: the straw and crown of plants(non-edible) left on the soil surface (agricultural field or orchard) after harvest or left after the crop(rice).**
- **Stubble burning: the practice of deliberately setting fire to crop residue left in the fields after harvesting.**
- **Impact: Increases levels of aerosol, SO2, and NO2 in the air, deteriorates soil health leading to low yield, loss in biodiversity, climate change and so on.**

Farmers in Haryana and Punjab engage in burning nearly 35 million tonnes of parali, significantly contributing to the elevated air pollution levels in Delhi-NCR. This crop residue burning results in the release of substantial emissions, including 149 million tonnes of CO2, 9 million tonnes of carbon monoxide, 0.25 million tonnes of sulphur oxides, and 1.28 million tonnes of particulate matter.

THE PARALI PROBLEM

- "Parali": rice straw residue left over after harvesting rice, a common agricultural by product.
- Rice Parali Problem in Punjab:
  - After rice harvest, Parali (rice straw) burning contributes to air pollution.
  - Punjab faces a significant challenge due to extensive rice cultivation (4.8m hectares approx.)
  - In 2020, Punjab recorded 35,204 cases of crop residue burning.
  - Parali burning releases harmful pollutants like PM2.5, affecting air quality.

Source: NASA Earth Observatory

ALTERNATIVE USES FOR PARALI

Biochar

Bioethanol

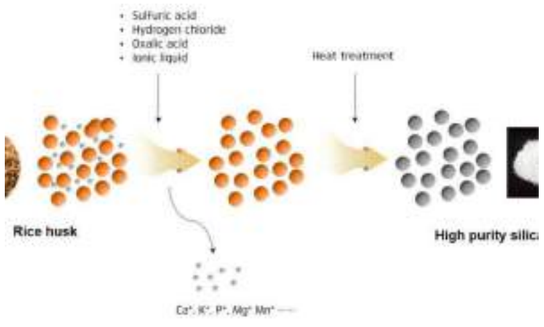
Biogas

Pellets

Cutlery, Paper & Packaging

Animal Feed

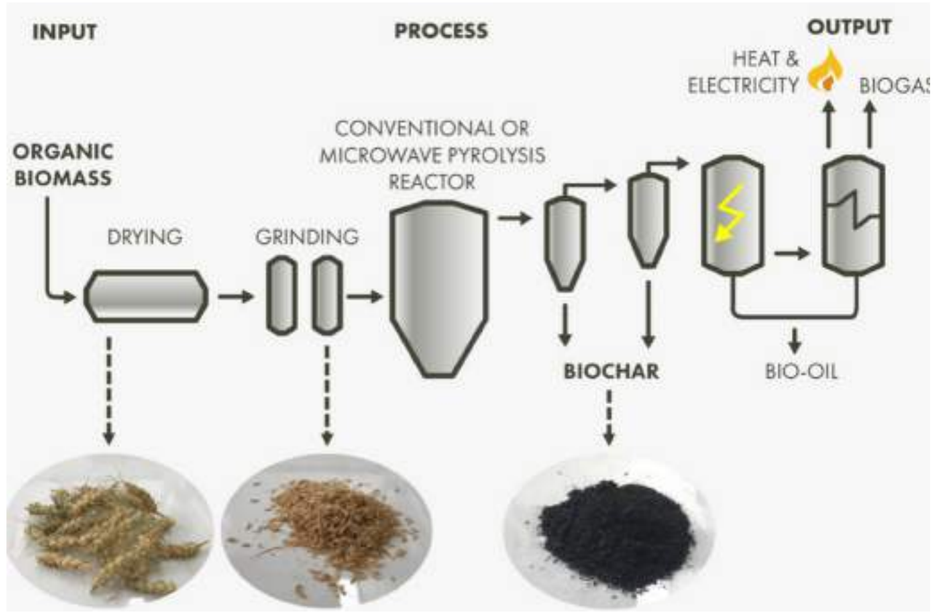
Mushroom cultivation



Rice Husk to Silica

BIOCHAR

Produced from Parali through Pyrolysis, it's stable carbon for soil improvement, fertilizer, and wastewater remediation.



RESEARCH AREAS TO EXPLORE

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

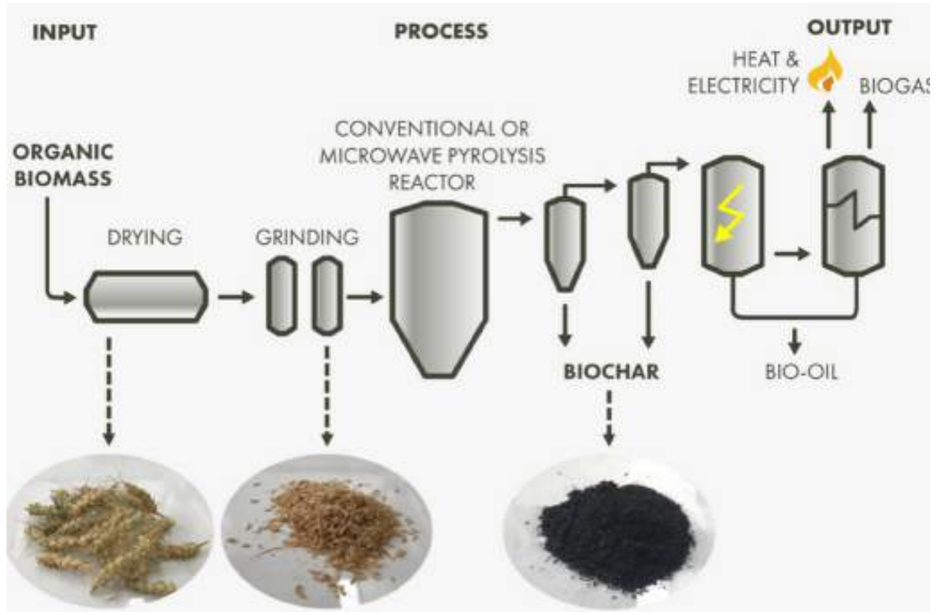
- Evaluating the overall environmental impact of large-scale biochar production, including energy consumption and emissions.
- Understanding market dynamics and price trends is crucial to assess the economic feasibility of biochar production and identifying potential market niches

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.

2G ETHANOL

Second generation (2G) ethanol: Utilizes cellulose and hemicelluloses from rice straw for bioethanol, reducing greenhouse gas emissions significantly compared to gasoline.



RESEARCH AREAS TO EXPLORE

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 .
- Water-efficient and energy-efficient processes are crucial for sustainability and reducing the environmental footprint

Applied Science

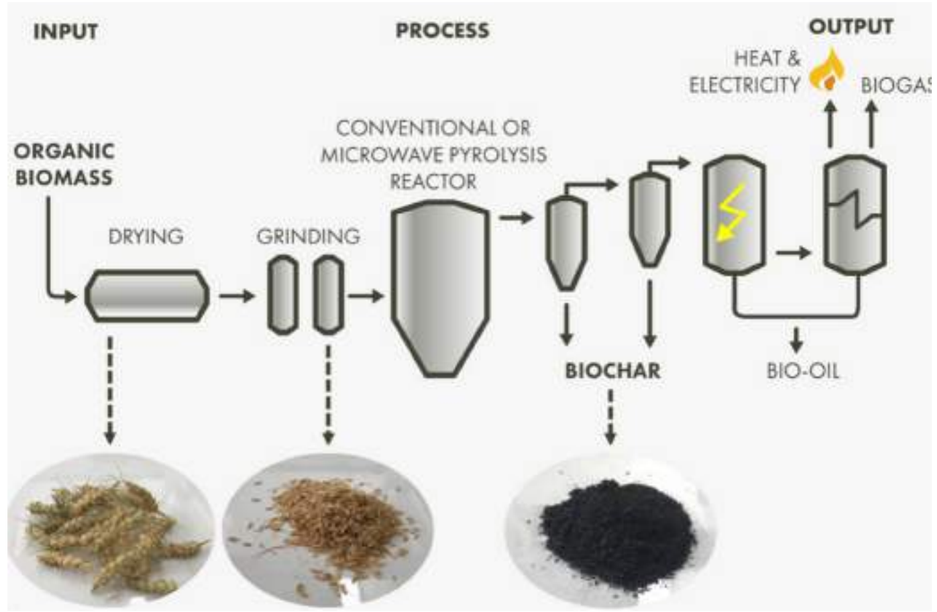
- High ethanol yields and production rates is essential for the economic viability of 2G ethanol
- Scalability might be a challenge.
- Engineering microbial strains to enhance ethanol yield.

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.

BIOGAS

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



RESEARCH AREAS TO EXPLORE

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

Art 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.

PELLETS FOR BIOENERGY

Pellets- Rice straw (Parali) based biomass pellets are compressed and densified forms of rice straw, offering waste reduction, storage ease, transportation convenience, and energy generation potential.

RESEARCH AREAS TO EXPLORE

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.
- 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

BIODEGRADABLE CUTLERY, PAPER AND PACKAGING

Made from rice straw pulp, these products are compostable, durable, heat/cold resistant, microwave-safe, and environmentally friendly.

RESEARCH AREAS TO EXPLORE

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.

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 TO EXPLORE

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.

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.

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 TO EXPLORE

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

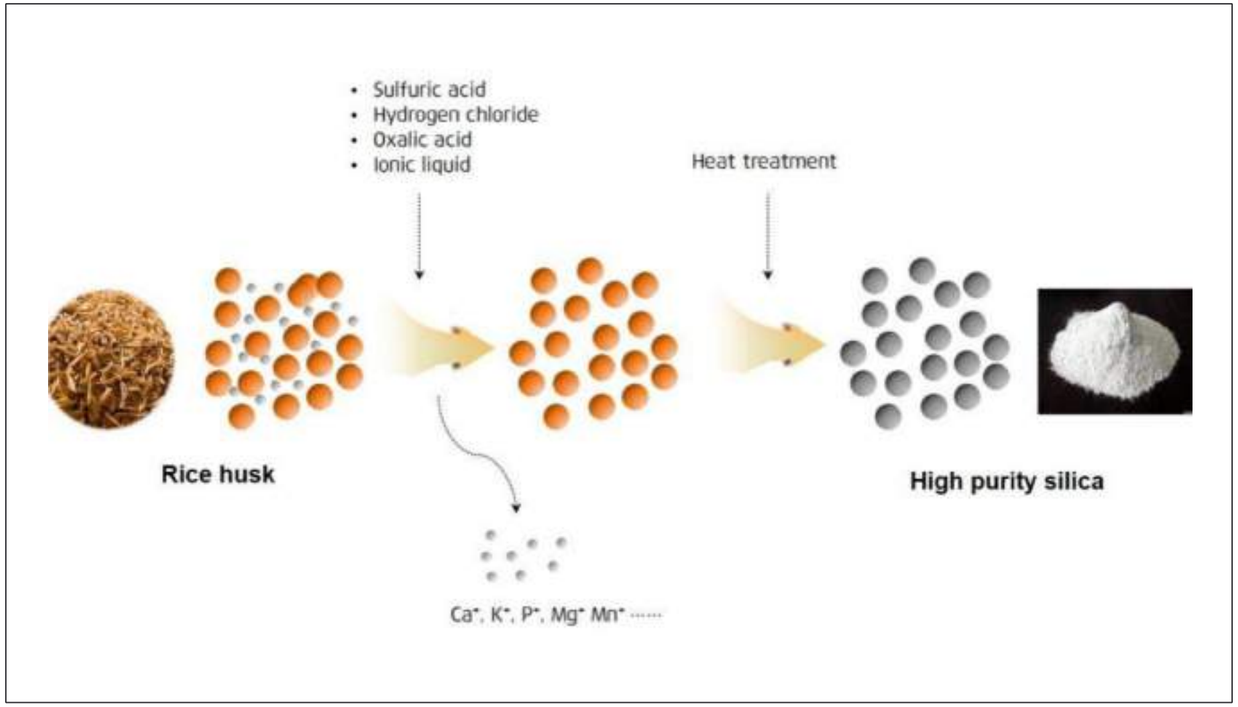
- Sustainable and cost-effective nutrient supplementation of rice straw for mushroom growth is a challenge
- Automating substrate preparation and mushroom cultivation processes for large-scale production is challenging
- Developing cost-effective and efficient automation solutions is an ongoing area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

RISK HUSK TO SILICA

- Rice husk ash (RHA): material that remains after incinerating rice husk for fuel
- Can be extracted using Cyclone separator.
- Proper incineration and controlled burning are two main factors for producing RHA.
- The silica content in RHA is around 80-84% indicating scope for silica recovery.
- Silica can be used in solar panels, semi conductors, adsorbing material



RESEARCH AREAS TO EXPLORE

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
- Needs efficient pre-treatment and purification methods
- 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
- Need for establishing new standards
- Extracted silica must meet customer expectations and newly set standards

Thank you!