Investing in the crop residue supply chain to reduce open burning:

The case of rice straw in Punjab, India

Manas Puri, Luis Rincon, Irini Maltsoglou
Climate and Environment Division
Food and Agriculture Organization of the United Nations
Rome, Italy

14 December 2021
ACKNOWLEDGEMENTS

- CCAC/UNEP, FAO India, FAO HQ/OCB
- Centre For Research In Rural And Industrial Development (CRRID)
- Niti Aayog
- Ministry of Agriculture and Farmer Welfare
- Ministry of New and Renewable Energy
- Department of agriculture, State of Punjab, India
- Punjab Energy Development Agency, State of Punjab, India
- National experts and technical experts in related fields
Agriculture and Agrifood Systems need energy along the entire value chain to produce food and use 30% of energy globally.

Agriculture contributes to climate change and emits around a 1/3 of global GHG emissions, climate change affects agriculture.

Diversity in access and disparity in agriculture systems.

Agrifood systems, energy and climate change are closely intertwined.

Energy Smart Food (ESF) Programme of FAO

To support countries in this area of work.

(Source: IRENA FAO 2021)
• An estimated 500 Mt of crop residues are generated annually across India

• Residues from many crop are burnt across India. In the north of India, straw from rice and wheat is a major challenge

• While wheat straw is largely used as animal feed, *rice straw is burnt* as a way to quickly and cheaply dispose them off.

• Around 39 million tonnes of paddy straw is burnt in Haryana, Punjab, Rajasthan and Uttar Pradesh

• In Punjab alone, around 15.4 million tonnes of rice straw is burnt in the fields

*Source: MNRE*
CROP RESIDUE ARE A VALUABLE RESOURCE

- **Ex-Situ Uses**
  - Chemicals
  - Paper
  - Compressed boards
  - Charcoal
  - Other industrial products
  - Energy

- **In-Situ Uses**
  - Feed
  - Bedding
  - Composting
  - Mushroom production
  - Other local applications
  - Mulch
  - Happy seeder
Aim and objectives

1. Assess the total quantity of rice straw produced and its distribution across the districts in Punjab;

2. Design a model rice straw value chain to mobilize rice straw in Punjab and estimate the investment required;

3. Assess the techno-economic viability of using rice straw to produce 2G ethanol, biomass pellets and compressed biogas.
Steps of the residue availability assessment

Total rice straw produced = Quantity of rice produced × RCR

- Rice production data for 2020 was used.

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Harvest Index (%)</th>
<th>RCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parmal Varieties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PR 126</td>
<td>45.30%</td>
<td>1.21</td>
</tr>
<tr>
<td>PR 124</td>
<td>44.50%</td>
<td>1.25</td>
</tr>
<tr>
<td>PR 122</td>
<td>45.00%</td>
<td>1.22</td>
</tr>
<tr>
<td>PR 121</td>
<td>45.20%</td>
<td>1.21</td>
</tr>
<tr>
<td>Pusa 44</td>
<td>44.00%</td>
<td>1.27</td>
</tr>
<tr>
<td>Overall average</td>
<td>44.80%</td>
<td>1.23</td>
</tr>
</tbody>
</table>

- Several meetings were done with Ministry of Agriculture and Farmer Welfare during the project.
- The ministry suggested that a maximum of 30 percent of the straw could be used for ex-situ purpose
- The remaining 70 percent should be managed in-situ
### How Much Straw for Ex-Situ

<table>
<thead>
<tr>
<th>District number</th>
<th>5 Percent</th>
<th>15 percent</th>
<th>30 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amritsar</td>
<td>36 819</td>
<td>170 438</td>
<td>340 913</td>
</tr>
<tr>
<td>Barnala</td>
<td>55 274</td>
<td>165 822</td>
<td>331 644</td>
</tr>
<tr>
<td>Bathinda</td>
<td>49 871</td>
<td>149 612</td>
<td>299 225</td>
</tr>
<tr>
<td>Faridkot</td>
<td>43 768</td>
<td>131 301</td>
<td>262 602</td>
</tr>
<tr>
<td>Fatehgarh Sahib</td>
<td>37 989</td>
<td>113 966</td>
<td>227 931</td>
</tr>
<tr>
<td>Fazilka</td>
<td>35 058</td>
<td>105 174</td>
<td>210 349</td>
</tr>
<tr>
<td>Firozpur</td>
<td>75 533</td>
<td>226 599</td>
<td>453 198</td>
</tr>
<tr>
<td>Gurdaspur</td>
<td>62 402</td>
<td>187 205</td>
<td>374 409</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1 258 695</strong></td>
<td><strong>3 776 084</strong></td>
<td><strong>7 552 169</strong></td>
</tr>
</tbody>
</table>

We consider only a (small) share.
Value chain structure
VALUE CHAIN STRUCTURE

How to collect rice straw within the 20 days available between rice harvest and wheat sowing?

- Raking of straw into lanes
- Baling straw into small/medium square bales
- Loading bales on to the trailer

Transport bales using trailer attached to tractor to a temporary collection point near the road

Coding of straw

Collecting the bales from different fields temporarily
- Loading the bales to a large cargo truck to transport to aggregation centre.

Transport bales on a large cargo trucks to aggregation centre

- Storage of bales
- Covered with plastic sheets
- Stored on a raised platform
- Well ventilated warehouse
- Acts as wholesale point

Harvesting & Baling

Transport
15 km radius

Collection Centre
(Temporary Storage)

Transport
30 km radius

Aggregation Centre
(Storage and Wholesale)
IMPACT OF COLLECTION QUANTITY ON COST

5% straw
- Collection costs per tonne
  - Range: ₹ 1,288 to ₹ 1,976
- Average = 1,570 INR/tonne

15% straw
- Collection costs per tonne
  - Range: ₹ 745 to ₹ 1,976
- Average = 899 INR/tonne

30% straw
- Collection costs per tonne
  - Range: ₹ 611 to ₹ 1,976
- Average = 733 INR/tonne
<table>
<thead>
<tr>
<th>District</th>
<th>Aggregation centres (Crore)</th>
<th>Tractors (Crore)</th>
<th>Balers (Crore)</th>
<th>Rakers (Crore)</th>
<th>Trailers (Crore)</th>
<th>Trucks (Crore)</th>
<th>Total Investment required (Crore)</th>
<th>Total Investment required (Million USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amritsar</td>
<td>₹ 29</td>
<td>₹ 13</td>
<td>₹ 51</td>
<td>₹ 10</td>
<td>₹ 3</td>
<td>₹ 10</td>
<td>₹ 117</td>
<td>$16</td>
</tr>
<tr>
<td>Barnala</td>
<td>₹ 28</td>
<td>₹ 8</td>
<td>₹ 32</td>
<td>₹ 6</td>
<td>₹ 2</td>
<td>₹ 10</td>
<td>₹ 86</td>
<td>$12</td>
</tr>
<tr>
<td>Bathinda</td>
<td>₹ 38</td>
<td>₹ 13</td>
<td>₹ 49</td>
<td>₹ 9</td>
<td>₹ 3</td>
<td>₹ 13</td>
<td>₹ 126</td>
<td>$18</td>
</tr>
<tr>
<td>Faridkot</td>
<td>₹ 22</td>
<td>₹ 8</td>
<td>₹ 32</td>
<td>₹ 6</td>
<td>₹ 2</td>
<td>₹ 8</td>
<td>₹ 79</td>
<td>$11</td>
</tr>
<tr>
<td>Fatehgarh Sahib</td>
<td>₹ 19</td>
<td>₹ 6</td>
<td>₹ 24</td>
<td>₹ 5</td>
<td>₹ 2</td>
<td>₹ 7</td>
<td>₹ 63</td>
<td>$9</td>
</tr>
<tr>
<td>Fazilka</td>
<td>₹ 18</td>
<td>₹ 8</td>
<td>₹ 32</td>
<td>₹ 6</td>
<td>₹ 2</td>
<td>₹ 6</td>
<td>₹ 73</td>
<td>$10</td>
</tr>
<tr>
<td>Firozpur</td>
<td>₹ 38</td>
<td>₹ 14</td>
<td>₹ 52</td>
<td>₹ 10</td>
<td>₹ 3</td>
<td>₹ 13</td>
<td>₹ 131</td>
<td>$18</td>
</tr>
<tr>
<td>Gurdaspur</td>
<td>₹ 32</td>
<td>₹ 13</td>
<td>₹ 48</td>
<td>₹ 9</td>
<td>₹ 3</td>
<td>₹ 11</td>
<td>₹ 116</td>
<td>$16</td>
</tr>
<tr>
<td>Hoshiarpur</td>
<td>₹ 15</td>
<td>₹ 6</td>
<td>₹ 22</td>
<td>₹ 4</td>
<td>₹ 1</td>
<td>₹ 5</td>
<td>₹ 54</td>
<td>$8</td>
</tr>
<tr>
<td>Jalandhar</td>
<td>₹ 37</td>
<td>₹ 13</td>
<td>₹ 49</td>
<td>₹ 9</td>
<td>₹ 3</td>
<td>₹ 13</td>
<td>₹ 124</td>
<td>$17</td>
</tr>
<tr>
<td>Kapurthala</td>
<td>₹ 24</td>
<td>₹ 9</td>
<td>₹ 33</td>
<td>₹ 6</td>
<td>₹ 2</td>
<td>₹ 8</td>
<td>₹ 81</td>
<td>$11</td>
</tr>
<tr>
<td>Ludhiana</td>
<td>₹ 59</td>
<td>₹ 19</td>
<td>₹ 72</td>
<td>₹ 14</td>
<td>₹ 5</td>
<td>₹ 20</td>
<td>₹ 188</td>
<td>$26</td>
</tr>
<tr>
<td>Mansa</td>
<td>₹ 27</td>
<td>₹ 9</td>
<td>₹ 34</td>
<td>₹ 6</td>
<td>₹ 2</td>
<td>₹ 9</td>
<td>₹ 87</td>
<td>$12</td>
</tr>
<tr>
<td>Moga</td>
<td>₹ 43</td>
<td>₹ 13</td>
<td>₹ 51</td>
<td>₹ 10</td>
<td>₹ 3</td>
<td>₹ 15</td>
<td>₹ 134</td>
<td>$19</td>
</tr>
<tr>
<td>Mohali</td>
<td>₹ 5</td>
<td>₹ 2</td>
<td>₹ 8</td>
<td>₹ 1</td>
<td>₹ 1</td>
<td>₹ 2</td>
<td>₹ 18</td>
<td>$3</td>
</tr>
<tr>
<td>Muktsar</td>
<td>₹ 38</td>
<td>₹ 13</td>
<td>₹ 51</td>
<td>₹ 10</td>
<td>₹ 3</td>
<td>₹ 13</td>
<td>₹ 128</td>
<td>$18</td>
</tr>
<tr>
<td>Pathankot</td>
<td>₹ 5</td>
<td>₹ 2</td>
<td>₹ 8</td>
<td>₹ 1</td>
<td>₹ 1</td>
<td>₹ 2</td>
<td>₹ 19</td>
<td>$3</td>
</tr>
<tr>
<td>Patiala</td>
<td>₹ 49</td>
<td>₹ 17</td>
<td>₹ 65</td>
<td>₹ 12</td>
<td>₹ 4</td>
<td>₹ 16</td>
<td>₹ 164</td>
<td>$23</td>
</tr>
<tr>
<td>Rupnagar</td>
<td>₹ 7</td>
<td>₹ 3</td>
<td>₹ 11</td>
<td>₹ 2</td>
<td>₹ 1</td>
<td>₹ 3</td>
<td>₹ 27</td>
<td>$4</td>
</tr>
<tr>
<td>Sangrur</td>
<td>₹ 71</td>
<td>₹ 21</td>
<td>₹ 81</td>
<td>₹ 15</td>
<td>₹ 5</td>
<td>₹ 24</td>
<td>₹ 218</td>
<td>$31</td>
</tr>
<tr>
<td>Shahid Bhagat Singh Nagar</td>
<td>₹ 13</td>
<td>₹ 5</td>
<td>₹ 17</td>
<td>₹ 3</td>
<td>₹ 1</td>
<td>₹ 4</td>
<td>₹ 43</td>
<td>$6</td>
</tr>
<tr>
<td>Tarn Taran</td>
<td>₹ 38</td>
<td>₹ 13</td>
<td>₹ 51</td>
<td>₹ 10</td>
<td>₹ 3</td>
<td>₹ 10</td>
<td>₹ 130</td>
<td>$20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>₹ 2,201</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>₹ 309</strong></td>
<td></td>
</tr>
</tbody>
</table>
MARKET PRICE AND INCOME FOR FARMERS

Market price of baled straw (INR/Tonne):
- ₹5,000/Tonne
- ₹2,500/Tonne
- ₹1,400/Tonne
- ₹556/Tonne
- ₹1,601/Tonne
- ₹1,976/Tonne

Farmer income per tonne of straw sold (INR/Tonne):
- INR 1,000
- INR 2,000
- INR 3,000
- INR 4,000
- INR 5,000
- INR 6,000

Paddy Straw, Pack Size: 51 X 39 X 27 CM
- ₹8,600/Ton

Dry Paddy Straw Bales, 29 Kg
- ₹21/Kilogram

Paddy Straw Bales
- ₹200/Roll

No Image Available

Paddy Straw Bales, 15-155 Kg
- ₹3,650/Ton
ENERGY TECHNOLOGIES
ENERGY TECHNOLOGIES ANALYSED

- Coal is the bedrock of electricity generation and remains the largest single fuel in the energy mix.

- Energy in the transport sector has increased fivefold over the last three decades reaching more than 100 Mtoe in 2019.

- Diesel and petrol are the two dominant fuels used in the transport sector,

- Majority of transport fuel in India is imported

- In recent years the use of natural gas as a transport fuel has increased substantially
ENERGY TECHNOLOGIES ANALYSED

- Government of India aims to reduce use of imported fossil fuel.

- In COP 26, countries agreed to reduce reliance on coal to mitigate climate change.

- India’s bioenergy policy has specific targets to increase local production of bioenergy.

- This includes,
  - Ethanol to achieve E20 blending by 2025
  - Production of Compressed biogas (CBG) to replace natural gas used as transport fuel
  - Production of biomass pellets to cofire with coal in thermal power plants
  - Rice straw can be used to produce all three energy carriers.
**TARGETS**

**Ethanol**
- Ethanol blending program
- Aims to achieve E20 by 2025
- Both 1G and 2G ethanol envisaged
- Multiple feedstock expected to be utilized
- Need to produce around 9 billion litres to reach the E20 target by 2025.

**CBG**
- Sustainable Alternative Towards Affordable Transportation (SATAT) scheme aims to increase production of compressed biogas in the country
- Planned to roll out 5,000 CBG plants by 2024
- The target is set to produce 15 million tonnes of CBG per year
- Currently around 1,500 CNG station networks in the country

**Pellets**
- NTPC is India's largest coal consumer power producer.
- NTPC aims to use pellets made from biomass to co-fire with coal
- Already invited bids for the procurement of biomass pellets
- Five million tonnes of pellets are expected to be used per year.
PELLETS RESULTS
RESULTS: Pellets (technical potential)

<table>
<thead>
<tr>
<th>Biomass</th>
<th>Pre-treatment</th>
<th>Pelletizing</th>
<th>Packaging</th>
<th>Final use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Potential Production Vs. Production Target

- Target pellets quantity/year
- Technical Potential (tonnes)

Contribution to target: 143%

Is it economically viable?
RESULTS: Pellets (Economic viability)

- **Capital cost**
  - ₹ 4
  - ₹ 45
  - ₹ 179
  - ₹ 713

- **Unit production cost**
  - ₹ 47
  - ₹ 13
  - ₹ 6
  - ₹ 6

- **Break-even size = 130 kg pellets/h**
RESULTS : 2G ETHANOL (Economic viability)

At current level pellets production is profitable in all districts of Punjab.
2G ethanol and CBG Results
RESULTS: TECHNICAL POTENTIAL - 2G ethanol and CBG

2G Ethanol – E20 Blending target

- Ethanol Target India (Million Litres)
- Ethanol Target Punjab (Million Litres)
- Potential Ethanol Production (Million Litres)

Contribution to all India Target (%)

- 22%

CBG target production (SATAT)

- Current CNG Consumption Vs Potential CBG Production

- 5%
RESULTS: 2G ETHANOL & CBG (Economic viability)

- Price of ethanol is set, no specific price is set for 2G ethanol.
- 2G ethanol will be based on the maximum price as currently set for 1G ethanol (INR 62.65/litre)
RESULTS: 2G ETHERAL (Economic viability)

At current level – 2G ethanol is only viable in a few districts.

At current level – CBG is viable in most districts.
OVERALL RESULTS : VALUE CHAIN

• Rice straw is a valuable resource that can support India by increasing its local supply of energy while reducing its reliance on imports.

• The amounts of rice straw are extremely large, leaving large volumes unused once soil amendment and other needs are considered.

• Mobilizing rice straw within the limited period of 20 days would require large amounts of machinery and manpower.

• The result suggests that to mobilize 30 percent of the rice straw produced in Punjab an investment of around ₹ 2,201 crore (USD $309 million) would be needed to collect, transport and store it within a 20 day period.

• This would reduce GHG emission of about 12 million tonnes of CO₂ equivalent and around 66 000 tonnes of PM2.5 emissions.

• Pellets and CBG production seem viable, 2G ethanol needs very high investment and support to reduce costs.

• The districts of Sangrur, Ludhiana and Barnala seem most suitable for piloting
Thank you

Questions welcome!