Outcomes and Findings of CSAM
Integrated Straw Management Research

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• Dr. Pham Van Tan
Deputy Director, Sub-Institute of Agricultural Engineering and Post-harvest Technology (SIAEP) of Vietnam

• Dr. He Jin
Professor, China Agricultural University

And ……..
CONTENTS

1. Background
2. Status of crop straw resources
3. Straw management patterns and benefit
4. Research and demonstration
Section I: Background
1. World main cereal production

![Diagram showing world cereal production with wheat, maize, and rice]

- The world produces 2.8 billion tons of cereals (FAO, 2014)
- The maximum three cereals are maize, wheat, rice

*Source: International Grains Council, 2017
16/17 estimated, 17/18 forecast*
2. Straw yield of three main cereals (in the world)

<table>
<thead>
<tr>
<th>Year</th>
<th>Wheat</th>
<th>Maize</th>
<th>Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>13/14</td>
<td>988 Mt</td>
<td>2048 Mt</td>
<td>612 Mt</td>
</tr>
<tr>
<td>14/15</td>
<td>1007 Mt</td>
<td>2095 Mt</td>
<td>614 Mt</td>
</tr>
<tr>
<td>15/16</td>
<td>1016 Mt</td>
<td>2005 Mt</td>
<td>605 Mt</td>
</tr>
<tr>
<td>16/17</td>
<td>1041 Mt</td>
<td>2212 Mt</td>
<td>622 Mt</td>
</tr>
<tr>
<td>17/18</td>
<td>1032 Mt</td>
<td>2120 Mt</td>
<td>617 Mt</td>
</tr>
</tbody>
</table>

Source: International Grains Council, 2017

Straw yield was calculated by the ratio of straw-grain: wheat-1.38; maize-2.05; rice-1.28

Enormous cereals produces enormous straw
3. Straw yield of five main crops (in Asia & Pacific)

Asia-Pacific is one of the largest cereal production region (44.8%).

<table>
<thead>
<tr>
<th>Crop</th>
<th>World cereal production Asia-Pacific</th>
<th>Other regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>89.7%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Potatoes</td>
<td>44.4%</td>
<td>55.6%</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>39.7%</td>
<td>60.3%</td>
</tr>
<tr>
<td>Wheat</td>
<td>36.9%</td>
<td>63.1%</td>
</tr>
<tr>
<td>Maize</td>
<td>28.4%</td>
<td>71.6%</td>
</tr>
</tbody>
</table>

Crop: Mt
- Rice: 665
- Potatoes: 169
- Sugar cane: 748
- Wheat: 269
- Maize: 295

Straw: Mt
- Rice: 851
- Potatoes: 84.5
- Sugar cane: 224
- Wheat: 371
- Maize: 596

Source: FAOSTAT, 2014. Ratio of straw-grain: potatoes-0.5; sugar cane-0.3

Huge amounts of straw in Asia-Pacific, 2126.5 Mt (calculated) of the major 5 crops!
How to deal with such a large amount of straw is the **great challenge** in Asia Pacific!!!
4. Straw burning in Asia-Pacific

- China
- Sri Lanka
- India
- Indonesia

Images show farmers burning straw in fields in China, Sri Lanka, India, and Indonesia, presumably for land clearance for palm oil plantations.
Impacts of straw burning

- Loss of nutrients
- Fire disaster
- Environment pollution
- Traffic accident

Resource usage straw burning troubles
5. The 4th Regional Forum on Sustainable Agricultural Mechanization in Asia and the Pacific

- Promote climate-smart agriculture/agricultural mechanization
- A new initiative on Integrated Straw Management to address the shared issue of straw burning
Objectives

- Understand current situation of crop straw resources; collect available and proven practices/technologies of straw management
- Design an action plan for pilot interventions of integrated straw management in selected member countries; and
- Identify requirements, and recommend appropriate pilot sites and partners
Section Ⅱ: Status of Crop Straw Resources in Asia-Pacific
1. Types of crop straw

<table>
<thead>
<tr>
<th>Grain crop straw</th>
<th>maize</th>
<th>wheat</th>
<th>rice</th>
<th>barley</th>
<th>oat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil crop straw</td>
<td>sunflower</td>
<td>rape</td>
<td>peanut</td>
<td>bean</td>
<td>sesame</td>
</tr>
<tr>
<td>Fiber crop straw</td>
<td>cotton</td>
<td>ramie</td>
<td>linen</td>
<td>kenaf</td>
<td>jute</td>
</tr>
<tr>
<td>Other crop straw</td>
<td>sugar cane</td>
<td>flue-cured tobacco</td>
<td>sugar beet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Straw yield in East, South and Southeast Asia

Top 3 straw crops in Asia-Pacific: Rice, Maize, Wheat
3. Crop straw distribution (East Asia)

Source: FAOSTAT, 2014
## Crop straw yield (Mt) in East Asia

<table>
<thead>
<tr>
<th>Crop</th>
<th>Straw-grain ratio</th>
<th>China</th>
<th>Japan</th>
<th>KOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain</td>
<td>Straw</td>
<td>Grain</td>
</tr>
<tr>
<td>Rice</td>
<td>1.28</td>
<td>208.24</td>
<td>266.55</td>
<td>10.55</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.38</td>
<td>126.22</td>
<td>174.18</td>
<td>0.85</td>
</tr>
<tr>
<td>Maize</td>
<td>2.05</td>
<td>215.81</td>
<td>442.41</td>
<td>0.25</td>
</tr>
<tr>
<td>Potato</td>
<td>1.16</td>
<td>95.57</td>
<td>110.86</td>
<td>2.46</td>
</tr>
</tbody>
</table>

*Source: FAOSTAT, 2014*

- China produces maximum straw in East Asia
- Rice straw is the main straw in Japan and KOR
3. Crop straw distribution (South Asia)

Source: FAOSTAT, 2014
Crop straw yield (Mt) in South Asia

<table>
<thead>
<tr>
<th>Crop</th>
<th>Straw-grain ratio</th>
<th>India</th>
<th>Bangladesh</th>
<th>Nepal</th>
<th>Shri Lanka</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain</td>
<td>Straw</td>
<td>Grain</td>
<td>Straw</td>
</tr>
<tr>
<td>Rice</td>
<td>1.28</td>
<td>108.8</td>
<td>139.26</td>
<td>34.57</td>
<td>44.25</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.38</td>
<td>96.6</td>
<td>133.30</td>
<td>1.30</td>
<td>1.79</td>
</tr>
<tr>
<td>Maize</td>
<td>2.05</td>
<td>26.15</td>
<td>53.60</td>
<td>2.75</td>
<td>5.63</td>
</tr>
</tbody>
</table>

*Source: FAOSTAT, 2014*

- **India** produces maximum straw in South Asia
- **Rice straw** is the main straw in South Asia
3. Crop straw distribution (Southeast Asia)

- Rice and maize straw are the two main crop straws.
- Wheat is mainly in the Northern parts, Myanmar and Northern of Thailand.

Source: Bakker et al, 2013
Crop straw yield (Mt) in Southeast Asia

<table>
<thead>
<tr>
<th>Crop</th>
<th>Straw-grain ratio</th>
<th>Indonesia</th>
<th>Vietnam</th>
<th>Myanmar</th>
<th>Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grain</td>
<td>Straw</td>
<td>Grain</td>
<td>Straw</td>
</tr>
<tr>
<td>Rice</td>
<td>1.28</td>
<td>70.84</td>
<td>90.68</td>
<td>44.07</td>
<td>49.59</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.38</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maize</td>
<td>2.05</td>
<td>18.51</td>
<td>37.94</td>
<td>5.19</td>
<td>10.64</td>
</tr>
</tbody>
</table>

(Source: FAOSTAT, 2014); a: Statistical Yearbook of Vietnam 2013; b Diep Quynh Nhu, 2014

➢ Indonesia 90.68Mt/yr (Rice), much more than other Southeast Asia countries

➢ Total amount of rice straw was about 210.10Mt/yr.
Section III: Crop Straw Management Patterns and Benefits
Integrated Straw Management

1. Fertilizer
2. Fodder
3. New energy resources
4. Base stock
5. Industry material
Selection principles of straw management

◆ **Availabilities of technologies**
  ① Advanced ② Mature ③ Reliable stability

◆ **Matched conditions in the region**
  ① Equipment ② Machines ③ Land

◆ **Adaptation of technologies**
  ① Current situation ② Characteristics ③ Development requirement

◆ **Adaptation of technologies**
  ① Reduce cost ② Environment-friendly
1. Used as fertilizer

① Soil cover

Harvest ➔ Straws chopping and mulching ➔ No-till seeding

② Mix-buried with soil

Harvest ➔ Straw chopping and spreading ➔ Straw burying by roto-till/harrow
③ Pre-decomposed straw returning

Harvest → Adding decomposition agent → Composting → Returning to field

④ Carbonized straw returning

Straw collection → Carbonization → Slow release fertilizer → Returning to field
<table>
<thead>
<tr>
<th>Area</th>
<th>County</th>
<th>Major used crop straw</th>
<th>Ratio</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Asia</td>
<td>China</td>
<td>Maize, Wheat, Rice</td>
<td>43.2%</td>
<td>Straw directly returning to field, Straw indirectly returning to field</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>Rice, Wheat</td>
<td>55.0%</td>
<td>Straw directly returning to field, Decomposed straw returning</td>
</tr>
<tr>
<td></td>
<td>KOR</td>
<td>Rice</td>
<td>45.7%</td>
<td>Straw directly returning to field</td>
</tr>
<tr>
<td>South Asia</td>
<td>India</td>
<td>Rice</td>
<td>15-20%</td>
<td>Straw directly returning to field</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>Vietnam</td>
<td>Rice</td>
<td>26.1%</td>
<td>Straw directly returning to field</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>Rice</td>
<td>29.7-40.2%</td>
<td>Straw directly returning to field</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>Rice, Maize</td>
<td>35.3%a</td>
<td>Straw directly returning to field</td>
</tr>
</tbody>
</table>

**East Asia** → About 43% of the crop straw was returned to the field  
**South Asia** → Straw was poorly utilized for fertilizer  
**Southeast Asia** → Returned directly to the soil by plough/roto-till
2. Used as fodder

① Ensilage
- Harvest
- Chopping and adding additive
- Bagging

② Silken straw fodder
- Dry straw
- Kneading and bundling
- Bagging
③ Briquetting

Chopping ➔ Drying ➔ Compression molding

④ Ammoniation treatment

Chopping ➔ Mix with ammonia sources ➔ Sealing treatment
<table>
<thead>
<tr>
<th>Area</th>
<th>Country</th>
<th>Ratio</th>
<th>Major used crops straws</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Asia</td>
<td>China</td>
<td>18.8%</td>
<td>Maize, rice</td>
<td>Ensilage and coarse fodder</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>10.3%</td>
<td>Rice</td>
<td>Coarse fodder</td>
</tr>
<tr>
<td></td>
<td>KOR</td>
<td>20.8%</td>
<td>Rice</td>
<td>Ensilage</td>
</tr>
<tr>
<td>South Asia</td>
<td>India</td>
<td>/</td>
<td>Rice, maize, wheat</td>
<td>Ensilage and coarse fodder</td>
</tr>
<tr>
<td></td>
<td>Indonesia</td>
<td>31%</td>
<td>Rice</td>
<td>Ensilage and coarse fodder</td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td>23%</td>
<td>Rice</td>
<td>Coarse fodder</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>15%</td>
<td>Rice</td>
<td>Ensilage and coarse fodder</td>
</tr>
<tr>
<td></td>
<td>Philippines</td>
<td>2-4%</td>
<td>Rice</td>
<td>Coarse fodder</td>
</tr>
</tbody>
</table>

East Asia → Applied well, but still, with a need for potentiality exploitation
South Asia → Wheat straw and chopped maize stalk are the most favored fodder
Southeast Asia → Raw rice straw was used popularly for animal feed
3. Used as new energy resource

① Briquette fuel

Raw material ➔ Smash and briquette ➔ Warehousing and using

② Biogas production

Raw material ➔ Stack retting and fermentation ➔ Produce biogas
③ carbonization fuel

- Raw material ➔ Carbonization ➔ Pulverize ➔ Carbon dust

④ gasification fuel

- Straw and air ➔ Gasifier and scrubber ➔ Separator ➔ Gas tank

⑤ degradation and ethanol production

- Pretreatment of raw material ➔ Saccharification ➔ Fermentation ➔ Distill
## Status for straw used as new energy resource

<table>
<thead>
<tr>
<th>Area</th>
<th>Country</th>
<th>Ratio</th>
<th>Major used crops straws</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Asia</td>
<td>China</td>
<td>11.4%</td>
<td>Maize, rice</td>
<td>Fuel</td>
</tr>
<tr>
<td></td>
<td>Japan</td>
<td>/</td>
<td>Rice</td>
<td>Degraded into ethanol</td>
</tr>
<tr>
<td>South Asia</td>
<td>India</td>
<td>2-4%</td>
<td>Rice</td>
<td>Biomass briquettes</td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td>0.36%</td>
<td>Rice</td>
<td>Ensilage</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>Indonesia</td>
<td>25%</td>
<td>Rice</td>
<td>Fuel production</td>
</tr>
<tr>
<td></td>
<td>Thailand</td>
<td>0.2%</td>
<td>Rice</td>
<td>Fuel production</td>
</tr>
</tbody>
</table>

**East Asia →** Biogas and briquette fuel have been greatly developed

**South Asia →** Decrease, due to cheaper option of solar power generation projects

**Southeast Asia →** Biofuel from residues could displace all fuel used for transport
4. Used as base stock

Cultivating fungi

House construction and material reserving
Composting and fermentation → Planting
Fungi management → Harvest
## Status for straw used as base stock

<table>
<thead>
<tr>
<th>Area</th>
<th>Country</th>
<th>Ratio</th>
<th>Major used crops straws</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Asia</td>
<td>China</td>
<td>4%</td>
<td>Maize, rice</td>
<td>Cultivating fungi</td>
</tr>
<tr>
<td>South Asia</td>
<td>India</td>
<td>-</td>
<td>Rice</td>
<td>Cultivating fungi</td>
</tr>
<tr>
<td>Southeast Asia</td>
<td>Vietnam</td>
<td>-</td>
<td>Rice, maize</td>
<td>Bedding materials for cattle houses</td>
</tr>
</tbody>
</table>

**East Asia** → Only accounted for a small fraction of all crop straw

**South Asia** → The quantity straw used for this purpose is almost negligible as compared to its production

**Southeast Asia** → Not much popular
5. Used as industry material

① Papermaking

- Infiltration and calcify
- Straw pulp
- Molding and incision
- Package and products

② Sheet production

- Smash
- Roller-compaction
- Maintenance
- Package
③ Crafts production

Collecting high quality straw ➔ Manually flattening straw ➔ Framing

④ Xylitol production

Raw material ➔ Hydrolysis and hydrogenation ➔ Concentrate and crystallize ➔ Crystalline xylitol
East Asia → China is the largest straw pulp making country, and the straw pulp can occupy 33.95% of total paper pulp in the country

South Asia → About 30% of India’s paper is made from agricultural residue and/or non-wood fibers

Southeast Asia → Rice straw is used as raw material for industry in Indonesia is about 7%
Beneficial impacts (Social benefits)

- Broaden the channel of straw resource utilization
- Adapts the new requirements of beautiful livable rural construction
Beneficial impacts (Ecological benefits)

- Reduce soil erosion and improve soil structure
- Protect environment and reduce greenhouse gas emissions
- Replace non-renewable resources
- Protect forest resource
Beneficial impacts (Economic benefits)

- Achieve multiple value-added income
- Save agricultural cost and invest

- Promote the development of agriculture and rural economy
Section IV: Research and Demonstration
(For selected options of Integrated Straw Management)
1. Scientific research

- Machines and Equipments
- Technical modes

- Soil and Crop
- Animal
- Social, economic and ecological effects
- .......
Selection principles of partners and sites

◆ **Cooperative partners**
  ① Staffs and facilities
  ② Scientific ability

◆ **Pilot sites**
  ① Good facilities
  ② Good conditions for training
  ③ Large areas for demonstration
Recommended partners and pilot sites

① East Asia

China

CAU
Qingdao Shandong Province

② South Asia

India

ICAR
Punjab Agricultural University

③ Southeast Asia

Vietnam

SIAEP
Can Tho City/Tien Giang
THANK YOU!
GOV level cooperation, Policies, ......

Association, exhibition, cooperative regional laboratory