Regional Workshop on Integrated Straw Management in Asia and the Pacific

Mechanization Solutions for Sustainable and Climate-Smart Agriculture

Country Presentation (Pakistan)

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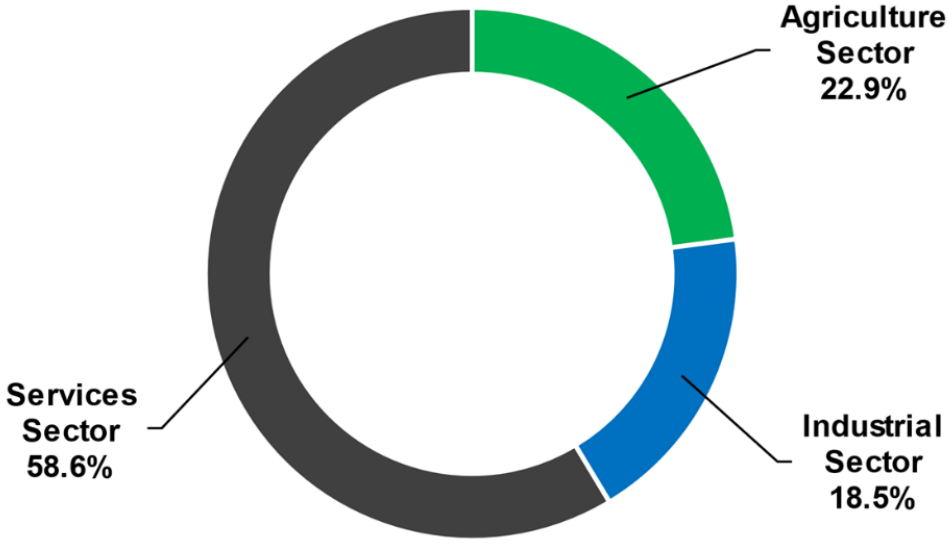
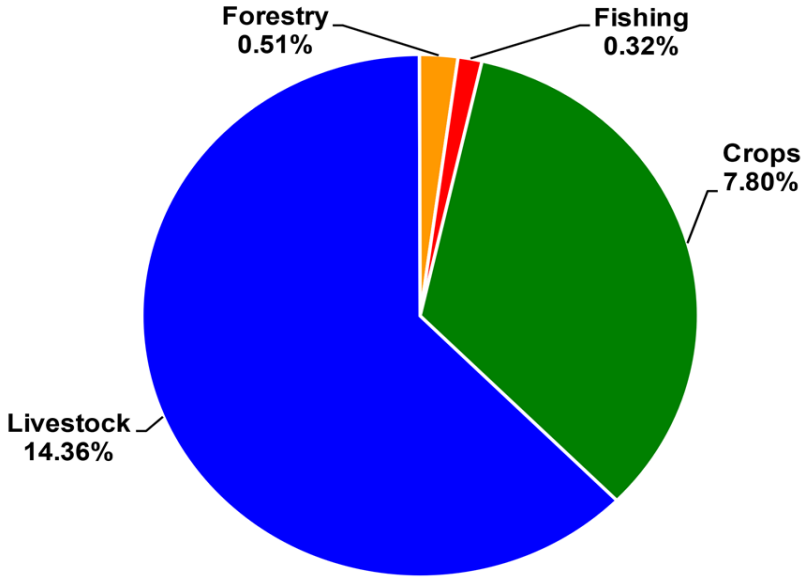
Agriculture in Pakistan

- Agricultural sector contributes 22.9% in national GDP and employs 37.4% labour force
- About 63% rural population depends on this sector for their livelihood



Sectoral share in national GDP



Agricultural sub-sectors

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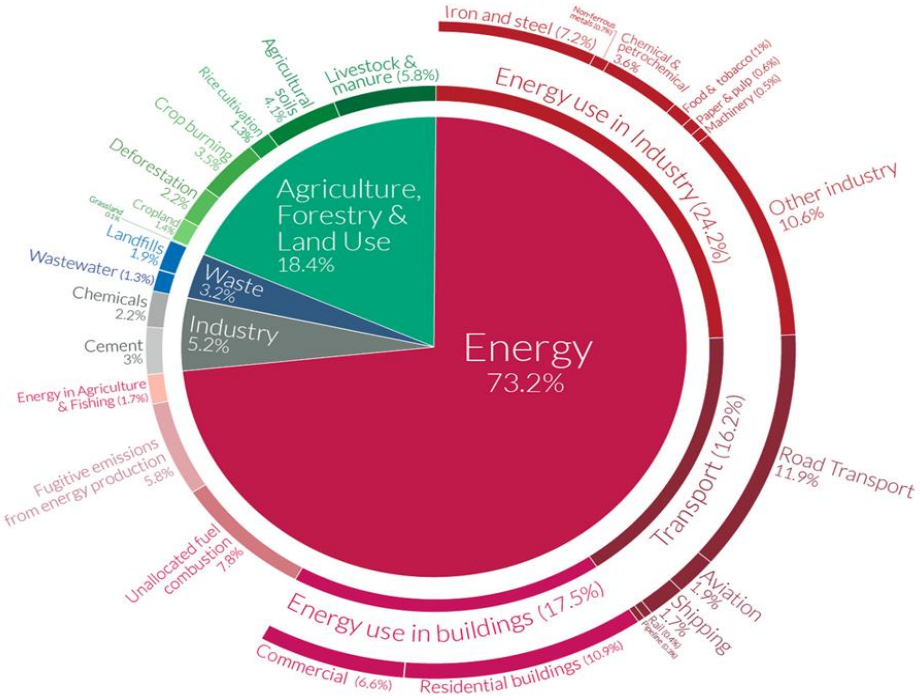
Major Crops in Pakistan

Crop	Area (mha)	Production (mt)	Pakistan's Ranking
Wheat	9.043	27.634	
Rice	2.976	7.322	
Maize	1.720	10.183	
Sugarcane	1.319	91.111	
Cotton	2.144	4.910 million bales	

Agriculture and Climate Change

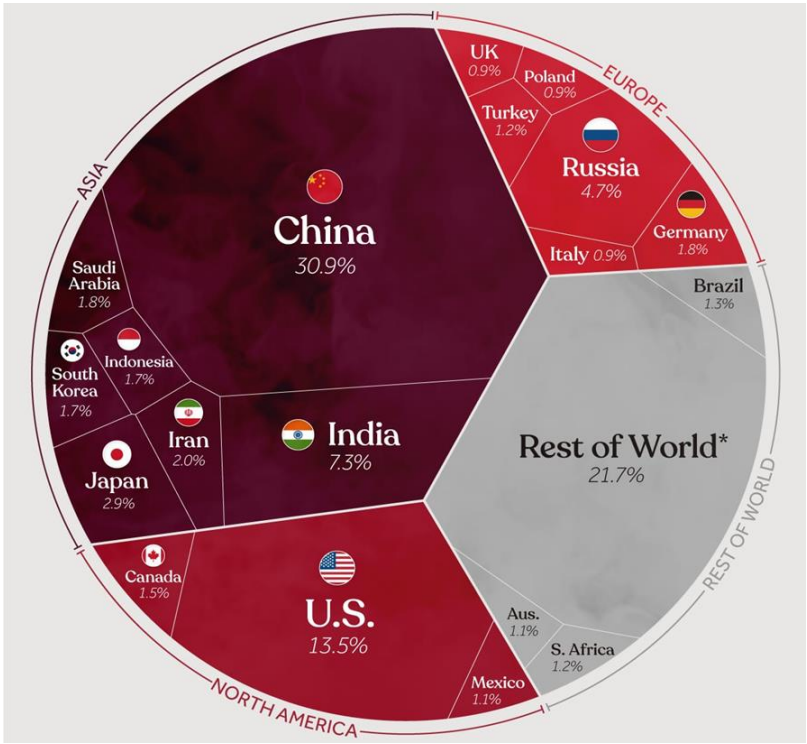
- Agriculture is both a victim and a contributor to climate change
- This sector contributes approximately 25% of CO_2, 50% of CH_4 and 70% of N_2O emissions worldwide
- Agriculture contributes 18.4% to greenhouse gas (GHG) emission out of which 13.5% share is through anthropogenic activities
- It is the need of time to promote climate smart mechanization technologies to boost agricultural productivity, enhance resilience and reduce GHG emissions

Global GHG Emissions (%)



Energy sector is the largest contributor to GHG (73.2%)

Global Carbon Emissions (%)



China, the USA and India are the leading carbon emitting countries in the world

Source: Global Carbon Atlas, 2021 (175 countries)

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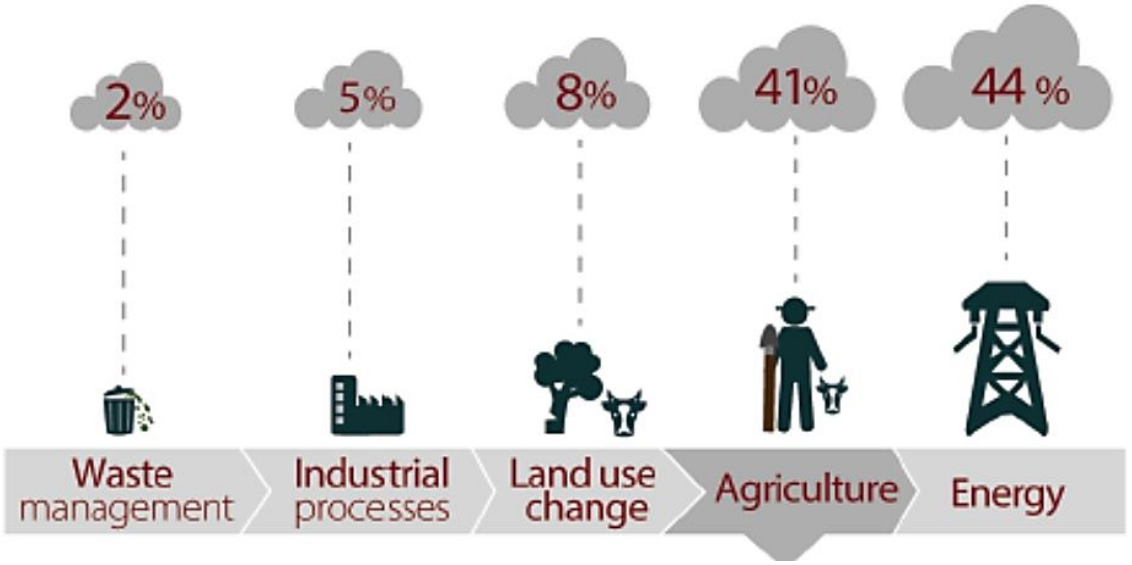
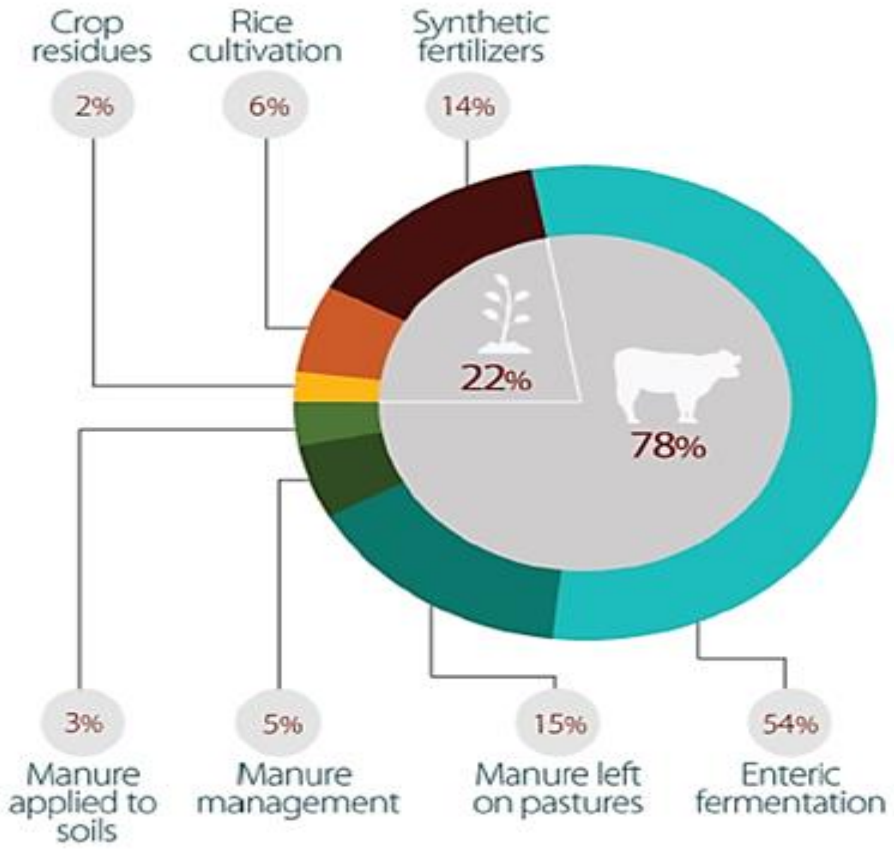
Pakistan's Contribution in Global GHG Emissions

- Pakistan's contribution to global GHG is < 1.0 %, but it is among the most vulnerable countries facing threats of climate change
- The country is ranked low at 148th in global GHG emissions
- Total emissions of Pakistan are 355 MT of CO_2 equivalent annually
- Per capita GHG emission is 1.96 T of CO_2 equivalent annually

GHG Emissions of Pakistan's Agricultural Sector





(GHG emissions include gases, CO_2, CO, CH_4, N_2O and NO)

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Crop Residue in Pakistan

- About 80 million tonnes of crop biomass is produced annually in Pakistan
- About 90% crop residue is produced from five major crops: wheat, rice, sugarcane, maize and cotton
- About 70% rice straw and 23% sugarcane trash are burnt in fields for sowing of subsequent crops
- Less than 10% wheat and maize straw is burnt as they are used as animal fodder and feed
- About 50% cotton stalks are used as domestic fuel and 5-10% is shredded in the soil using shredders
- Large cotton growers have started making pellets and briquettes heating industry and brick kilns

Crop Biomass in Pakistan

Crop Residue	Residue (mt)	Used as fodder and other purposes (mt)	Burnt (mt)	Burning Percentage (%)
Wheat straw	28.40	26.13	2.27	8
Rice straw	7.32	2.19	5.12	70
Maize stovers	12.73	11.97	0.76	6
Sugarcane trash	10.93	8.42	2.51	23
Cotton stalks	16.66	15.49	1.17	7

Residue burning: Impact on soil and environment

Impact on soil

(loss of nutrients kg/ton of burned residue)

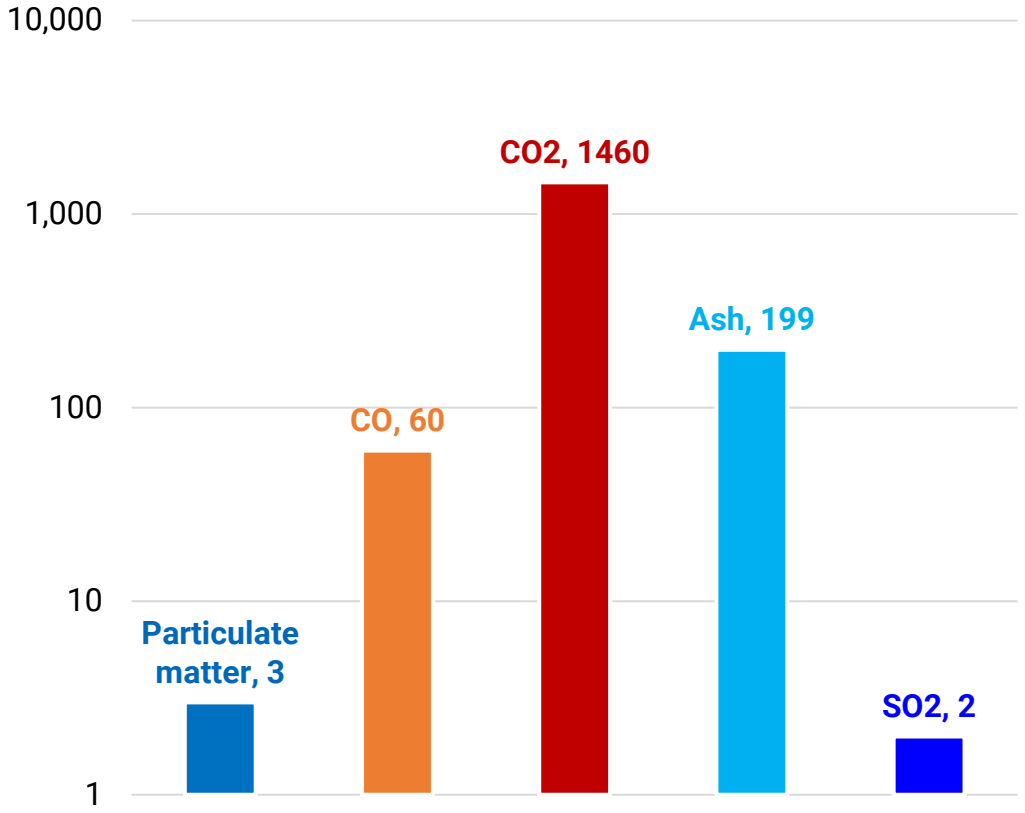
5–8kg Nitrogen

0.7–1.2kg Phosphorus

12–17kg Potassium

Greenhouse Gas Emissions

(emissions kg/tonne of burned residue)



(Source: EPD, Government of the Punjab, 2018)

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Reasons for Residue Burning

- Insufficient time for sowing of subsequent crops
- High cost of residue collection
- Burning is an easy method for crop residue disposal
- Unavailability of seasonal agricultural labour
- Lack of proper crop residue management machinery
- Poor economic condition of farmers
- Low quality agricultural machinery

Traditional Residue Management Techniques

Burning in fields

- Easy and cost-effective: Burning is a fast and inexpensive method for clearing fields
- **Environmental Impact:** Contributes significantly to air pollution, releasing particulate matter and greenhouse gases
- **Soil Degradation:** Reduces soil fertility by destroying organic matter and beneficial microorganisms.

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Traditional Residue Management Techniques

Incorporation in soil

- **Nutrient Recycling:** Enhances soil fertility by returning nutrients to the soil.
- **Improves Soil Structure:** Increases organic matter, leading to better soil structure and moisture retention.
- **Labour Intensive:** Requires significant labour and time compared to burning.

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Traditional Residue Management Techniques

Animal feed

- **Supplementary Feed Source:** Crop residues like straw and stalks provide an additional feed resource for livestock.
- **Nutritional Benefits:** Adds roughage to animal diets, aiding in digestion and overall health.
- **Seasonal Dependency:** Availability of residues as feed varies with crop cycles and harvest times.

Crop Residue Management

Systematic handling of leftover plant materials after harvest

1. In-situ (in-field) crop residue management
2. Ex-situ (off-field) crop residue management

In-situ crop residue management includes incorporation of residue in soil or in-field residue burning

Ex-situ residue management includes removing crop residue from the field to use for other purposes, i.e., bio-energy production, growing mushrooms, cattle feed raw material, mulching for other crops, silica manufacturing, etc.

Best Practices for In-Situ Residue Management

- Promotion of crop residue management machinery
- Provision of 50-80% subsidy on residue management machinery
- Provision of interest-free loans to farmers to purchase straw management machinery
- Launch awareness campaign through information, education and field seminars for in-situ crop residue management practices

Example for In-Situ Residue Management using Agricultural Mechanization

Pak Seeder / Happy Seeder

- It saves land preparation cost
- Direct seeding of wheat in combine-harvested paddy stubbles is possible
- Increase in yield from 10-15%
- Helps in timely planting of wheat

Example for In-Situ Residue Management using Agricultural Mechanization

<u>Combine Seeder / Pak Seeder</u>

- It incorporates rice residue in soil
- saves land preparation cost
- Direct seeding of wheat in combine-harvested paddy stubbles is possible
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- Helps in timely planting of wheat after rice

Example for In-Situ Residue Management using Agricultural Mechanization

<u>Straw Chopper / Shredder</u>

- It chops straw and mulches on the surface
- The straw can be either incorporated in the soil or wheat is planted using Pak Seeder / Happy Seeder
- It saves land preparation cost
- It helps in timely planting of wheat after rice

Wheat Yield Data (3-Years' Comparison)

Sr. No.	Location	Combine Seeder (mnd/a)	Pak Seeder (mnd/a)	Control (mnd/a)
1.	Gujranwala	49.45	46.82	42.70
2.	Sialkot	51.50	46.66	41.35
3.	Sargodha	46.80	46.96	40.25
4.	Sheikhupura	38.46	35.04	33.95
5.	Sheikhupura	47.12	46.89	42.56
6.	Gujrat	37.39	38.62	33.50
	Average (Mnd/a)	**45.12**	**43.49**	**39.05**
	Average (kg/ha)	**4,458**	**4,298**	**3,858**

Best Practices for Ex-Situ Residue Management

- Biomass baling, briquetting and pelleting for power plant fueling
- Biogas production
- Ethanol production from crop residue for alternative fuels
- Compost making from biomass
- Bio-degradable kitchen items, such as pots, plates and cups from rice straw
- Production of building materials from crop residue

Example for Ex-Situ Rice Residue Management using Rake and Baler

Rake and Straw Baler

- **Rake collects the straw and windrows**
- **Balers makes rectangular bales for industrial purposes**

Example for Ex-Situ Wheat Residue Management

Wheat Straw Chopper

- **It chops combine harvested wheat straw and throws in the trolley**
- **The chaff is used as animal feed**

Sugarcane residue management techniques

- **Sugarcane tops/leaves/trash**
  - Trash burning in field (discouraged)
  - Low use as industrial fuel due to low Low Heating Value (LHV)
  - Shredding/ mulching in soil
  - Domestic burning purposes
- **Sugarcane bagasse**
  - High use in biomass industry for energy generation due to high LHV
  - Briquettes

AI generated imagery

Potential Utilization of Crop Residues

In China, USA, Brazil, India, Sweden, Germany and Thailand, residues are used for:

Bio-fuel, briquette fuel, power generation fuel

In-situ fertilizer, animal feed, compost

Building material, straw board and paper

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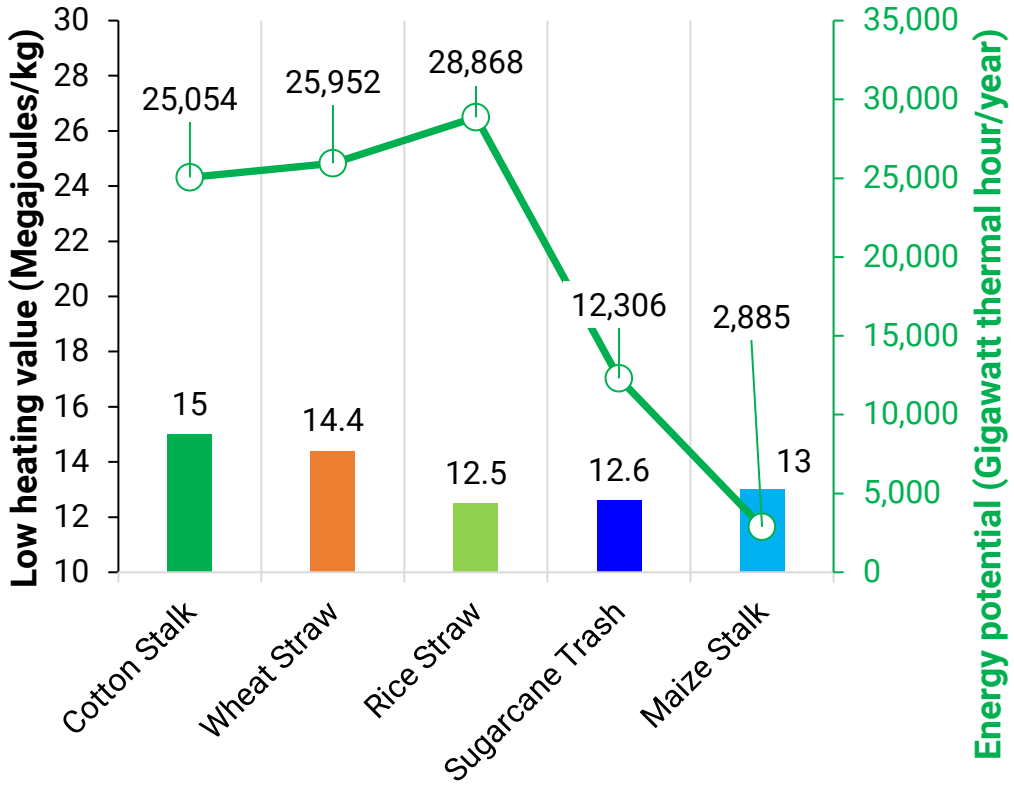
Crop residues as energy source

Energy potential vs LHV



(Source: Competition Commission of Pakistan, GoP, 2019)

Examples for Electricity Production from Biomass

Location	Plant size (MW)	Primary fuel	Alternate fuel
Karachi, Sindh	5.8	Natural gas	Natural gas
Jhang, Punjab	20	Bagasse	Furnace oil
Mirpurkhas, Sindh	12	Bagasse / Rice husk	Cotton stalk / wood chips
Jhang, Punjab	12	Cotton stalk / Rice husk	Cotton stalk / wood chips
Tando Muhammad Khan, Sindh	9.132	Biogas	Not Applicable (N/A)
Rahim Yar Khan, Punjab	26.35	Biogas	Biomass
Chiniot, Punjab	62.40	Bagasse	Biomass
Rahim Yar Khan, Punjab	30	Bagasse	Furnace oil
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Bioenergy production facilities

License for electricity generation was awarded to these biomass production facilities by the National Electric Power Regulatory Authority (NEPRA) in 2014.

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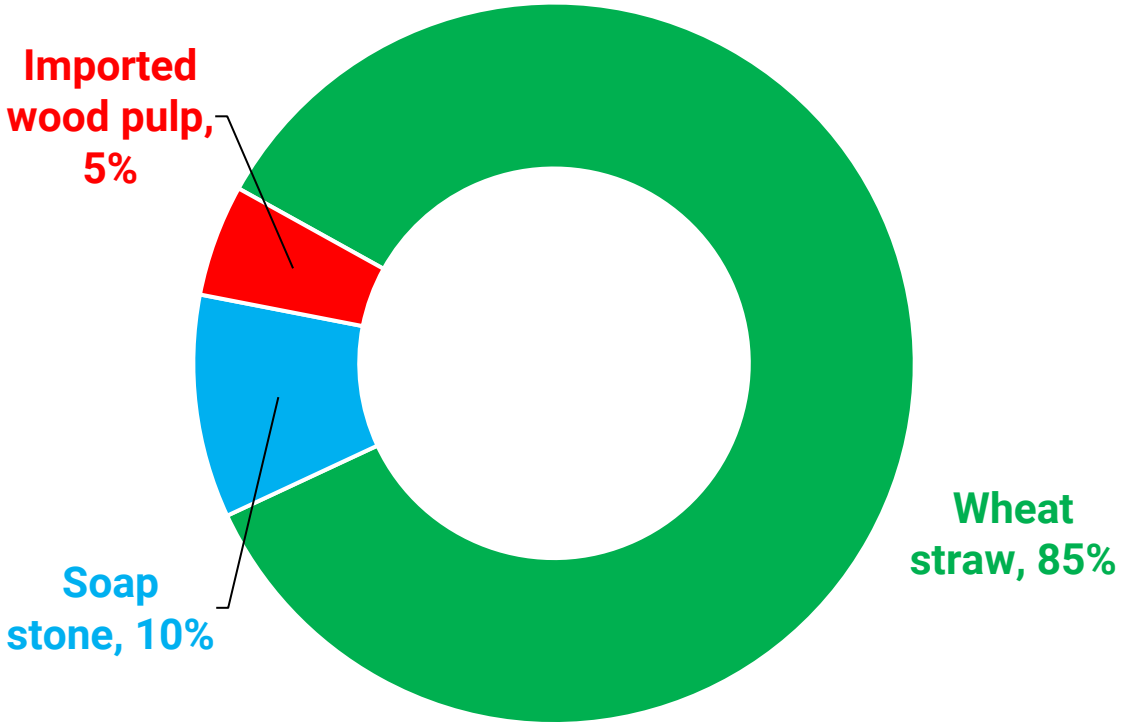
Wheat residue in paper industry

Proportions in local paper/pulp industry



(Source: Competition Commission of Pakistan, GoP, 2019)

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Straw Management through Microbes

- **Introduction to Microbial Decomposition**
- Microbial decomposition is a natural process where microbes break down organic matter into simpler substances
- Utilizing microbes to decompose rice straw offers an eco-friendly alternative to burning, reducing environmental pollution
- **Environmental Benefits:**
  - Reduces air pollution by avoiding straw burning.
  - Lowers greenhouse gas emissions.
- **Soil Health Improvement:**
  - Enhances soil organic matter and nutrient content.
  - Improves soil structure and fertility.
- **Economic Benefits:**
  - Provides a cost-effective solution compared to the traditional methods of disposal.
  - Long-term soil health benefits lead to better crop yields and quality.
- **Types of Microbes Involved**
- **Bacteria:**
  - *Bacillus*: Known for its ability to produce enzymes that break down cellulose and lignin.
  - *Pseudomonas*: Effective in decomposing complex organic compounds in straw.
- **Fungi:**
  - *Trichoderma*: Produces enzymes that decompose cellulose, hemicellulose, and lignin.
  - *Aspergillus*: Known for its strong lignin-degrading enzymes, aiding in faster decomposition.

Mechanism of Action

- **Breakdown of Complex Polymers:**
  - Microbes produce enzymes such as cellulases, hemicellulases, and ligninases.
  - These enzymes break down the complex polymers in rice straw (cellulose, hemicellulose, lignin) into simpler, more manageable molecules.
- **Enzymatic Activity:**
  - Enzymes like cellulase break down cellulose into glucose.
  - Hemicellulase breaks down hemicellulose into pentoses and hexoses.
  - Ligninase breaks down lignin into phenolic compounds.
- **Field Application of Microbial Solutions**
- **Spray Solutions:**
  - Liquid formulations of microbial inoculants can be sprayed directly onto the straw in the fields.
  - Requires proper dilution and uniform application for effective decomposition.
- **Soil Incorporation:**
  - Straw can be mixed into the soil along with microbial inoculants.
  - Enhances microbial activity in the soil, leading to faster decomposition.
- **Case Studies and Success Stories**
- **Punjab,Pakistan:**
  - Farmers adopted microbial solutions to manage rice straw.
  - Significant reduction in air pollution and improvement in soil health reported.

Recommendations

- Promotion of in-situ and ex-situ crop residue management machinery
- Subsidy on in-suit and ex-suit crop residue management machinery up to 80%
- Microbial decomposition of crop residue
- Soft and interest-free loan facility to farmers to purchase crop residue management machinery
- Policy enforcement from the government about biomass burning
- Biomass pelleting with blending of coal using as fuel in power plants
- Biogas production from crop biomass
- Power generation from biomass
- Ethanol production from crop residue for alternative fuel production
- Briquetting for power plant fueling
- Composting
- Bio-degradable kitchen items, such as pots, plates and cups from rice straw
- Building and false ceiling from rice straw

Thank you

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