IRRI International Rice Research Institute

Rice Straw:
Manage it, don't burn it.

A rice straw management options guide

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Introduction

Every harvest of rice creates a large volume of straw as a leftover or byproduct. As rice demand rises and cropping cycles tighten, more straw is produced with less time to deal with it. Annually, about 600 to 800 million tons of rice straw are produced in Asia; globally approximately 1 billion tons are produced.[1] Open-field burning of residue has increased dramatically over the last decade.

The problem should be understood as burning being a value-chain failure. Farmers burn when straw has low or no value at the farm gate and when no market demand for reutilization exists. This is where policy and farm realities often miss each other.

Burning is a fast, cheap, and reliable way to clear fields before the next crop. But the result is a double loss: avoidable air pollution and the waste of biomass that could have been reused. While rice producing countries suffocate in post-harvest and pre-season burning of leftover field residue, the question is what practical alternatives can work and which at scale. Several options do exist, with each their benefits and caveats.

This brief summarizes practical straw management options and what makes them succeed or fail by looking at each option through three lenses:

What does the option do?	What makes it useful?	What must be in place for it to work?
➢ To explain the basic function of the option, such as collecting straw, returning nutrients to the soil, producing feed or food, or recovering energy.	➢ To identify the main economic, environmental, and social benefits, such as reduced burning, improved soil management, additional income, lower transport costs, or cleaner air.	➢ To highlight the practical conditions that determine whether the option can scale, including field access, machinery, moisture control, market demand, technical skills, safety safeguards, and public or private support.

The purpose is not to promote one universal solution. There are several manageable options. Rice straw management depends on local farming calendars, field conditions, labor availability, market integration, and policy support.

[1] Sarkar and Aikat 2013; McLaughlin et al. 2016

Mechanized Collection

After harvest, rice straw is often scattered across the field. Traditionally it is gathered by hand with simple tools and carried away, but this is slow and labor-intensive. Mechanized collection uses machines, such as balers, to pick up loose straw, compress it into bales, and move it to bunds or storage points for later use. The main purpose is to clear fields faster and make straw usable for downstream options like composting, mushrooms, feed, or energy. Mechanized collection turns straw from scattered waste into a usable value chain input that can be sold or processed for other uses.

Opportunities

Faster field clearance. Mechanization by means of balers for straw collection and compaction reduces labor needs and speeds up field clearance. Scattered straw being gathered faster reduces the time pressure between harvest and the next crop. A baler has a collection capacity equal to five people, addressing the labor shortage problem in rice agriculture.[2]

Lower handling and transport burden. Rice straw is bulky to move in loose form. Baling compacts straw, which reduces volume and makes loading and transport more efficient than moving loose straw. The volumetric weight of mechanically compacted straw bales is 50–100% higher than that of loose straw, which significantly reduces handling and transportation costs.[3]

Lower methane emission. By removing straw from the field, mechanized collection can help avoid straw decomposing under oxygen-poor conditions. Straw soil incorporation can emit about 1.5–2.0 times more methane than when rice straw is removed.[4]

Challenges

Field trafficability and limitations. Wet or muddy fields can prevent machines from operating or increase the risk of getting stuck or damaged, which makes collection unreliable in wet seasons or poorly drained landscapes. Many rice fields are too small and scattered, which limits even the use and efficiency of smaller machinery.[5]

Access and logistics constraints. Even if baling works in-field, bales still need to be moved to bunds and onto transport; road access, field layout, and distances (<100km) influence whether collection is practical and affordable. Collection without intermediate storage also shifts the bottleneck from in- to off-field.[6]

[2] Balingbing et al., 2020
[3] Ibid.
[4] Romasanta et al., 2017
[5] Ibid.
[6] Delivand et al., 2011; GIZ, 2025

Make straw movable and tradable biomass: Collection and compaction reduce bulk so straw can enter value chains.

Dependence on equipment, fuel, and skilled operators. Mechanized collection may only need one or two skilled operators in the field, but it depends on machine availability, fuel, maintenance, and service reliability, which can be hard to sustain without steady demand for straw.

New cost and service dependence. Farmers can end up dependent on contractor schedules and prices. Where labor cost is reduced, affordable service and equipment access becomes another factor in more efficient collection.

Recommendations

Promote mechanized collection only where field conditions, service access, and downstream demand make it practical. It is most useful where straw has a clear next use, such as composting, mushroom production, livestock feed, energy, or sale to a processor. It should not be treated as a stand-alone solution, because collecting straw without storage, transport, or buyers simply moves the problem from the field to the roadside.

Match equipment to field conditions. Large machines should not be promoted where fields are small, scattered, wet, or poorly drained. In these settings, smaller balers or track-based machines may be more suitable, but only if they can operate reliably within the short post-harvest window.

Build the service chain around farmers. For most farmers, mechanized collection is more realistic as a contractor, cooperative, or shared service than as individually owned machinery. This requires predictable scheduling, trained operators, fuel and maintenance access, transparent service fees, aggregation points, temporary storage, and buyer linkages.

Do not promote collection without a use pathway. If collected straw does not create income or serve a practical farm or local use, farmers take on extra cost and dependence without enough benefit. In that case, burning remains the easier fallback.

High-density Compaction

High-density compaction turns loose rice straw into dense products, such as briquettes (compressed blocks) and pellets (small dense cylinders). The purpose is to reduce straw's bulk so it is easier and cheaper to handle, store, and transport. The highly compacted straw becomes more practical to use in energy and industrial applications. Briquettes are typically made by compressing chopped straw in a press. Pellets are made by forcing prepared straw through a press plate. Product quality depends strongly on how the material is prepared and pressed, especially moisture, particle size, pressure, and heat generated during compaction.[7]

Opportunities

Efficient handling and processing. Briquettes and pellets are uniform and dense, so they are easier to load, stack, store, and feed into equipment than loose straw. This condition improves processing efficiency and reduces losses during straw handling.[8]

Economical transport and storage. Compaction can increase the amount of straw that fits into a truck or storage space many times over, which is why high-density products can cut transport costs substantially compared with moving loose straw. Moreover, highly densified straw offers transport ranges of several hundred km depending on supply chain assumptions.[9]

A tradable product. Standardized briquettes and pellets are easier to price, sell, and move across longer distances than loose straw, which supports more stable markets rather than one-off local use.[10]

Challenges

Moisture control. If straw is too wet, briquettes and pellets can be weak and inconsistent; if moisture varies, product quality varies, which makes buyers and equipment performance less predictable.[11]

Durability and dust. Low durability leads to breakage ("fines") during transport and handling, which reduces product value.[12]

Equipment and energy needs can be high. Briquetting presses and pellet mills require investment, power/fuel, maintenance, and a steady throughput to be economical for reliable supply and demand. Briquetting costs are also about twice pelletizing costs.[13]

Added costs in pre-processing. Drying and size reduction improve

[7] Balingbing et al., 2020; Tumuluru et al., 2010; Kaliyan & Morey, 2009; Whittaker & Shield, 2017
[8] Tumuluru et al., 2010; Whittaker & Shield, 2017
[9] GIZ, 2025
[10] Balingbing et al., 2020
[11] Kaliyan & Morey, 2009; Said et al., 2015
[12] Whittaker & Shield, 2017
[13] Tumuluru et al., 2010; Balingbing et al., 2020; GIZ, 2025

compaction and durability but it adds time, energy use, and cost—especially in humid climates or wet-season contexts where drying is harder.[14]

Recommendations

Promote high-density compaction only where there is steady straw supply, quality control, and a reliable end use. Briquetting and pelletizing should not be treated as a simple machinery solution. They only become viable when enough straw can be collected, dried, pre-processed, compacted, stored, and sold or used consistently. Without reliable demand, compaction adds cost without solving the burning problem.

Control moisture and product quality before scaling. Drying, chopping, and size reduction should be planned as part of the system, not as afterthoughts. Straw moisture needs to be managed carefully because poor moisture control leads to weak products, breakage, dust, machine problems, and uneven performance for buyers.

Use compaction where transport distance or industrial use justifies the added cost. Dense briquettes and pellets are useful when loose straw is too bulky to move economically, or where processors need uniform feedstock. However, compaction requires investment, energy, maintenance, and steady throughput. It is therefore more realistic around aggregation hubs, processors, or organized service models than as a farmer-level activity.

Apply clean end-use safeguards. If briquettes or pellets are used as fuel, they should be used only in suitable stoves, boilers, or industrial facilities with adequate emissions control. Otherwise, shifting from open-field burning to poorly controlled combustion may reduce one problem while creating another.

[14] Kaliyan & Morey, 2009; Tumuluru et al., 2010

Rice Straw Incorporation

Straw is mixed into the field after harvest so it decomposes in place (usually with tillage) while managing water and time so decomposition proceeds in a way that supports the next crop.). This option can recycle nutrients and build soil organic carbon. Timing and water management before the next crop are important. Straw is typically to be incorporated into non-flooded soil at least about three weeks before sowing or transplanting so decomposition happens under oxygen-present conditions. This helps reduce negative effects tied to anaerobic breakdown and allows nutrients to mineralize before peak crop demand.[15] Waterlogging affects methane and nitrous oxide emissions and the balance between aerobic and anaerobic decomposition.[16]

Opportunities

Nutrient recycling. Rice straw contains large amounts of potassium, about 80% of potassium taken up by rice plants is in straw. Rice also contains other plant nutrients in smaller amounts, nitrogen, phosphorus, sulfur, and silicon. When incorporated into the soil, straw can help recycle these nutrients for later crop uptake, especially potassium, although the nutrients become available only as the straw decomposes.[17]

Soil organic matter. Incorporation can increase soil organic matter which enhances water-holding capacity and stabilizes soil structure, which together support better root growth and resilience against drought. Soil organic matter is also an indicator of soil health.[18]

Less external resource reliance. Incorporation keeps biomass and nutrients re-cycling on-farm, which can be attractive where straw markets or collection services are limited.[19]

Challenges

Greenhouse gas effects. Straw incorporation can increase methane if straw decomposes anaerobically; managing waterlogging between crops is central to reducing this risk.[20]

Nitrogen tie-up. Rice straw has a high Carbon-to-Nitrogen ratio, making it decompose slowly. This can temporarily immobilize nitrogen, making it unavailable early in the next crop and sometimes reducing yields if not managed. The nutrients become available only as the straw decomposes, so timing, water

[15] Dobermann & Fairhurst, 2002; Witt et al., 2000; Chivenge et al., 2020
[16] Sander et al., 2014; Chivenge et al., 2020
[17] Chivenge et al., 2020
[18] Bijay-Singh et al., 2004; Gupta et al., 2007; Chivenge et al., 2020
[19] Chivenge et al., 2020
[20] Sander et al., 2014; Alberto et al., 2015; Chivenge et al., 2020

management, and nitrogen management are important.[21]

Labor- and cost-intensive. Incorporation can make seedbed preparation and crop establishment harder and more expensive than burning.[22]

Toxic by-products. If straw breaks down under flooded or oxygen-poor conditions too close to planting, it can release compounds (including phenolic compounds) that harm crop establishment.[23]

Recommendations

Use straw incorporation only where there is enough time and water control for safe decomposition. Incorporation is suitable where farmers can mix straw into the soil several weeks before sowing or transplanting and avoid prolonged waterlogging. If straw is incorporated too late or under flooded conditions, it can increase methane emissions, delay nutrient release, and create conditions that harm crop establishment.

Manage nitrogen attentively. Because decomposition is slowly and can temporarily immobilize nitrogen, farmers may need guidance on fertilizer timing and nitrogen adjustment. Incorporation should not be promoted as an immediate fertilizer substitute. Its nutrient benefits and are more gradual, especially for nutrients becoming available to the next crop.

Support the added labour and field-preparation burden. Incorporation can make seedbed preparation more difficult and costly than burning. It is more realistic where farmers have access to suitable tillage, irrigation or drainage control, and advice on timing. Where labour, machinery, or water control are limited, farmers may carry higher costs and risks with uncertain short-term returns.

Do not frame incorporation as universally beneficial. It can recycle nutrients and support soil organic matter, but it is not an unlimited soil-building strategy and does not fit every production system. It should be promoted where the agronomic conditions are right; otherwise, composting, collection for other uses, or other straw pathways may be more practical.

[21] Bird et al., 2001; Thuy et al., 2008; Chivenge et al., 2020

[22] Chivenge et al., 2020

[23] Olk et al., 2006; Chivenge et al., 2020

Rice Straw Composting

Compost is a stabilized, decomposed organic material made by letting plant residues and other organic wastes break down under aerobic (oxygen-present) conditions. Rice straw is mixed with other organic materials, such as animal manure and enzymes, and actively managed so microorganisms can decompose it in a controlled way. Compost is a soil conditioner and plant fertilizer that improves soil quality and provide nutrients that support crop growth when produced and applied properly.[24] Compost quality and speed of composting depend on the raw material properties and processing conditions.[25] When temperature, moisture, and pH stay in a favorable range, the material breaks down into a compost by the help of microbes.

Opportunities

Low value, high usability. Unlike options that require clean, dry, transportable straw, composting works even when straw is wet, mixed, and not suitable for baling or selling, because it can be processed locally in piles rather than needing transport-quality straw.[26]

Soil improvement. Compost adds stable organic material and nutrients in a slower-release form than fresh straw, which can improve soil condition and support crop growth.[27]

Lower emissions pathway. Composting breaks straw down in an oxygen-present process before it reaches the field. Less straw is subject to oxygen-poor conditions that drive methane formation.[28]

Challenges

Process control is laborious. Composting only works well if moisture, airflow, temperature, and pH are actively managed. While each in itself is a challenge, they are all connected.

Moisture and oxygen. Too little moisture slows microbial activity because they cannot thrive without moisture, and dry straw stays too tough for microbes to break into. Too much moisture fills air spaces and blocks oxygen, creating anaerobic conditions where decomposition shifts to decomposition that produces less beneficial heat but more odors.[29]

pH and nitrogen losses. pH swings affect microbes, slow the process, and reduce compost quality.[30] Early in composting, microbes break down organic compounds producing acids. If the pile is poorly aerated, those acids build up (acidic pH) and less heat from

[24] Nghi et al., 2020; Diaz et al., 2007
[25] Nghi et al., 2020; Diaz et al., 2007; Haug, 1980
[26] Nghi et al., 2020
[27] Nghi et al., 2020; Diaz et al., 2007
[28] Nghi et al., 2020
[29] Nghi et al., 2020; Vigneswaran et al., 2016; Shilev et al., 2007
[30] Nghi et al., 2020; Diaz et al., 2007

microbial activity is generated leading to delayed decomposition. When pH is high (alkaline pH), more nitrogen shifts into ammonia gas. That means the finished compost loses fertilizer value, and the strong ammonia smell can become a nuisance. Farmers need to manage pH by balancing carbon-rich straw with nitrogen-rich inputs, keeping moisture in the right range, and turning the pile to maintain oxygen.

Maturity and sanitation risk. Compost may stay immature and may not reduce pathogens and weed seeds if the pile does not heat up enough or is not managed well through the hot phase.[31]

Recommendations

Promote composting where process control and local use are realistic. Composting is most useful where straw is wet, mixed, or unsuitable for sale, and where the mature compost can be used on-farm or sold locally. It should not be treated as a simple pile-and-wait solution. Good compost requires active management of moisture, airflow, temperature, pH, and maturity.

Match the composting model to the straw volume. Vermicomposting is more suitable for small to medium volumes where producers can keep conditions stable, protected, and hygienic. For larger straw volumes, mechanized windrow composting is more realistic because turning equipment reduces manual labor and improves aeration, mixing, and decomposition speed.

Prevent low-quality compost through simple quality control. Composting systems should include regular turning, moisture checks, balanced mixing of carbon-rich straw with nitrogen-rich inputs, and enough time for the compost to mature. Without this, compost may decompose slowly, smell, lose nitrogen, remain immature, or fail to reduce pathogens and weed seeds.

Use shared or service-based models where individual management is too demanding. For many farmers, composting is more realistic through cooperatives, local service providers, or shared composting sites than as a household task. Support should focus on access to turners, fuel, maintenance, trained operators, input mixing, and clear users or buyers for the finished compost. Without these conditions, composting becomes labor-heavy, unreliable, or too costly.

[31] Nghi et al., 2020; Shilev et al., 2007; Ameen et al., 2016

Biochar

Biochar is a charcoal-like, carbon-rich solid made when biomass is heated under low-oxygen conditions (pyrolysis; heated without burning). Biochar is the main non-energy product from heat-based conversion of rice straw. It is mainly used as a soil amendment and as a material that can bind or trap some pollutants. Biochar is produced by heating straw (often above ~300°C) with little or no oxygen. Temperature, heating rate, and residence time determine the quality with higher temperatures producing a more carbon-rich char.[32]

Opportunities

Soil improvement and productivity. Biochar can improve soil conditions by supporting water and nutrient retention through its porous, sponge-like material, by helping soils stay more crumbly and less compacted, which supports root growth and infiltration, and adjust soil acidity as they are neutral to slightly alkaline.[33]

Carbon storage potential. Adding biochar to soil can store carbon in a more stable form than fresh straw residue incorporation, which is why it is often framed as a carbon sequestration option. Its use in paddy reduces methane emissions. [34]

Pollution control. Biochar can act as an adsorbent for contaminants, such as heavy metals and some organic compounds (pesticides, antibiotics).[35]

Challenges

Production matters. Biochar is not a single uniform product: temperature and process choices change its structure and surface chemistry. A biochar that works well for soil improvement may not perform the same way for contaminant adsorption, and vice versa. To increase biochar's absorption properties, "activation" may be needed, treating the char with steam, carbon dioxide, or chemicals at high temperature to enlarge its pores.[36]

Emissions balance is not automatic. The carbon-climate benefit can shrink if biochar production relies heavily on fossil energy, where more carbon dioxide emissions and their equivalent are expunged into the air than biochar can store in the soil. On a large scale the emissions can be addressed with technical solutions, but this is difficult for farm-level devices requiring additional cost. [37]

[32] Maguyon-Detras et al., 2020; Jonsson, 2016; Wu et al., 2012; Thammasom et al., 2016
[33] Schmidt, 2012; Amarasinghe et al., 2016; Zhang et al., 2015; Ahmad et al., 2014
[34] Maguyon-Detras et al., 2020; Thammasom et al., 2016; Yun-Feng et al., 2014; Yang et al., 2019; Qin et al., 2016
[35] Tan et al., 2015; Uchimiya et al., 2012
[36] Wu et al., 2012; Thammasom et al., 2016
[37] Roos, 2009; Agarwal, 2014; GIZ, 2025

Byproducts and safety need management. Thermochemical conversion of straw can also produce ash that contains heavy metals and needs leachability checks. It should not be disposed uncontrolled. Nevertheless, the ash high in silica can be reused in construction materials or cement.[38]

Recommendations

Promote biochar only where the intended use, production method, and quality requirements are clear. Biochar should not be treated as one uniform product. Its value depends on how it is produced and what it is meant to do, such as soil improvement, carbon storage, or contaminant adsorption. Production temperature, heating time, oxygen conditions, and post-treatment should match the intended use.

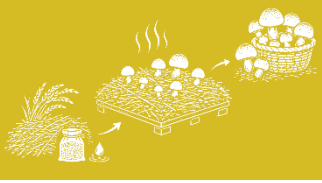
Do not promote farm-level pyrolysis without technical support. Farmer involvement is most realistic as users of tested biochar products or as straw suppliers to trained producers. Operating pyrolysis units requires technical control, safety measures, and quality checks. Without these, biochar quality may be inconsistent and expected soil or climate benefits may not materialize.

Check the full energy and emissions balance. Biochar should only be promoted for climate benefits where production does not rely heavily on fossil energy and where process heat can be recovered or used efficiently. Otherwise, the carbon-storage benefit may be weakened or cancelled out by emissions from production.

Set quality and safety standards before scaling. Biochar use should be supported by basic checks for product quality, contaminants, application rates, and suitability for local soils. By-products from thermal conversion, such as ash, should also be managed safely and not disposed of uncontrolled.

[38] Young, 2010; Lam et al., 2010; Chen et al., 2017; Caraos, 2018; Liu et al., 2014

Mushroom Production



Rice straw can be used as a growing medium (substrate) to cultivate edible mushrooms such as *Volvariella volvacea*. Farmers prepare straw beds (often outdoors, sometimes indoors), add mushroom spawn, and manage basic conditions so the fungus colonizes the straw and produces mushrooms. Production can be relatively fast (around six weeks from preparation to harvest), but it depends on clean, suitable straw and stable growing conditions. Straw needs to be clean, not spoiled, and at suitable moisture before preparation—not moldy or rotting—because bacteria and unwanted fungi can contaminate the crop. Rice-straw mushrooms grow best in warm, humid conditions typical of tropical climates, and production is sensitive to sudden temperature changes. Outdoor systems are lower cost but exposed to weather, while indoor systems require more investment but offer more stable control.[39]

Opportunities

Higher value from low-value residue. Instead of being a byproduct, straw becomes a productive input and resource material, creating a practical alternative to burning or leaving straw unused.[40]

Fast in come cycle. Mushroom cultivation can generate additional income quickly after the previous rice harvest, because mushroom production cycles are short and freshly harvested mushrooms can fetch decent market prices.[41]

Low entry barrier at small scale. Outdoor cultivation can fit smallholder settings well because it relies on locally available straw and limited equipment compared with many other straw utilization options.[42]

Scalable pathways. Where markets and skills exist, farmers can expand an eventual profitable production and improve production reliability by shifting from outdoor beds to controlled indoor systems.[43]

Challenges

Outdoor weather sensitivity. Temperature swings, heavy rain, low sunlight at key stages, or poor aeration can reduce yields and stop production. Although outdoor production requires minimal preparation, weather influences can make outputs unpredictable.[44]

High contamination risk. Moldy straw and unmanaged pathogens can spoil fungi production. Attention and control for clean and dry straw inputs are

[39] Thuc et al., 2020; Biswas & Layak, 2014; Akinyele & Adetuyi, 2005
[40] Thuc et al., 2020
[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Ibid.

essential, which does however demand disciplined straw handling and additional labor hours.[45]

Cost versus reliability trade-off. Outdoor systems are cheaper but riskier, while indoor systems are more reliable. The trade-off is that indoor production needs investment in an adequate shelter with at least basic climate and hygiene controls, such as racks or beds, ventilation, humidity control, and reliable water and power to keep conditions stable and reduce contamination.[46]

Perishability. Fresh mushrooms spoil within days, so farmers need access quickly to markets, cold storage, or a processing option to avoid harvest losses.[47] These are conditions often beyond a farmer's control.

Recommendations

Promote mushroom production only where clean straw, producer skills, and fast market access are in place. Rice-straw mushroom production can generate income quickly, but it is not suitable everywhere. It depends on clean, suitable straw, careful spawn handling, hygiene, and a reliable outlet for a fresh product that spoils quickly.

Use outdoor production as a low-cost entry point only where weather risks are manageable. Outdoor systems can be attractive for smallholders because they require less investment, but they are exposed to rain, temperature changes, poor aeration, and contamination. They are best suited for learning, small-scale production, and areas where local conditions are already favorable.

Move toward semi-controlled or indoor systems only after demand and skills are proven. More controlled systems can reduce crop losses and improve reliability, but they require investment in shelter, racks or beds, ventilation, humidity control, water, power, and hygiene management. They should not be promoted before producers have the skills and buyers needed to justify the added cost.

Build the market and post-harvest link before scaling. Fresh mushrooms need quick sale, collection, cooling, drying, or processing options. Support should focus on direct buyer links, local collection, simple cooling, drying options, and producer training. Without these, higher production can quickly turn into losses rather than income.

[45] Thuc et al., 2020; Ahlawat & Tewari, 2007
[46] Thuc et al., 2020
[47] Thuc et al., 2020; Jamjumroon et al., 2012; Bernaś et al., 2006

Livestock Feed

Rice straw is already being widely used as roughage feed for ruminants such as buffaloes, cattle, goats, and sheep. Straw can be stored for lean months when fresh forage is scarce. However, rice straw is a low-quality feed and more of a filler: it is low in crude protein (often between 4–5%) and has low digestibility (often below 50%) because its fiber structure is hard to break down and it can contain high silica and lignin. To better use rice straw as ruminant feed, it can be "upgraded" in its feeding value so animals can eat more of it and digest it better. This can be done through physical processing (chopping/grinding/pelleting), alkali treatment (sodium hydroxide, urea, lime), biological treatment (fungi, enzymes), and through feeding protocols that combine straw with supplements such as concentrates, molasses, or legumes to balance nutrients.[48]

Opportunities

Feed security in lean months. Unlike fresh produce, straw can be stored over long periods of time and used when green forage is limited. This helps maintain basic ruminant feeding through seasonal gaps.[49]

Treated straw for productivity gains. Treating straw or combining it with supplements raises nutrient intake and digestibility, which can improve cattle growth, milk yield, and overall animal performance compared with feeding untreated straw alone. Higher milk output and better weight gain (meat) translates into improved household income and livestock value.[50]

Challenges

Low basic feed value. Untreated straw is poor in protein and digestibility, so relying on it as the main feed will reduce cattle performance, especially for fast growth, late pregnancy, and early lactation.[51]

Treatment adds cost, work, and risk. Treatment methods, especially chemically-based, can improve digestibility but require additional resource inputs, careful handling, and safe disposal practices. They are only adopted if benefits outweigh effort and expense.[52]

Biological methods are hard to control. Fungi and enzymes require time (days to weeks) to breakdown the fibrous straw, and they only perform well if moisture, temperature, and cleanliness stay within a narrow range. On farms, those conditions are hard to keep stable, so results can be inconsistent. Long incubation also

[48] Aquino et al., 2020; Agbagla-Dohnani et al., 2003; Vadiveloo, 2000; Devendra & Thomas, 2002; GIZ, 2025
[49] Aquino et al., 2020
[50] Aquino et al., 2020; Vu et al., 1999
[51] Aquino et al., 2020; Vadiveloo, 2000
[52] Aquino et al., 2020; Jackson, 1977

means more handling, and a higher risk of unwanted fungi (safety risk).[53]

Service and knowledge dependence. Many options depend on farmer skills, storage space, and access to input resources (such as urea or lime); without experienced support, preparation and consistent use of straw as fodder can be counterproductive and risky.[54]

Recommendations

Use rice straw as reserve roughage, not as a complete feed. Rice straw is useful during lean months when green forage is scarce, but untreated straw should not be promoted as the main feed for animals with high nutritional needs, such as fast-growing cattle or animals in late pregnancy or early lactation. It is low in protein and digestibility, so it needs to be combined with better-quality feed or treated before it can support stronger animal performance.

Prioritize simple improvements farmers can apply consistently. The most practical first steps are chopping or grinding straw to improve intake and mixing it with locally available supplements, such as concentrates, molasses, legumes, or other protein and energy sources. These options are easier to adopt than more complex biological or chemical treatments.

Use chemical or biological treatments only where safe handling and advisory support are available. Urea, lime, sodium hydroxide, fungi, and enzyme-based treatments can improve digestibility, but they add cost, labor, storage needs, and safety concerns. They should be promoted only where farmers have reliable access to inputs, clear instructions, safe preparation methods, and support from extension workers or trained service providers.

Link straw-feed use to livestock value, not just straw disposal. Rice straw feeding is most useful where it helps farmers maintain animals through feed shortages or improve milk, meat, or live-animal value. If treatment costs, labor, or risks are higher than the expected livestock benefit, farmers are unlikely to adopt it consistently.

[53] Aquino et al., 2020; Rodrigues et al., 2008

[54] Aquino et al., 2020

Biogas

Rice straw can be converted to biogas in a sealed digester. Biogas is a renewable fuel gas produced when microorganisms break down organic material without oxygen (anaerobic digestion). It is a mixture of ga ses, dominated by methane and carbon dioxide; methane is the key component because it provides most of the energy value. The exact gas composition depends on the straw and process conditions, such as temperature, pH, and how long the material stays in the digester. Because straw is fibrous and carbon-rich, its performance is better when straw is mixed with wetter, nitrogen-richer materials, such as livestock manure (co-digestion) and when straw is chopped or otherwise pretreated to make it easier to break down. The process also produces a nutrient-containing residue (bioslurry) that can be used as fertilizer if managed well.[55]

Opportunities

From waste to renewable energy. Biogas turns straw and other organic wastes into usable energy for cooking, heating, or electricity, which can reduce reliance on traditional fuels if systems are well operated.[56]

Nutrient recycling. Bioslurry retains nutrients and can be used in agriculture (and in some contexts linked to aquaculture), helping return nutrients to production systems instead of losing them through burning or disposal.[57]

More feasible when co-digested. Rice straw digests poorly on its own, so mixing it with wet wastes like manure improves moisture and nutrient balance and helps keep the process stable, making reliable biogas production more likely.[58]

Challenges

Straw is a difficult raw material. Rice straw breaks down slowly and can destabilize digestion if fed without preparation, so systems often need pretreatment (for example size reduction) and co-digestion to achieve stable gas production.[59]

Process instability. Anaerobic digestion is sensitive to operating conditions; if feeding is poorly managed, acids can build up and pH can drop, which suppresses methane-forming microbes and can stop gas production.[60]

Logistics makes or breaks viability. Straw is bulky and seasonal, but

[55] Ngan et al., 2020; Alvira et al., 2010; Deublein & Steinhauser, 2011
[56] Ngan et al., 2020
[57] Ngan et al., 2020; Gurung, 1997; Balasubramanian & Bai, 1994
[58] Ngan et al., 2020
[59] Ngan et al., 2020; Deublein & Steinhauser, 2011; Alvira et al., 2010
[60] Gerardi, 2003; Yadvika et al., 2004; McCarty, 1964

digesters perform best with steady feeding. Its collection, transport, storage, and digester input are main practical bottlenecks that need careful planning.[61]

Bioslurry needs safe handling. Bioslurry can create odor, hygiene concerns, or water pollution if mishandled. Careful planning is again essential for storage and farm application.[62]

Maintenance and service support. Digesters require consistent operation and repair capacity. Inattentive operation can lead to breakdown of the digester, and eventual loss of trust in the technology.[63]

Recommendations

Promote biogas only where steady feedstock and co-digestion are realistic. Rice straw is difficult to digest on its own, so biogas systems should be planned around reliable access to straw and wetter, nitrogen-richer materials such as livestock manure. Straw collection, chopping or other pretreatment, storage, and regular feeding into the digester need to be organized before investment in the digester itself.

Treat digesters as managed systems, not passive infrastructure. Anaerobic digestion is sensitive to feeding rates, pH, temperature, retention time, and input balance. Operators need clear guidance to avoid overfeeding, acid build-up, process failure, and loss of gas production. Training, maintenance, repair services, and simple operating routines should be part of the model from the start.

Plan for logistics and ownership before scaling. Straw is bulky and seasonal, while digesters need steady feeding. This makes biogas more realistic where farmers are organized as suppliers to a managed facility, or where household or community systems have reliable feedstock and service support. Straw supply should be treated as a logistics and service issue, not as a farmer motivation issue.

Require safe use of both outputs. Biogas projects need an end-use plan for the gas and a safe handling plan for bioslurry. Bioslurry should be stored and applied properly so it remains a useful fertilizer rather than creating odor, hygiene, or water pollution problems. Without reliable operation and safe residue management, biogas systems can become costly, fragile, and quickly lose user trust.

[61] Ngan et al., 2020
[62] Gurung, 1997; Ngan et al., 2020
[63] Balasubramaniyam et al., 2008; Ngan et al., 2020

Syngas

Syngas (synthesis gas) is a fuel gas produced when biomass is heated in an oxygen-limited environment so it converts into gas rather than burning completely. It is mainly made of carbon monoxide and hydrogen, plus smaller amounts of other gases depending on the setup. Rice straw is converted into syngas through gasification, a high-temperature heat-based process that uses a limited amount of oxygen (or steam/air/oxygen as a gasifying agent) to drive chemical reactions that turn solid carbon in straw into carbon monoxide and hydrogen. The gas composition depends on temperature and pressure, reactor design, feedstock properties (including moisture and minerals), and the gasifying agent. Gasification systems can be built in different reactor designs (fixed-bed, fluidized-bed, entrained-flow), which influences performance and operational complexity.[64]

Opportunities

Energy carrier. Syngas can be used for heat and power uses, including engines, turbines, fuel cells, and combined-cycle systems, offering a pathway that converts straw into usable energy rather than disposing of it.[65]

Industrial potential. Because syngas contains carbon monoxide and hydrogen, it can serve as a starting material for producing industrial chemicals and fuels (such as methanol, hydrogen, ammonia, and synthetic fuels), which is a more value-added pathway than using straw only for direct heat.[66]

Promising early technical performance (with caveats). Studies reported encouraging initial results for rice-straw gasification, including efficiency outcomes in fluidized-bed systems and methods to improve gas quality (for example increasing hydrogen-rich gas yields).[67]

Challenges

Tar management is a barrier. Producer gas can contain tar that clogs or damages engines and equipment, so systems require tar removal (filters, scrubbers, condensers) or tar conversion (catalytic cracking/reforming), and these solutions add complexity and are still developing.[68]

Ash and mineral behavior can disrupt operation. Rice straw's mineral content can cause problems, such as bed agglomeration in certain reactors. Fixing this can require design

[64] Agarwal, 2014; Young, 2010; Maguyon-Detras et al., 2020
[65] Agarwal, 2014; Maguyon-Detras et al., 2020
[66] Young, 2010
[67] Calvo et al., 2012; Baloch et al., 2016
[68] Brandin et al., 2011; Maguyon-Detras et al., 2020

changes or alternative bed materials to increase technical demands.[69]

Pre-processing needs. Moisture, particle size, and mineral content strongly affect performance and stability, requiring straw pre-processing and high-quality control which smallholder settings may not be able to manage easily.[70]

High capital and maintenance. Gasification is typically more complex and capital-intensive than low-tech straw options and requires trained operators, reliable maintenance, and stable supply and demand to remain viable.[71] This increases farm-external dependencies.

Environmental and health risks. Gasification can create serious risks if tar condensates and wastewater are not handled safely, potentially exposing operators and communities to harmful substances.[72]

Recommendations

Treat gasification as an industrial or cooperative-scale option. *It should not be promoted as a simple on-farm alternative to burning.* Rice-straw gasification requires controlled feedstock quality, trained operators, reliable maintenance, and safety systems.

Solve feedstock quality before investing in gasification units. Straw moisture, particle size, mineral content, and supply consistency need to be managed through organized collection, drying, preprocessing, and aggregation.

Require technical and environmental safeguards. Gasification systems should include tar removal or conversion, safe management of condensates and wastewater, and controls for ash, mineral behavior, and emissions. Without these safeguards, the technology can create new health and environmental risks while trying to solve the burning problem.

Use gasification only where there is a stable energy or industrial demand. Because gasification is capital-intensive and maintenance-heavy, it needs steady straw supply and a reliable user for the gas, heat, power, or industrial output. Without trained operation, repair capacity, buyer demand, and safety controls, system failure is likely and burning remains the easier fallback.

[69] Calvo et al., 2012
[70] Agarwal, 2014; Maguyon-Detras et al., 2020
[71] Maguyon-Detras et al., 2020; Young, 2010
[72] Dimpl, 2010; Stassen, 1995; Maguyon-Detras et al., 2020

Options by scalability and enabling conditions

The options for rice straw differ not only in their technical function, but also in how easily they can be applied at scale. Some options, such as mechanized collection, enable other uses but do not solve straw management on their own. Others, such as mushroom production, livestock feed, or composting, can create local value where skills and markets exist. More complex options require managed facilities, trained operators, and stronger safeguards.

The table summarizes these differences. It is not a ranking of “best” and “worst” options. Instead, it shows what each option is most suitable for, how scalable it is likely to be, and what conditions need to be in place before it should be promoted. This helps avoid treating all alternatives to burning as equally practical or equally ready for farmers.

Option	When it is useful	Main conditions needed	Scalability
Mechanized collection and baling	Not an end use by itself, but it enables many other uses by turning scattered straw into a movable product	Field access, workable soil conditions, machinery services, aggregation points, transport, buyer linkages	**Highly scalable enabling option**
Livestock feed, mushroom production, compost	Can create direct use or income, but they depend on local demand, skills, and reliable handling	Clean straw, farmer or service-provider skills, local buyers or users, storage, quality control	**Scalable where markets exist**
Straw incorporation	Can work where farmers have enough time before planting and can manage water and nitrogen properly	Around three weeks before planting, dry or oxygen-present decomposition conditions, fertilizer timing, water control	**Locally scalable under suitable agronomic conditions**
High-density compaction, pellets, briquettes	Useful where transport distance and industrial demand justify processing costs; not worth promoting without reliable buyers	Dry straw, preprocessing, steady supply, processing equipment, quality standards, clean end-use	**Conditional supply-chain option**
Biochar	Promising for soil and carbon benefits, but not automatically scalable because production quality, cost, and energy balance matter	Controlled production, quality checks, clear use case, safe by-product handling, viable cost-benefit case	**Conditional technical option**
Biogas	More realistic where straw can be co-digested with manure or other wet wastes and operated as a managed system	Steady feedstock, co-digestion material, trained operators, maintenance, safe bioslurry use	**Managed-facility option**
Syngas/ gasification	Technically complex and risky if pushed to farm level; better suited to managed facilities	Trained operators, stable straw supply, tar and wastewater management, emissions controls, maintenance capacity	**Industrial or cooperative-scale only**

The Way Forward

Open-field burning is not only a local farming issue but a transboundary haze and public health problem with region-wide economic costs. Burning should be treated as a systems failure, not a farmer preference. Straw supply is high while demand and processing capacity remain low, and technical know-how is still uneven.

No single rice straw management option will solve all problems. The right choice depends on what the intervention is trying to achieve and which enabling conditions are in place. For reducing open-field burning and air pollution, collection is often the starting point, because straw first needs to be removed from the field and made usable. Composting, mushroom production, livestock feed, and industrial uses can then create practical alternatives to burning.

For farmer income, the strongest options are those **linked to clear markets or direct use**, such as mushroom production, livestock feed, and sale of collected or compacted straw. These options **only work when farmers can access buyers, services, or local users quickly enough after harvest**.

For soil improvement, incorporation, compost, and biochar are most relevant, but they should not be treated as interchangeable. Incorporation depends on timing, water control, and nitrogen management. Compost depends on process control and local use. **Biochar depends on controlled production**, quality, cost, and a **clear soil or carbon purpose**.

For energy recovery, **biogas and syngas should be treated as managed-system options** rather than farmer-level solutions. They require steady feedstock supply, trained operators, maintenance, safe handling of residues, and clean end-use conditions.

Across all options, **the main lesson is that rice straw management should not start with the technology**. It should **start with the use pathway**: who will collect the straw, who will process it, who will buy or use it, what quality is needed, and what risks must be managed. Without that chain, alternatives remain technically possible but practically weak.

Where straw can be reused, priority should go to higher-value circular pathways *before* energy recovery, so that soil-return, food, and feed options are explored first, and energy use is treated as a later resort rather than the default.

Making **market integration is central** to these considerations. Straw only moves and is reused at scale when there are **reliable buyers** and a logistics set-up that can collect, store, and transport it on time.

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Rice straw burning is often treated as a farmer behaviour problem. It is better understood as a systems failure.

Each rice harvest leaves behind large volumes of straw. When farmers have little time before the next crop, limited access to collection services, and no reliable buyer or use pathway, burning remains the fastest and cheapest way to clear the field. The result is avoidable air pollution, lost biomass value, and missed opportunities for circular use.

This brief reviews practical rice straw management options and the conditions that make them work. It looks at mechanized collection, high-density compaction, soil incorporation, composting, biochar, mushroom production, livestock feed, biogas, and syngas. For each option, it explains what the option does, where it can add value, and what must be in place before it can scale.

The brief does not promote a single solution. Rice straw management depends on farming calendars, field conditions, labor availability, machinery access, market demand, and public or private support. Some options create direct local value. Others require organized supply chains and managed facilities.