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Accelerating the implementation of the 2030 Agenda for Sustainable Development in Asia and the Pacific through environmental solutions

Reducing straw residue burning and air pollution through sustainable agricultural mechanization**

Summary

Burning of straw residue is a common practice in many countries of the Asia-Pacific region. In recent times, this practice has drawn the attention of policymakers and the public due to its adverse effects on the environment including air pollution which impacts the life of millions of people across countries, and contributes to climate change as well as loss of fertility on agricultural land.

Appropriate agricultural machinery can help farmers adopt sustainable and integrated management of straw residue including its use as fertilizer, cattle feed, bioenergy, substrate for growing mushrooms and industry material.

In order to promote integrated straw management through sustainable agricultural mechanization in member States, it is recommended that awareness raising about the adverse effects of residue burning and the economic benefits accruing from more sustainable approaches should be prioritized. Moreover, support should be provided to farmers towards initial investments for the adoption of the required machinery and equipment while tailoring the solutions to match local conditions.

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I. Introduction and regional overview

1. Burning of straw residue is a common practice in many countries of the Asia-Pacific region often undertaken by farmers twice a year. In recent times, this practice has drawn the attention of policymakers and the public due to the adverse effects of the burning on the environment including air pollution which impacts the life of millions of people across countries, and contributes to climate change. In order to address this issue, it is important to understand why many farmers still choose this method despite the fact that it severely undermines soil fertility in the long run.

2. Rice, wheat and maize are the main staple crops produced in the region. The cultivation method of these crops implies that the farmers have to deal with an abundance of stalks, the remaining part of the plant left on the field once the grain is harvested. Since the stalks have no palpable value and interfere with planting of the subsequent crop, smallholders are compelled to clear them from the field. With little resources at hand and a tight seeding schedule for the next cycle, which cannot be delayed without negative effects on the crop yield, residue burning presents itself as the most convenient and cheap option to farmers.

3. Burning of straw results in severe consequences for the environment as it leads to soil deterioration. Soil nutrients, pH level, moisture, available phosphorus, soil organic matter and microbial population are all adversely influenced by burning. According to some estimations, 1 ton of rice straw contains 5.5 kilogram (kg) of nitrogen, 2.3 kg of phosphorous, 25 kg of potassium and about 1.2 kg of sulphur which are lost due to burning.¹ In other words, farmers seeking to intensify agricultural production end up eliminating essential micro-nutrients from the soil by burning resulting in infertile land in the long run. The other side effect of residue burning is air pollution caused by the emission of carbon dioxide, carbon monoxide, nitrogen oxides, methane and nitrous oxide gases and discharge of ash. Worsening of air quality causes a negative impact on human health, resulting in respiratory, cardiovascular and other diseases, and can even lead to disruptions in the economy as smog may cause problems for transportation, closure of schools and public venues, and interfere with everyday life.² Air pollution caused by straw burning can also pose a transboundary issue as smog may be easily picked up by the wind and carried over extended distances across countries and regions.

4. Studies suggest that the main reasons contributing to straw burning are the high cost of straw collection, transportation and storage, partially caused by the shortage of rural labour, lack of adequate methods and machinery to treat straw residue and weak awareness of the impacts on the environment, security risks and health concerns. As per one estimate of cost, the complete collection of straw from the field can amount to around \$55 per acre, which is far more expensive than field burning when externalities are considered.³

¹ *National Policy for Management of Crop Residues (NPMCR)*. (2014). New Delhi, India: Government of India. Ministry of Agriculture. Department of Agriculture & Cooperation (Natural Resource Management Division).

² Datta, A, M A Emmanuel, N K Ram and S Dhingra. (2020). *Crop Residue Management: Solution to Achieve Better Air Quality*. New Delhi: TERI

³ Ahmed, T., & Ahmad, B. (2013). *Why do farmers burn rice residue? Examining farmers' choices in Punjab, Pakistan*. Kathmandu: South Asian Network for Development and Environmental Economics.

5. Despite the fact that straw burning is still a widespread problem in the Asia-Pacific region, it is important to understand that not all straw residue is burnt in the field. Since crop straw is rich in fiber, lignin, starch, protein, enzymes and nutrients, is also used as fertilizer, fodder, bioenergy, base stock and industry material. However, these practices often remain underdeveloped and have not been adequately scaled up.

6. In order to address the issue, several governments have developed national programmes aimed at combating straw burning. For instance, in the ongoing national project titled “Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and the National Capital Territory of Delhi” developed by the Department of Agriculture, Cooperation & Farmers Welfare under the Ministry of Agriculture & Farmers Welfare of the Government of India, the main focus is to achieve zero burning through the promotion of appropriate strategies for in situ crop residue management, provision of financial assistance for procurement of the needed machinery and equipment and offering on-field / off-field training to farmers and farmers’ societies.⁴ As another example, Indonesia initiated a project on ‘Carbon Efficient Farming’ which assessed biomass in terms of carbon and undertook modelling to reduce carbon dioxide emissions. Thailand and Viet Nam are among some of the other countries that have announced and undertaken measures to reduce open burning.

II. Sustainable agricultural mechanization solutions

7. The important role of machinery in the agricultural sector has been well recognized. However, nowadays the main requirement for mechanization is not only to reduce production cost and increase yield but also to minimize the impact on the environment. With the help of appropriate agricultural machinery, farmers have the solutions available to adapt their practices towards the reuse of straw residue for purposes such as fertilizer, cattle feed, bioenergy, substrate for growing mushrooms and industry material.

8. Among the more common uses of straw in the region is utilization of the crop residue as fertilizer, fodder, or mushroom substrate.⁵ Since straw can balance soil nutrients, increase soil organic matter content and consequently help reduce the input of chemical fertilizers, a large portion of retained straw is used as an organic fertilizer. This could be achieved through straw returning to the field with the help of relevant machinery such as choppers, no-till planters and straw chopping harvesters. Cattle fodder can be produced by fermenting green straw with anaerobic lactic acid bacteria under confined hypoxia conditions, or by balers making straw fodder bale or block for better storage. Mushroom substrate can also be prepared for which raw paddy straw should be softened, sterilized or incubated and inoculated with spawn to grow mycelium, and machinery such as choppers and sterilizers applied in this process. In brief, agricultural machinery plays a key role in the major straw retention practices.

9. The adoption of these practices can decrease the environmental footprint of straw management and reduce the emission of carbon dioxide, contributing to lowering of air pollution and reducing the degradation rate of the soil. At the

⁴ *Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and the National Capital Territory of Delhi*. (2018). New Delhi, India: Government of India. Ministry of Agriculture & Farmers Welfare. Department of Agriculture, Cooperation & Farmers Welfare (Mechanization & Technology Division).

⁵ Singh, K. K. (2018). *Status of Straw Management in Asia-Pacific and Options for Integrated Straw Management*. ESCAP-CSAM.

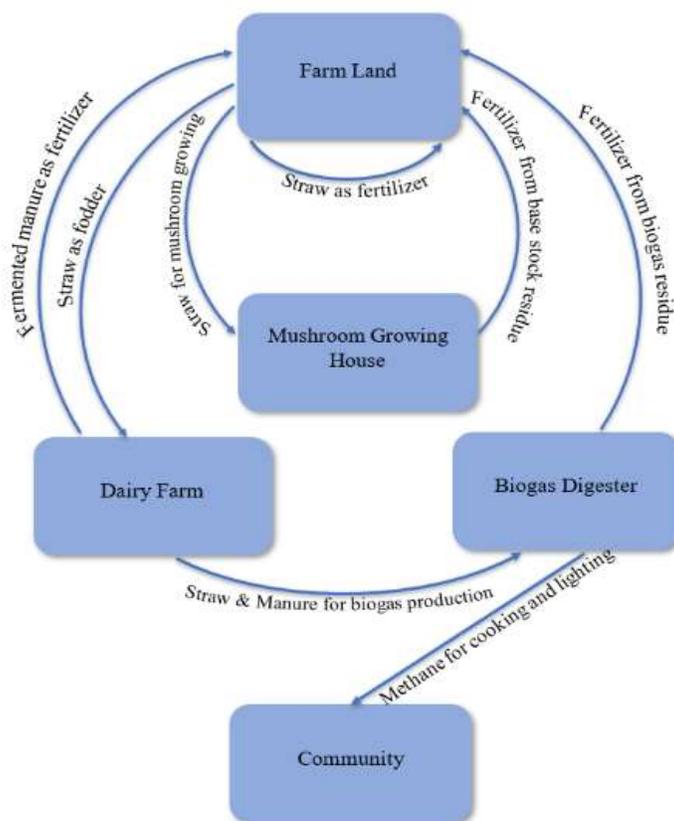
same time, these practices help to increase agricultural production contributing to improved livelihoods and poverty reduction among farming communities. With the abundant production of straw residue witnessed in the Asia-Pacific region, it is important to increase awareness of the good practices of straw management and introduce appropriate machinery that corresponds to farmers' needs and promotes sustainable agricultural production.

III. Economic and Social Commission for Asia and the Pacific initiatives

10. The Centre for Sustainable Agricultural Mechanization of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) is implementing a regional initiative on Integrated Straw Management which aims to identify, test and promote an integrated model of managing straw residue using agricultural machinery in two pilot countries, namely, China and Viet Nam, with a third pilot expected to be launched in Nepal soon. The initiative's pilot projects contribute to the attainment of Sustainable Development Goal 2 (Zero hunger) as well as Goal 1 (No poverty), Goal 12 (Sustainable production and consumption) and Goal 13 (Climate action). India is also participating in this initiative as a knowledge sharing partner.

11. Building upon a strong understanding of the status and availability of straw management practices in the region, the regional initiative has identified and is testing an integrated model to utilize straw as fertilizer, fodder, base material, and clean energy source with a circular approach, particularly in areas applying the farming-livestock system (see the figure I). According to specific local conditions, the pilot countries have adopted suitable approaches from the model for a higher rate of straw utilization. Encouraging results have been obtained so far from the pilots.

Figure I
Circular model of straw utilization



12. The pilot in China is being implemented in Laixi in Shandong Province and was launched in 2018. Its objective is to develop an innovative, green and circular model of integrated straw management in order to enhance the awareness of farmers and other key stakeholders on integrated straw management approaches and upscale the application of identified successful practices. After one year of testing (July 2019 to July 2020), the following positive outcomes were attained: a) 110 tons of wheat and maize straw per year were sustainably utilized from the 7 ha of the pilot demonstration site which, when compared to the alternative scenario of burning of the same quantum of straw, amounts to an equivalent reduction of 134 tons in carbon dioxide emission per year;⁶ b) new formula of cattle fodder from the ensilage process improved milk production by 1 litre/day per cow, increasing the value of milk produced by \$53/day; and c) the net income from sustainably returning straw to the field and returning cow manure to the field increased by \$157 /ha and \$386 /ha respectively.

13. The establishment of the demonstration site under the pilot in Viet Nam was undertaken in 2018 with the aim of upscaling the application of an improved indoor mushroom growing method involving the usage of sterilizer (an appliance that inhibits pathogenic bacteria and, therefore, improves mushroom growing conditions) as a substitute to the traditional (outdoor) method, in order to demonstrate the effective usage of rice straw residue as a substrate for mushroom growing. Overall, the indoor mushroom growing method applying a steam sterilizer led to a higher mushroom yield, lower production cost and higher mushroom quality as mushrooms were more protected from insects, pests and diseases. In line with the integrated approach of straw management, the substrate already used for mushroom growing was further used as a natural fertilizer for fruit trees and vegetables. This considerably reduced the application of chemical fertilizers and lowered the production cost. It also improved porosity and fertility of the soil and reduced the negative impact on the environment induced by straw burning. The combined approach involved application of machinery such as choppers and sterilizers, while other equipment such as water pumps, sensors, hygrometers and thermometers helping to monitor mushroom growing conditions in the greenhouses were also used.

14. In addition to activities in the regional initiative's target countries, the Centre for Sustainable Agricultural Mechanization organized the Integrated Straw Management Regional Study Tour in India to share with the partners of the ongoing and potential pilot projects, representatives of the ministries of agriculture, municipal authorities, research institutions and agricultural cooperatives knowledge on good practices of straw retention, incorporation and mulching, and fiscal incentives for agricultural machinery applied under the framework of the ongoing national project in India.

IV. Recommendations

15. Use of agricultural machinery is an integral component of the aforementioned methods of straw utilization. However individual farmers, particularly smallholders, in many developing and least developed countries in the region cannot afford to buy or at times even rent machinery, and machinery

⁶ The carbon dioxide emission calculation is expressed as the equation:
 $E = P \times R \times F \times EF$, Where: E is the carbon dioxide emissions, (kg); P is straw production, (ton); R is the ratio of crop residues burned in field, (%), which R for wheat and maize were 0.9 and 1.0, respectively; F is the combustion efficiency, which F for wheat and maize were 0.93 and 0.90, respectively; EF is the emission factor for crop residue burned in field, which EF for wheat and maize were 1,460 and 1,350 g/kg, respectively.

is often not locally available at all for many farming communities. Hence, in order to support changes in the practice of straw burning and move towards a sustainable and integrated approach to straw management, three main areas of action are recommended.

16. Firstly, awareness raising should be prioritized. Stakeholders, including government officials and farmers, should be further sensitized about the adverse effects of residue burning on human health and the environment, including land degradation and air pollution. Emphasis should be placed on the economic benefits that accrue to farmers when they adopt sustainable and integrated solutions for managing straw residue. The good practices on integrated straw management should be shared with farmers and their associations along with training on how to operate and maintain the required machinery.

17. Secondly, initial investments for the adoption of equipment should be facilitated. In order to allow farmers to gain access to machinery, several measures could be adopted. Governments could provide direct financial support through incentives, loans and other financial schemes in order to encourage farmers to use agricultural machines by making them affordable. Financial support could also include tax exemptions on import of agricultural machinery and preferential interest rates for loans for machinery. It is important not only to develop the financial schemes, but also make their implementation effective by simplifying bureaucratic processes and eligibility criteria. Furthermore, mechanisms monitoring the use of subsidies should be in place. In addition to direct subsidies to individual farmers, the establishment of associations for the custom-hiring of machinery could also ease issues related to maintenance and repair, in addition to making machinery more accessible.

18. Thirdly, the relevance of the agricultural machinery should be taken into consideration, implying that machines and equipment used for straw utilization should correspond to the local land conditions, climate, and other circumstances. This also requires that research and development be strongly encouraged and linked with all segments of the market.

V. Issues for consideration by the Committee

19. The Committee may wish to review the present report and provide guidance on the issues highlighted therein for addressing the problem of burning of straw residue and air pollution through sustainable agricultural mechanization in the Asia-Pacific region. The Committee is also invited to share experiences and provide guidance to the Centre for Sustainable Agricultural Mechanization to further strengthen the relevance and effectiveness of its work.
