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SUSTAINABLE RICE STRAW MANAGEMENT IN VIETNAM: CURRENT SITUATION, CHALLENGES AND POTENTIAL

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Abstract

Vietnam is now one of the world's largest rice-producer all over the world. The development of intensified production systems and high-yielding mordern rice varieties has increased the amount of rice straw for the last three decades. In this paper, the quantity of rice straw in different agro-ecological zone of Vietnam were estimated based on statistical data of rice productivity and ratio value of dry rice straw with rice grain. The use and potential of rice straw were evaluated by reviewing existing articles from scientific journals and reports. The results showed that Vietnam produce annually more than 51 million tons of dry rice straw so that rice straw management is an opportunity

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to utilize the available resource and reduce agriculture's carbon footprint in Vietnam. Currently, there are common types of rice straw treatment and management exist (Open-field burning, incorporation into soil, livestock fodder, composting, mushroom production, mulching etc…) but the use of rice straw also varied seasonally and regionally. The review results also showed that 75% of Vietnamese farmers have still burned or incorporated rice straw into soil after harvesting since it was a quick and cheap way to eliminate rice residues. Better management option to handle rice straw should therefore be explored further and should be widely adopted by farmers. Off-field rice straw management option and business models should also be piloted and disseminated through suitable business models. Government policies should also be supportive of banning open-field straw burning and encourage farmer to implement alternatives rice straw management practices by providing incentive to farmers and advocating more technology transfer.

Keywords: Rice straw, management, burning, sustainable, greenhouse gas

INTRODUCTION

Agriculture is not only affected by climate change but it is also a major contributor to climate change because it is a major source of greenhouse gas (GHG) emissions, which are accelerating global climate change. Nationally, key sources of GHG emissions are rice cultivation, enteric fermentation, agricultural soils, and manure management and burning of agricultural residues. The Second Biennial Updated Report of Vietnam to the UNFCCC (BUR2) identified the agricultural sector as one of key sources in the total GHG emission 2013 in Vietnam, estimated at about 34%. Within the agricultural sub-sector in Vietnam, emissions from rice cultivation contributed the largest share with 50.3% of all agricultural emissions and 17.2% of national GHG emissions in 2013 (MONRE, 2017).

Most of the rice-related GHGs are methane and nitrogen oxides, mainly from flooded and moist soils. The Ministry of Agriculture and Rural Development has already initiated action to reduce GHG emissions through a master program that includes a commitment to a 20% reduction in GHG emissions while increasing rural productivity by 20% and reducing poverty by 20%. The country is committed to the development of the Vietnam Green Growth Strategy (VGGS). Within the context of VGGS, agriculture is identified as a key sector through delivering ecosystem services, such as increasing carbon sequestration and reliable and secure access to food and contributing to continued economic growth.

This paper aims to provide a broad overview of rice straw management and use issues in Vietnam, one of the largest rice-producing countries in the world and what is currently being done about them. It outlines potential options to addressing these issues going forward. In addition, it also identifies policy gaps, R&D needs, and suggests priorities for future research and investment.

MATERIALS AND METHODS

The paper review existing articles (academic papers, conferences, laws and regulations etc…) from scientific journals and reports published by relevant organizations, research institutes and ministries.

To estimate the dry rice straw quantity (Q_{st}), the data relates to rice production (Q_{rp}), ratio between dry rice straw with rice grain (R) is used. Following by that, the amount of rice straw will be calculated by the equation: $Q_{st} = P_{rp} * R$. *In which: Qs is quantity of rice straw (ton or 1000 tons); Pr is rice production (ton or 1000 tons); R is mean value of dry rice straw: rice grain ratio. The mean value of ratio between dry rice straw with rice grain (R) is 1.135* (Tran Sy Nam *et al*., 2014).

RESULTS AND DISCUSSION

Status of rice straw production and utilization in Vietnam

Vietnam, being an agriculture-dominant country, produces annually almost 100 million tons of crop residues including rice straw, rice husks, coffee husks, and other agricultural by-products. For instance, in 2010, these generated wastes included 61.9 million tons of paddy straw, 5.6 million tons of rice husks, 4.8 million tons of maize by-products, and 0.3 million tons of coffee husks. By 2013 - 2015, these wastes increased annually to 67.6 million tons of paddy straw, 11 million tons of rice husk, 4.4 million tons of maize by-products, and 0.7 million tons of coffee husks. Vietnam, being a major rice-producing country, produces a lot of rice straw. Table 1 shows the country's production of rice straw during 1998 - 2014. In 2017, Vietnam produced approximately 70.7 million dry tons of rice straw. The Mekong River Delta and the Red River Delta are the country's two major regions that generate rice straw (Figure 1).

Table 1. Estimation of generated rice straw by region in Vietnam

Region	2010			2015		
	Planted area (1000 ha)	*Rice Production (1000 tons)*	*The estimated rice straw quantity (1000 tons)*	*Planted area (1000 ha)*	*Rice Production (1000 tons)*	*The estimated rice straw quantity (1000 tons)*
Red River Delta	1,150.1	6,805.4	7,724.1	1,110.4	6,734.5	7,643.7
Northern Midland & Mountainous	666.4	3,087.8	3,504.7	684.3	3,334.4	3,784.5
Northern Central & South Central Coast	1,214.1	6,152.0	6,982.5	1,220.5	6,860.5	7,786.7
Central Highlands	217.8	1,042.1	1,182.8	238.0	1,213.3	1,377.1
Southeast	295.1	1,322.7	1,501.3	273.2	1,372.6	1,557.9
Mekong River Delta	3,940.9	21,595.6	24,511.0	4,308.5	25,699.7	29,169.2
Total	*7,484.4*	*40,005.6*	*45,406.4*	*7,834.9*	*45,215.0*	*51,319.0*

Notes: Authors estimated rice straw quantity based on GSO data (2010, 2015) and mean value of dry rice straw: rice grain ratio is 1.135 (Tran Sy Nam et al., 2014).

The Mekong Delta has played a central role in sustaining Vietnam's high level of rice production: Although the entire delta (3.9 million ha) only accounts for approximately 10% of the country's total area, half of the national rice production and approximately 90% of annual rice exports originate from it. With favorable conditions for rice production, the Mekong Delta annually yields 25 million tons of rough rice (GSO, 2015) and an estimated 25 million tons of straw (dry weight of the total aboveground biomass (Nguyen Pham Hong Van *et al.*, 2014). The rate of rice straw generation in Mekong River Delta accounts for 56% of the total amount in the country, followed by the Red River Delta with 16% (Figure 1).

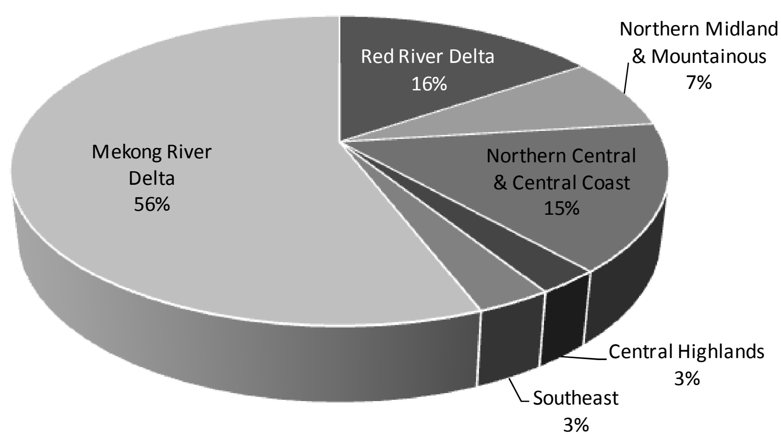

Figure 1. Percentage of generated rice straw by region in Vietnam (2015)

According to survey data from Low Carbon Agricultural Support Project (LCASP, 2015) farmers have several kinds of rice residue management (Table 2) in order to manage rice straw in the field: (1) burn in the field, (2) incorporate into the soil, and (3) remove it from the field, either for feeding cattle herds or mulch for succeeding crop. Rice straw removed from the field were also used as cooking fuel, as a substrate for composting, or for mushroom cultivation. Individual household conditions will determine the disposal method. The survey data also showed that more than 75% of the farmers burned or incorporated rice straw into soil after harvesting. Up to 98.2% of farmers in the MKD burn straw after the winter-spring season; 89.7% burned it after the summer-autumn season, and 54.1% burned it after the autumn-winter season (Tran Sy Nam *et al.,* 2014). This means that open-field burning of rice straw is a major problem in intensive rice-based cropping systems in Vietnam. Rice straw is generally considered a form of waste, and most has usually been burned after rice harvest. Burning of rice residues (straw and stubble) has been a common practice to eliminate "wastes" after harvesting because it was a quick and cheap way, not only to manage rice residues while preventing pests and diseases, but also to reduce the fallow time between two rice crops. It is also a rapid way to address time and labor constraints as labor is in short supply and expensive if the straw is to be dealt with any other way than burning.

Table 2. The current use of rice residue in some provinces of Vietnam (unit: %)

Province	Open field burning	Left in the field for incorporation	Livestock fodder	Mulching	Composting	Others*
Son La	75	5	10	-	5	5
Lao Cai	70	10	4	8	2	6
Phu Tho	50	15	5	10	15	5
Bac Giang	30	25	20	-	15	10
Nam Dinh	25	30	15	10	15	5
Ha Tinh	5	-	75	5	5	10
Binh Dinh	-	-	90	-	5	5
Ben Tre	70	5	10	5	-	10
Tien Giang	50	10	30	5	-	5
Soc Trang	70	5	10	5	-	10

*Notes: *: Livestock bedding, mushroom production, cooking fuel, compacting & selling etc.)*

Source: Low Carbon Agricultural Support Project - LCASP project, VIE-2968 (2015).

It leads to environmental pollution, unsustainable cropping, and increased greenhouse gas (GHG) emissions. Burning the straw also prevents farmers from creating additional value from it by developing profitable options. Open-field burning directly contributes to air pollution and human health problems. Burning residues emits air gaseous pollutants such as sulfur dioxide (SO_2), oxides of nitrogen (NO_x), carbon dioxide (CO_2), carbon monoxide (CO), black carbon (BC), organic carbon (OC), methane (CH_4), volatile organic compounds (VOC), non-methane hydrocarbons (NMHCs), ozone (O_3), and aerosols, which affect global atmospheric chemistry and climate (Tripathi *et al.,* 2013). On average, 1 kg of rice straw burnt in the field emits 1.46 kg of CO_2, 34.7 g of CO, (Gadde *et al.*, 2009), 0.7 - 4.1 g of CH_4 and 0.019 - 0.057 g of N_2O (Oanh *et al.* 2011,). CH_4 emissions from using rice straw for cattle feed are around 15,000 g (10,000 - 20,000 g) CH_4 per ton of rice straw (Singhal *et al.* 2005).

Challenges and gaps for sustainable rice straw management

Challenges

At the moment, rice straw management and use in Vietnam are facing challenges. The recent studies show that there are many constraints in current management practices of rice straw in Vietnam: Small-scale rice fields make it difficult to collect, transport (cost, distance, and equipment), and even possess rice straw. The decision to burn in certain regions depends on many factors including local habits and tradition, timing, weather, and most importantly the practicality of the alternatives themselves. The markets for the new rice straw products and other rice by-products are very limited. The awareness of local community and farmers, e.g., on producing straw bales, biochar, and pellets, is very low. Furthermore, the availability of capital investments for the required machinery to actually produce biofuel and fertilizer (using straw as the input material) is very limited. The payback period is often too long for the farmers and appropriate financial instruments are sometimes lacking to help them to purchase the required inputs.

Gaps

Based on the findings from the review, the following gaps were identified with regards to rice straw management in Vietnam:

Policy gap

- State legislations on environmental protection in general (Decree No. 59/2007/ND-CP, Decree No. 38/2015/ND-CP , etc.) do not directly address the issue of rice straw burning.

- The concerned ministries (MARD, MONRE) have issued some regulations and policies agricultural environmental protection and climate change response (Decision No.3119/QD-BNN-KHCN, Decision No.891/QD-BNN-KHCN, etc.) that mentioned mitigation options associated with rice straw management in Vietnam but little effort has been made to enforce, implement and monitor those policies.

Data gap

The data on rice straw management and use in Vietnam still have many gaps. The studies conducted, so far, have mainly focused on observations and description instead of looking into principles and relationships among pollution, its causes and impacts, and farming practices. The following gaps exist.

- Lack of updated quantitative data on levels of adoption and utilization of rice straw use (e.g., Vegetable cultivation, mushroom production, and animal feed; producing black coal for industries and for domestic use) at different levels.

- No official or statistical data on how the level of alternative uses of rice straw increased or helped to increase the selling price of rice straw and the availability of equipment to collect and roll it.

- Lack of updated quantitative data on levels of pollution caused by open-field burning and the impact of socioeconomics of rice-straw burning at the provincial, regional, and national levels.

Potential of sustainable rice straw management

The options for rice straw management comprise in-field and off-field options. Rice cropping systems intensification with shorter turnaround time and higher yields and rapid introduction of combine harvesters constitute a game changer because of the larger amount of straw produced in a shorter period of time and because combines leave the straw spread out on the field. Manual collection is unprofitable because of the high labor cost. Incorporation of rice straw into paddy soil is a widespread and popular way of straw management in Vietnam as it helps maintain and enhance soil fertility and nutrient balance in rice production. However, doing it improperly and ineffectively can result in a decrease in production efficiency (Dobermann and Fairhurst 2002) and an increase in greenhouse gas (GHG) emissions (Sander *et al.*, 2014). The recent research at IRRI showed that the total carbon dioxide equivalent (CO_2-eq) per ha converted from CH_4 and N_2O in a rice crop season with straw incorporation emitted about 3,500 kg CO_2-eq per ha. This amount of GHG emission was almost 1.5 times higher than the amount emitted from the practice of rice straw removal (Sander *et al.*, 2014). Some farmers, do not practice incorporation in intensive systems with triple-rice-cropping per year because of the slow decomposition rate of rice straw, which may not be completed within the short turnaround time of less than three weeks before the next rice cropping season. This has led researchers to conduct studies on how to foster its decomposition rate in the soil (the use of fungal inoculums a combined machine with three functions of harvesting, chopping rice straw, and spraying inoculums into chopped straw, etc.). Improved by-product management and technologies that can help the environmental footprint of carbon and increase revenues from rice production and processing are therefore important for sustainable rice production systems. In principle, rice straw can be processed and used in agriculture for multi-purposes such as soil improvement (through inoculant support), bio-energy production, and production of materials (silica and bio-fiber) for industrial uses. However, not all options are economically feasible because the costs of materials produced from the other traditional or existing feedstocks. The competitive-scalable options for rice straw will be composting, mushroom production, rice straw silage production for cattle feed and rice straw collection and compacting.

Thus, despite of having many challenges, the potential for rice straw in Vietnam is very huge. Rice straw can be a biomass resource with huge potential as a source for fertilizer production, renewable energy, material for mushroom production and feeding livestock. About 40% of the nitrogen (N), 30 - 35% of phosphorus (P), and 80 - 85% of potassium (K) taken up by rice plants during the growth cycle remain in the straw after harvest (Dobermann and Fairhurst, 2002). If Vietnam could turn 45 million tons of rice straw into compost fertilizer, it could result in more about 20 million tons of organic fertilizer containing 200,000 tons of N, 190,000 tons of P, and 460,000 tons of K. In another option, if using 20% of the straw (10 - 15 million tons) to produce fresh mushrooms, Vietnam could harvest 2 - 3 million tons of the mushroom-product whose export value could be between USD 1 - 2 billion (Nguyen Hong Tin, 2017).

Vietnamese farmers have turned to alternative uses of rice straw in recent years. Instead of burning, some farmers reportedly collect and recycle rice straw on their farms. For instance, they sometimes use the straw for vegetable cultivation, mushroom production, and animal feed; they sometimes use rice husks and straw for producing "black coal" for domestic use. Occasionally, rice straw is used for producing fermented and fresh animal feeds. Some reports suggest that alternative uses of rice straw increased after 2015, helped by increasing the straw's selling price and the availability of equipment to collect and roll it but official data or statistics have been not reported to verify.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Together with the trend of agricultural intensification and increasing rice production, the volume of rice residues has also increased very quickly over the past two decades. However, rice straw has been generally considered a form of waste, and most of it has been burned after rice harvest. Rice straw and residues in Vietnam are now considered to be a biomass resource with huge potential for use as sources for fertilizer, renewable energy, and biomass for mushroom production and feeding livestock. Vietnamese farmers have been urged to use these alternative uses for rice straw. In despite of the huge potential and opportunities, rice straw management and use in Vietnam are facing challenges, such as the small size of most rice fields, limited markets for the new products produced from the rice straw and other rice by-products, low awareness of the local community and farmers on how to produce and utilize straw bales, biochar, and pellets, and how to come up with adequate capital investments and appropriate financial instruments. There are a lot of gaps in policy and data about rice straw management in Vietnam, which include technical, socioeconomic, and policy aspects.

Recommendations

- MARD and relevant ministries should coordinate their research institutes and technical departments to carry out additional studies to fill in the knowledge and data gaps identified in this report. The ministries need adequate manpower and financial resources to effectively implement and achieve these objectives. Greater attention should be placed on enforcement, which should be an integral part of all government incentive programs.

- To boost sustainable rice straw management, technical solutions are now available and ready for scale-up. The government can prioritize and implement them in a phased approach. To do so successfully, it is critical to have strong political commitment, adequate technical capacity, and financial resources. The active engagement of the private sector and strong participation of small household producers are critical to having a successful transformation process.

- Develop a national policy roadmap with a strategic set of programs on soil nutrient development, rice residue management (e.g., the promotion of biochar and composting), including integrated pest management.

- Develop policies on development of sustainable rice straw value chain. This value chain should be developed within rice development program in order to address the gaps and bottlenecks along the value chain, improve the linkage among rice industry actors, as well as add value to sustainable rice production.

- Design a new set of long-term experiments to study the impact of conservation agriculture on soil optimization and competing uses of rice residues. Analyze the benefit-cost, socioeconomic impact, and technical feasibility of off- and on-farm uses of rice residues.

- Optimize rice residue use that can be retained for conservation agriculture without affecting the crop-livestock system, particularly in regions where rice residues are the main source of animal fodder. Assess the suitability of rice residue retention and incorporation in different soil and climatic situations.

- Quantify the permissible amount of rice residues of different crops that can be incorporated and retained, depending on the cropping systems, soil characteristics, and climate without creating operational problems for the next crop or chemical and biological imbalance.

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