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Agriculture biomass in India: Part 2. Post-harvest losses, cost and environmental impacts

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ABSTRACT

The growing bioeconomy sector aims to reduce the amount of waste generated and to promote the unavoidable waste generated as a resource and achieve higher levels of recycling and safe disposal. Post-harvest losses contribute to a substantial proportion of the loss that the agricultural biomass undergoes in India. It is therefore important to make an assessment of this loss and assign a certain cost to it. In this study, we have carried out an assessment of the residues that are generated in the field or on the farm at the time of harvest (for example wheat and rice straw), wastes generated as a result of post-harvest losses. In addition, the by-products from the processing of agricultural produce (for example sugarcane bagasse produced during the production of sugar from sugar cane, or cereal husks produced during milling) are also considered. Finally, certain aspects of the environmental impact and sustainability of the utilization of agricultural residues and by-products are addressed.

1. Introduction

Biomass and biowaste are delivering the most efficient and abundant renewable resources forming the basis for a bio-economy (Lin et al., 2013). The production of energy from biomass is part of the bio-economy that is going to be developed in the next decades. In the energy sector, energy crops could be used to produce heat and electricity and could substitute for fossil fuels and therefore help reduce greenhouse gas emissions and contribute to achieving environmental goals (Singh et al., 2013).

In developing countries, rapid urbanization and increasing economic growth has led to the increase in the generation of waste, subsequently bringing the issues related to its impacts to the fore. The problem of agricultural waste, industrial or municipal waste, domestic or agro-industrial waste, plastic waste or waste water effluent is serious in terms of their magnitude and potential impacts on air, land and health of people managing these waste streams (ElMekawy et al., 2014). Waste generation in India is showing an increasing trend, which if channelized appropriately can lead to a significant enhancement in conversion of waste to energy. However, to do that effectively, it is imperative to have an idea about the quantities of waste being generated and their existing fate. According to a recent study by ASSOCHAM (2013), India's post-harvest fruit and vegetable losses is over Rs. 2 trillion annually (approx. thirty-four billion US Dollar), owing to inadequate cold storage facilities and lack of proper food processing units. The lack of proper storage facility is responsible for wastage of substantial quantities of fruits and veggies produced in the country which can be prevented to a great extent. In the first part of this study, we reported the estimates about the amounts and availability of biomass residues/wastes generated in the Indian agriculture sector for organized use as an industrial feedstock within the context of the biorefinery concept.

The aim of this paper is thus to make an assessment of the post-harvest losses that the biomass undergoes in the Indian con-

Abbreviations: AEZ, agro-ecological zone; ASSOCHAM, The Associated Chambers of Commerce and Industry of India; BPR, by-product to product ratio; BAT, best available technologies; CIRY, crop-independent residue yield; FAO, Food and Agriculture Organization of the United Nations; FCI, Food Corporation of India; GOI, Government of India; Ha, hectare; HI, harvest index; IPCC, Intergovernmental panel on climate change; KHa, thousand hectares; Kton, thousand metric tons; TNPL, Tamil Nadu Newsprint and Papers Limited; MSP, minimum support price; Mton, Million Metric Tons; NIIST, National Institute for Interdisciplinary Science and Technology; PDS, public distribution system; UNCTAD, UN conference on Trade and Development; WPI, wholesale price index; RCR, residue-to-crop ratio.

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text, the costs associated with it and the environmental impacts of such losses. We continue from the part 1 of this study where we presented the amount of biomass generated with main crop types in India and the residues associated with them. Residues that are generated in the field or on the farm at the time of harvest (for example wheat and rice straw), wastes generated as a result of post-harvest losses, as well by-products from the processing of agricultural produce (for example sugarcane bagasse produced during the production of sugar from sugar cane, or cereal husks produced during milling) are considered. In addition, certain aspects of the environmental impact and sustainability of the utilization of agricultural residues and by-products are addressed.

2. Methodology

The results presented are based on data gathered from existing literature. Where relevant and possible, preference has been given to Indian and peer reviewed sources.

2.1. Post-harvest losses

Due to inadequacies along the transportation and storage chain from the field to the consumer, a considerable portion of the agricultural produce is lost for consumption. A 2007 report by the Ministry of Food Processing estimated that agricultural produce worth Rs. 580 billion [about fourteen million three hundred thirteen thousand nine hundred nineteen dollars (where \$1 equal to Rs. 40.52)] is wasted each year (Commodity Online, 2007).

The exact extent of these losses is largely unknown. Furthermore, due to the fact that these losses occur along many points of the chain and in many different manners (threshing losses, losses during loading and transportation, storage losses due to insects, rodents, rot etc.), it is far from obvious to assess what fraction of the waste generated due to post-harvest losses could be accessible for collection and utilization.

A distinction can be made between losses that are incurred at the farm before and during harvest, losses during distribution and transportation, and wastage at the level of the consumer.

Some estimates of farm level losses for paddy, wheat and onions are 3.8%, 3.3% and 14%, respectively (Basavaraja et al., 2007; Atibudhi, 1997). Due to its diffuse nature, the waste generated before and during harvest is waste that can be considered non-recoverable. Conservative estimates for the post-harvest losses incurred during transportation, storage and distribution – i.e., between field and consumer - are listed in Table 1. An estimated 13% of all the agricultural produce under consideration is lost during these stages, amounting to approximately 90 million tons per year of biomass, one third or more than 30 Mton of which can be contributed to sugarcane. This may be an indication of the fact that the sugar cane industry is relatively more aware of post-harvest losses and is less likely to be underestimating the losses.

Of all the wasted crops under consideration, the wasted sugar cane may be the most easily collectable. Loss percentages in vegetables and fruits are particularly high. Banana and mango losses constitute about 10 Mton per year. Vegetables together with potatoes and tapioca contribute approximately 20 Mton of waste per year. A sizeable fraction of these fruit and vegetable wastes may be recoverable from the fruit and vegetable markets.

For rice and wheat, the GOI has an extensive procurement network and distribution system of rice and wheat called the Public Distribution System (PDS), managed by the Food Corporation of India (FCI). The FCI manages large buffer stocks of these grains: as of June 2010, the stocks of wheat amounted to 33.5 Mton and those of paddy to 24.3 Mton (Food Corporation of India, 2014). It is well known that due to inadequate storage and stock management, considerable amounts of grains are wasted during storage. Between 1997 and 2007, more than 1.3 Mton of grain decayed in storage (Haq, 2010). Answers to parliamentary questions stated that in the period 2006–2008 about 30 Ktons of grains were damaged (Rajya Sabha, 2007) (Lok Sabha, 2009a,b). As they are part of a large-scale distribution network, such waste might be recoverable. In fact, the government currently spends considerable amounts of money to dispose of these wastes: between 1997 and 2007, the government spent Rs 26 million rupees just to get rid of rotten grain (Haq, 2010).

More than recovering the waste however, the obvious priority of the government should be the reduction of spoilage in its storage facilities. Indeed, it could be argued that efforts to organize the utilization of wastes generated from spoilage during government storage might well prove undesirable from a political point of view as long as sufficient measure have not been put in place to prevent the spoilage of food grains in government storage.

As far as could be discerned, the fate of waste generated during post-harvest operations in the form of spoiled produce is largely undocumented. It could be assumed that most of it is simply dumped. As such, the impact of post-harvest losses of agricultural produce is felt not just in terms of food security or finances, but likely also has an impact on the environment. Leaching from dumps contaminates groundwater as Indian dumps have no provisions for leachate prevention. In terms of greenhouse gas emissions, based on the assumption that the total amount of waste from post-harvest losses is disposed of through unmanaged dumping/landfilling, an estimated emission of 2.8 Mton CH_4/year is arrived at, or approximately 60 Mton CO_2-eq per year. For comparison, it can be noted that the total CO_2 emissions of India in 2006 were estimated at 1510 Mton (United Nations Statistics Division-Environment Statistics, 2007). Landfill emissions due to Municipal Solid Waste were approximately 0.4 Mton CH_4 in 1999 (Kumar et al., 2004), or 8.4 Mton CO_2-eq. Obviously the assumption leads to an estimation that is likely to be too high, as much of the post-harvest losses will not come just from spoiled food that must be dumped, but also from weight reductions due to moisture content reductions and insect and rodent consumption. A more detailed breakdown of the post-harvest losses would allow for a more accurate number.

Waste that is generated at the level of the consumer becomes part of the municipal solid waste. Source separation of waste in urban areas would be an important requisite for allowing food waste utilization. As it stands, most of the urban food waste ends up along with the other municipal waste in illegal dumps or landfills, whose location is commonly selected solely on the basis of availability. The waste is dumped in an uncontrolled manner, and as such the litter, odour, pathogenic vectors, landfill gas and leachates pose significant risks towards public health and the environment (Talyan et al., 2008).

2.2. Utilization or consumption patterns

The generation of residues, as discussed in the previous paragraph, tells only part of the story. When trying to assess the availability for new uses of residues, it is critical to know what the existing utilization pattern of the residues is. Indeed, when it comes to Indian agriculture, the idea of residues as "waste" is often sorely mistaken. Although very little is documented, it is clear that there is a very high local use of residues and that these residues are often of critical value to the farmers and to the sustainability of the agricultural system.

The most important manner of utilization is as a fodder for livestock. India suffers from large shortages of fodder. One of the consequences of this is that people, particularly women, spend a considerable amount of time looking for and collecting fodder from common lands such as forest and grasslands to make up for the shortage of fodder, often leading to degradation of these com-