Green Industry

Resource Efficient and Cleaner Production for Sustainable Rice Milling in Cambodia

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ABSTRACT

DESCRIPTION
The tradition of rain-fed rice cultivation in Cambodia dates back to more than 2,000 years ago. Like many countries in Asia and around the world, it plays a central role in the agricultural sector, where subsistence, for many, is still a way of life; the economy, as the number one agricultural product and a major cash crop; and the national psyche, as a staple on dinner tables around the country. Environmentally sustainable rice production is therefore intrinsically linked to economic competitiveness, food security and livelihoods. This case study draws from United Nations Industrial Development Organisation's (UNIDO's) technical cooperation work under its Green Industry Initiative, focusing on resource efficient and cleaner production (RECP) in Cambodian rice mills. It highlights the experience of one of UNIDO's pilot companies, Sokh Sroow Paddy Milling, addressing the problem of waste rice husks indiscriminately dumped in rice producing areas and in addition, stresses policy solutions which have the potential to deliver triple-bottom line benefits.

Learning objective:
To promote resource efficient and cleaner production (RECP) for better informed policymaking**.**

Subjects covered:
RECP; Policy for environmental management; Socio-development and poverty alleviation

Setting:
- Kampong Cham, Cambodia

DISCLAIMER
It is herewith explicitly stated that neither the authors nor UNU-IAS have any responsibility whatsoever in regards to the accuracy and comprehensiveness of the data provided. Readers are reminded to seek independent advice prior to acting on any information provided in this case study. The company, Sokh Sroow Paddy Milling, on which this case study focuses is a composite company; its operations, the challenges it faces and all other details provided are all typical and representative of the companies which were assisted by UNIDO through its technical cooperation projects in Cambodia.

RICE CULTIVATION AND LIVELIHOODS IN CAMBODIA

Cambodia has a gross domestic product (GDP) per capita of US $830 (World Bank 2011) and is classified as a low income country. High sustained growth rates have helped reduce the incidence of absolute poverty from 35% in 2004 to an estimated 31% in 2007. Accounting for 30% of GDP, industry, in particular, has been the main engine of real GDP growth.

Box 1: Cambodia at a glance

Country: Area 181,035 sq km
Water: 2.5%.
Population: 14,241,640.
Population growth rate: 1.75% (2008)
GDP per capita: US$ 830 (World Bank 2011)

Agriculture comprised some 35% of GDP in 2011, yet it contributed to the livelihoods of approximately 70% of the population. Cambodia is richly endowed with land, as well as substantial natural resources, notably forests and fisheries and a wide variety of natural habitats and ecosystems, including upland and lowland forests, freshwater wetlands and diverse riverside areas ideally suited for the dominant rice production (grown by 80% of farmers and by 60% of them for subsistence). Rice cultivation is resource intensive, requiring more water than any other cereal crop. Overall, half of all the freshwater used in Asia is for the irrigation of agriculture and of this, 90% for rice (Greenpeace 2006). Paddy (unprocessed) rice yields in Cambodia doubled from 3.4 to 8.77 million tons between 1997 and 2011, a level far exceeding the domestic consumption of around 4 million tons. Paddy is traded locally, yet national and international trade is confined to milled rice.

While nationally, rice production reaches levels that are in absolute terms self-sufficient, 80% of the population live in rural areas and typically produce at least part of their food needs. Yields vary greatly and are closely linked with poverty; food security is a major concern exacerbated by a lack of crop diversification and extreme weather events. Basic infrastructure including poor roads – an estimated 60% of which are in a poor state of repair and in many rural areas non-existent – along with limited storage capacity translate into high transaction costs for farmers wishing to bring their products to the market. Post-harvest losses (PHL) are a problem in many developing countries and not just Cambodia. At a regional level, UNIDO and ASEAN (2012) estimate losses of between 35-50% of total production in Asia which would have a market value of USD 5 billion per annum. Of this amount, rodents, for example, contribute to 6% of total losses in rice production or the equivalent of the rice consumption of 220 million people.

The government is keen to unlock the potential of the rice sector as a driver for sustainable rural development.

RICE MILLING

The processing of rice along with other types of cereals offers good opportunities for small-scale rural enterprises. Compared to other types other types of food processing, the technology is readily available and affordable and the level of skill and expertise needed to make products is lower while demand is also very high. Opening up markets for trading of surplus rice is one of the levers for expanding the rice sector. This is critically dependent on the performance of the milling sector, in terms of capacity and productivity and quality of milled rice.

Box 2: Challenges faced by industry

Cambodia is a net importer of fossil fuels. Electrification rates are amongst the lowest in Asia at 12% and at present, around 90% of energy needs are met through diesel generators, which are vulnerable to volatile fuel pricing and also shortages in remote areas. Identified by business as one of the major constraints to the development of the manufacturing sector in a survey by Bangkok Research Centre (BRC) and New Zealand Institute of Economic Research (NZIER), the cost of electricity relative to neighbouring countries was double that of Viet Nam and quadruple that of Thailand.

Apart from diesel and fuel oil, certain industries such as the garment industry, food processing and brick works also use large amounts of fuel wood, which also contributes to deforestation. The problem is further compounded by the low levels of energy efficiency at which industry operates. Energy consumption per unit of output in Cambodia is higher than many countries in the region and more than double that of developed countries.

Access to finance was ranked as the second most severe constraint in the 2009 BRC and NZIER survey and as a minor or moderate constraint to many companies surveyed by the World Bank. In the food and beverage sector, firms considered access to credit a more significant constraint than any other type of firm, and almost comparable to that of electricity costs. In investment decisions, expansion of production capacity more often than not takes priority over projects improving environmental management and industrial energy efficiency.

Milling is the step in the processing of rice where the husk and bran are removed to leave behind an edible, white rice kernel free of impurities. The final product should be edible, aesthetically appealing to the consumer and produced in a manner that minimizes rice losses due to grain breakage. The final quality varies at 5-35% broken grain. Husks, stones, and other non-grain debris should be adequately removed and when grain is sorted, higher prices can be obtained for longer and aromatic varieties.

This process is typically done by small to medium scale companies, as for example at Sokh Sroow Paddy Milling. Established in 1968, it has installed annual capacity of 8,000 ton paddy (equivalent to 5,000 tons of milled rice), yet in 2007 only 34% of capacity was actually utilized, for various reasons, inter alia, the result of power failures, insufficient paddy supply and market demand and limited warehouse capacity. The company employs 20 workers.

Upon retrieval from the warehouse, the different types of paddy are dumped together into a bin and transferred by conveyor belt to a sieving unit where unwanted materials like stones, soil and rice stalks are removed for a higher quality rice input and to avoid damaging milling equipment. Rice husks are then removed mechanically using a hulling machine and the outer bran layers removed by means of mechanical abrasion. Less milled rice has more bran, making it more nutritious, but is also darker in colour, chewier, takes longer to cook and has a shorter shelf-life. The de-husked rice – a mixture of rice, paddy and husk – is then brought to the twin sieving unit to separate rice from rice husk. Un-ground paddy is sent back to the grinding unit again and de-husked rice flows through a series of vibratory sieves where the rice is completely separated from any grain of paddy then passed through polishing units, which each unit consists of air blower, bran separator and husk separator. The remaining rice is then polished to get rid of the innermost layer of bran although this process is optional depending on consumer preferences and willingness to pay for whiter rice. The polished rice is then separated according to size – using vibrating screens with different sized holes, similar to those used for other grains - and sieved to separate any remaining unwanted materials before being filled and sewn into bags and stored.

Low rice quality, high rice losses and high energy consumption are key constraints for Sokh Sroow Paddy Milling. Quality is mostly moisture related, milling losses increase along with spoilage and discolouration, with higher moisture content, typical for harvesting during the wet season. Grain breakage affects the company's bottom line, with high quality unbroken rice fetching US$ 470/ton and broken rice just US$ 220/ton. Grid power is not accessible and hence the company relies on diesel generators for electricity generation which contributes to a large amount – approximately 25% - of production costs. Low technical efficiency and operating conditions such as deficient cooling further reduce efficiency.

DISPOSAL OF RICE HUSKS

Rice husks are low in nitrogen and phosphorous and have a high lignin content and so they decompose slowly if brought back to the field. However, high in silica (SiO_2), they are also abrasive and do not make good fodder. Considered a waste product for many years, rice husks are still indiscriminately dumped in waterways or open fields in many places or just incinerated. As a result they are a source of pollution in rice producing areas. Although a low-cost material, rice husks have a low moisture content and bulk density, making storage and utilization problematic and resulting in significant costs being incurred through transport (due to a lower tonnage per vehicle and spillage from open trucks). To minimise costs, rice husks should be compressed first or ideally used at or close to the rice mill itself.

On average, 100 kg of paddy will generate approximately 20 kg of husk, the bulk density of which is 100-150 kg/m^3 and more than 100 million tons of rice husks are produced by the industry globally. In Cambodia alone, it is estimated that 1.1 million tons of husks are disposed off annually, equivalent to 22% of the paddy rice production.

Different uses are possible from technical perspectives, including:

- Combustion for heat generation: biomass, like rice husks, is typically combusted in a furnace, the heat generated thereof is used to produce steam in a boiler, which drives a steam turbine generating heat and/or electricity. This option is simple and has low sunk costs. Combusting rice husks as a fuel at or close to the rice mill would make use of its high average calorific value of 3,410 kcal/kg (IRRI, 2009). However, bulky and dusty, rice husks have the tendency to slag and foul easily, making them difficult to handle.

- Insulation material: with an R-value (a measure of thermal resistance in the building industry) of about R-3 per inch and being resistant to moisture penetration and also fungal decomposition, rice husks have a good insulation potential. Cellulose-based insulation materials typically require treatment with large quantities of flame and smoulder retardants which can comprise as much as 40% of the weight of conventional cellulose insulation materials. Rice husks do not and so the cost and pollution related with such chemical treatment is avoided.

- Cement: rich in silica, risk husks are a good pozzolan, with cementitious properties. When applied in cement production, energy consumption can be reduced (as calcination temperature can be reduced) along with process related greenhouse gas emissions. In addition, rice husk ash also improves the durability of concrete, its resistance to chemical attack, reduces shrinkage and permeability, and offers better insulation then concrete made from Ordinary Portland Cement.

  Catalysed by foreign investment, Cambodia's construction sector is developing rapidly and, at present, relies on imported materials, with around 2-5 million tons of cement each year sourced from overseas each year (Rith & Madra 2008).

- Biomass gasification: gasification is a process through which carbonaceous materials including agricultural residues like rice husks and municipal solid waste are converted into a gas by partial combustion at high temperatures with a controlled amount of oxygen and/or steam. The resulting syngas (synthesis gas) is then used as a fuel to generate electricity. While still in the advanced stages of development and early stages of application, biomass gasification promises higher efficiency for power generation based on gasified biomass. With seasonal fluctuations in biomass availability, syngas production is unpredictable and best utilized in combined systems with diesel or other fossil fuels.

THE CHALLENGE AHEAD

Rice cultivation and production are intrinsically linked to food security, livelihoods, and economic development in Cambodia and moreover have serious implications for environmental sustainability if not addressed in a holistic manner. The task at hand is therefore to develop a strategy ensuring that pursuit of these goals is balanced and coordinated.

Working Session 1: Baseline situation for rice cultivation and cleaner production options for rice milling

Take stock of the "big picture" considerations pertaining to the rice cultivation in Cambodia as presented in the case study using the matrix provided (see Worksheet 1). Moving onto the next stage of the value chain, evaluate the typical problems faced by rice milling companies as typified by the pilot company and identify appropriate cleaner production options (see Worksheet 2-3).

1. Sustainable development opportunities: characterize the baseline situation of the rice sector from the different sustainability perspectives and identify opportunities and constraints for enhancing the sector's contribution to sustainable development and poverty alleviation. (see Worksheet 1)

2. Rice milling – process flow diagram: waste and emissions arise from the points of production where materials are used, processed or treated, by identifying and analysing points of origin, volumes and causes of waste and emissions it is easier to find solutions to tackle them. From the description given in the case study, draw the process flow diagram showing the inputs, production processes and non product outputs at each stage of the rice-milling process. (see Worksheet 2)

3. Cleaner production options for rice mills: following the process flow in the rice mill, identify cleaner production opportunities that might reduce wastage and energy consumption and improve rice quality. In doing so, please consider the specific applicability of five key techniques, namely (see Worksheet 3):
   a. Good housekeeping – better work procedures,
   b. Input substitution – use of alternative input materials,
   c. Equipment modification – modifications of productive equipment,
   d. Reuse and recycling – opportunities for making use of waste and turning these into by-products, and
   e. Product modification – changes in product specifications.

Working Session 2: Rice husk utilization and a green industry sectoral strategy for rice cultivation and production

While the first session emphasized the assessment of the scenario, this session focuses on the identification of solutions, specifically addressing the problem of waste rice husk utilization and then, based on the overall scenario and the results of the first four tasks (from Worksheet 1-4), propose a sectoral strategy with suggestions for policy recommendations:

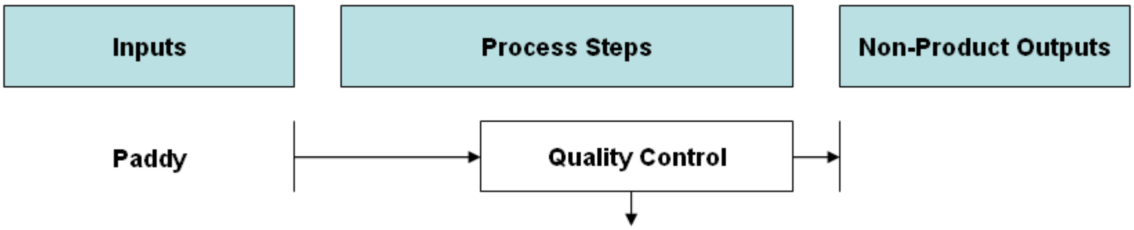
4. Rice husk utilization: consider the alternative use scenarios for rice husks, taking into consideration the dispersed generation of the total volume of rice husks from numerous small mills spread around the country. For each of these value-adding applications, identify the key market/economic potential and challenges for realization in the country context. Based on your analysis, make your appraisal of which option is the most feasible in the given context (see Worksheet 4).

5. A green industry sectoral strategy for rice cultivation and production: from your understanding of rice cultivation and production and the wider socio-economic context in Cambodia, identify the key development priorities in each of the areas and make your suggestions for policy recommendations in this regard (see Worksheet 5).

Worksheet 1: Sustainable development opportunities

Aspects	**Current situation**	**Potential** (What are potential benefits from rice sector development)	**Challenges** (What needs to change to realize these potential benefits
Agronomy and productivity			
Incomes and employment			
Food security			
Markets			
Resource use and environment			

Worksheet 2: Rice milling – process flow diagram



Worksheet 3: Cleaner production options for rice mills

Technique	Potential applications in rice milling
Good housekeeping	
Input substitution	
Equipment modification	
Reuse and recycling	
Production modification	

Worksheet 4: Rice husk utilization

Use Scenario	Potential	Market Challenges
Combustion: production of heat		
Insulation material		
Pozzolan: pozzolanic cement		
Gasification: power generation		

Worksheet 5: A sectoral strategy for the rice cultivation and production

	Development priorities	Policy recommendations for an enabling environment
Agriculture and rice cultivation		
Rice production		
Livelihoods		
Food security		
Resource use and environment		
Markets		

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