Grain postharvest status in Bhutan

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Abstract
Bhutan is landlocked country situated on the southern slopes of the Himalayas with a range of climates, topographic features and crops. Rice, wheat and maize are the main cereal crops. The paper presents the current situation of the postharvest in the grain sector with particular emphasis on the drying operations.

Introduction
Bhutan is situated between China in the North and India in the South. The longitude of 90° east and the latitude of 27.50 north run through the centre. The topography is totally mountainous with rugged terrain imposing severe resistance to any development activity. The elevation ranges from 160 metres above sea level in the South to more than 7,550 metres above sea level in the North. Six main agro-ecological zones, from north to south have been distinguished: alpine, cool temperate, warm-temperate, dry sub-tropical, humid sub-tropical, and wet sub-tropical. The rainfall varies from about 5500 mm in the narrow strip of wet sub-tropical region running along the border with India, to less than 650 mm in the alpine zone in the North.

Dominated by the monsoon, the country has a great variety of different climatic conditions. Altitude and orientation of the land mainly influence rainfall and temperature. There can be considerable variation in rainfall within relatively short distances due to rain shadow effects and other factors, but precipitation generally diminishes markedly from south to north. The diversity of agro-ecological zones represents both a constraint as well as an opportunity. The constraints arise in the research and extension efforts within a context of severe shortages of professional staff. The opportunity arises out of the potential to satisfy niche markets owing to the specific environmental and resource related features for specific products.

Land Use
Forests form an integral part of the Bhutanese farming systems with uses for firewood, fodder, manure and construction materials. The government has clearly prioritised the conservation functions of forests over its economic functions. Utilization is low and is a consequence of the lack of extraction capabilities, including the inadequate forestry management plans, and the extremely strict restrictions on the use of forests for commercial logging. Thus Bhutan has one of the highest per capita protected forests. The total land area used for agriculture is less than 12%.

The country is divided by four major river systems from east to west. The economy is based primarily on subsistence oriented communities. Agriculture is intensively practiced to produce mainly staple foods of rice and maize on small fields scattered on the steep mountain slopes. However, self-sufficiency in these basic cereals has not been achieved yet, resulting in the import of large quantities of rice and wheat.

Agricultural land is divided into five categories based on the land features and crops cultivated. Wet land is terraced and bounded, and usually cultivated for paddy under irrigated but often rain-fed condition. Dry land, usually sloping fields and not terraced, are the common features for the cultivation of dry land crops under rain-fed condition. Tser or pangshing land is under shifting cultivation and used for dry land crops once every five to six years. The other land categories are kitchen garden and orchard including plantation. Most of the agricultural land is in the wet or dry land categories, which are about 24% and 52% of the total area respectively.

Crop productivity is usually low due to traditional farming with local varieties, and less development of farm land and irrigation facilities. Most of agricultural lands, except wet land, are not terraced or bounded. About half of wet land is assumed to be rain-fed fields.

Rice and maize are the main cereals grown in all zones except the western cool temperate zone where wheat, buckwheat, potatoes, mustard and barley are produced instead. Where irrigation is available, wet land crops in winter include wheat, mustard and potatoes although some mustard may be grown on residual soil moisture. Maize rather than rice occupy the largest area of the land in the East where it constitutes the main diet. The only new basic

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food crop is the potato being cultivated in the temperate zone for export mainly.

Introduction of new technology: The country had been importing various types of agricultural machines, implements and tools from the neighboring countries already several decades ago. However, planned activity started only in 1983 when Agriculture Machinery Center was started with the objective of mechanizing the farming activities.

**Post-harvest in Grain**

Drying is still traditional, with the maximum use of sun drying being made. Normally the crop is not harvested until it is dry. After harvesting also in case of paddy, the crop is left in the field to dry for several days (Fig. 1). If further drying is required for storage, grains are spread on canvas cloth or bamboo mats and taken out of the stores on sunny days. Sometimes grain is dried by keeping it in flat bamboo baskets over the kitchen fire.

![Fig. 1. Field drying of paddy.](image1)

Cleaning is usually performed outside using screens and wind. Very simple forms of mechanical winnowing are being currently introduced (Fig. 2).

Due to poor drying methods, which are dependent upon the weather, a lot of grain is lost to pests and moulds. Losses as high as 75% are not uncommon. Spoilt grain is generally used as animal feed creating problems of intoxication of livestock by mycotoxins. In some cases, in the eastern part of the country, crops such as maize are sold off in the market right after the harvest, only to be bought back at higher prices later in the lean season. This is typical for maize grown in the subtropical regions, where the humidity is high. This practice reflects the lack of storage facilities and need of cash experienced by the farmers (Fig. 3 and 4).

![Fig. 2. Mechanical winnower used for paddy and wheat.](image2)

![Fig. 3. Typical drying method for maize.](image3)

Introduction of new drying methods, such as the flat bed dryer using kerosene or electric burners, has not gained popularity. In fact beside the modern recirculating batch dryers using forced air circulation, used by the government organizations, there are no other mechanical dryers used by the private farmers on individual basis. There are several reasons for this. Firstly, the landholding of individual farmers being small, the quantity of the grain each farmer has does not justify the investment in modern dryers, which are imported. Secondly, new designs appropriate to the local
technical and economic conditions are yet to be made. In this respect, the main reason is the lack of adequate technical know how within the backstopping institutions. There is also an obvious lack of awareness of the farmers about the new postharvest technologies. The only area where some appropriate dryer designs using locally available materials have been introduced is to dry mushrooms. These are firewood-based kilns. However, a significant effort has to be made in order to improve their efficiency.

Fig. 4. Storage of maize on cob in temporary bamboo sheds.