Chapter 1

Introduction

1.1 Background

Kingdom of Bhutan lies in the eastern Himalayan range and stretches between 26^0 and 28^0 north latitudes and 88^0 and 92^0 east longitude. It is land-locked, surrounded by two giant neighbors, China on the north and India on the remaining parts. Landscapes are characterized with rugged mountain terrains and narrow valleys. With a total area of 40,077 km^2 (MoA, 2002) Bhutan is a land of diverse flora and fauna and a home for many endangered plants and animals. It is identified as one of the ten-biodiversity hot spots of the world. Hydropower is increasingly contributing to its economy but agriculture still remains critical, as it is a way of life for 80% of its 734,340 people. Agriculture, which is largely subsistence farming and animal husbandry, contributed 38% to the GDP in 2000.

Out of the total geographical area, only 463,274.4 ha (11.7%) is arable and suitable for agriculture. However, actual operated agricultural area is 104,710.4 ha. Dryland (or upland) is the most dominant land-use with 43% followed by *Tseri* (Slash and burn) 27%. Wetland (Irrigated and rain fed paddy land) farming is relatively small with just 21%. Orchards make up eight percent and one percent of land falls under kitchen garden (MoA, 2002). Further, the farming communities have user rights over 7,181.6 ha *sokshing* (woodland) and 171,296.8 ha of *tsadrok* (grazing land). Land holdings are comparatively small, highly fragmented and scattered over rough terrains and mountain slopes. Many farming communities exist in isolation often several days walk away from the road head. Major food crops are rice, maize, wheat, mustard, buckwheat and millets.

At least 59% of the rural households own and operate wetland in all the districts except Bumthang. About 71% of the total wetland available in Bhutan is

found in the rice growing districts of Paro, Samtse, Punakha, Wangdue, Tsirang, Dagana, Sarpang and Trashigang. About 16% of the households own wetland less than 0.4 ha, while 68% have wetland between 0.4 ha and two ha. Less than one percent of the households own wetland above 10 ha.

Rice is the main staple food for the Bhutanese and is also intricately linked to culture and tradition of Bhutanese societies. It is an important source of income for resource-poor farmers. In early days the demand for rice was met from domestic production but with increasing demand due to increased population and improved economy, production could not keep pace with requirement despite introduction of modern varieties and improved management practices. The total rice area is estimated to be around 21,989 ha (MoA, 2000) and there is very little scope for the horizontal expansion. In fact with the rapid development, flat rice land is being converted to other forms of land use and there is frequent loss of paddy land due to natural disaster (DRDS, 2001). National average productivity of rice is 2.7 t/ha, this low rice yield is mainly due to poor management practices, poor soil quality, insect pest/diseases and non-adoption of high yielding varieties (DRDS,2001)

Farmers still prefer to grow traditional varieties as they believe that those varieties require low inputs and also due to cultural and traditional attachment. Adoption of improved rice varieties is low also due to inadequate risk management and sharing arrangement associated with introduction of new techniques and changes in traditional diversified farming system (DRDS, 2003). High labor requirement, labor shortage during peak rice season, lack of irrigation water, inadequate marketing systems are some other factors contributing to low production. Further, easy and cheap import arrangement with India is discouraging Bhutanese farmers to cultivate rice and can hinder achieving government objective of 70% food self-sufficiency. Food self-sufficiency in Bhutanese condition is largely interpreted as rice self sufficiency (Shrestha, 2004). Analysis indicates that Bhutan is only 40% self-sufficient in rice requirement, and imports 38,800 t of rice annually (MoA 2000). However, report on level of sufficiency and rice import varies significantly in absence of proper data.

Adoption of improved varieties and better nutrient management, especially nitrogen fertilizer, are seen as the vehicle for increasing rice production (DRDS, 2001). It is also reported that growing rice using traditional technology is not economical (Dorji, 1995). Further, research findings have indicated that mid altitude rice production zone has better potential to contribute to food basket as it is climatically favorable, and have relatively low pest and disease incidences.

However, to achieve increase production from improved varieties, there is a need to effectively match the technologies and farmers resources (land, labor, and capital) with biophysical environment (rainfall, temperature, soil). At each location the combination of management to correct mismatch is usually unique (Ogoshi *et al.*, 1998). Despite many efforts to increase rice production, there is still large gap between climatically achievable potential yield, experimental yield and farm yield in Bhutan.

Research addressing the issue of yield gaps and identifying measures to narrow the gaps is important both for increasing food security and for increasing efficient and sustainable resource use. Therefore, the purpose of this study was to analyze the yield gaps of three commonly grown improved rice varieties and identify possible measures to narrow the gaps considering the available resources and finding optimum match with environment using CERES-Rice model for mid altitude rice growing region in Bhutan.

1.2 Objectives

Considering the above background, constraint and potential, following are the objectives of the study:

1. To identify resource endowment and management practices adopted by farmers for rice production in mid altitude (600m to 1800m) in Bhutan;
2. To estimate the genetic coefficients and validate the CERES-Rice model in Bhutanese rice farming system; and
3. To analyze rice yield gaps using CERES-Rice model and identify agronomic factors contributing to the yield gap.

1.3 Scope of Study

The outcome of the study would help farmers and extension workers to better plan their resources to maximize rice yield in mid altitude. It will also help planner and decision maker to draw up efficient rice development strategies and policy to meet the important government objective 70% food self-sufficiency. Further, this study would give opportunity to use CERES-Rice model for effective and economical research to come up with site specific recommendations to meet the needs of the farmers and also act a tool for the decision makers to make effective decisions.