Biophysical and socioeconomic characterization of cereal production systems of northwest Bangladesh

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1. Introduction

The economy of Bangladesh is predominantly depending on agriculture, which contributes 24% to its national gross domestic product (GDP). Although crops make up 13% of it, it engages 62% of manpower of the country. Cereal crops occupy about 84% of the gross cropped area (GCA), with rice alone accounting for 79% (BBS, 2007). The rice-rice cropping system has remained the cornerstone for food security, rural development and natural resource conservation in the region, while rice-wheat system is also prominent in some locations (Paroda et al, 1994; Timsina and Connor, 2001; Gupta et al, 2003; Ladha et al, 2003). The growth rate is positive, entire rice area is marginal with less than 1%, but production rate is 4% (compound growth rates are estimated for the period 1997-2006; BBS, 2007). While growth rate of local rice area and production is negative, that of hybrid rice is positive. Wheat and maize cover only a small percentage (4% and 1% respectively) of GCA (BBS, 2007). Eastern Indo-Gangetic Plains, which comprise Bangladesh, is not highly suitable for wheat production. Owing largely to shortening of winter season, wheat acreage and production showcase significantly negative growth rate of (-5% of area and -8% for production) (reference). On the other hand, a rapid expansion of maize production sector is registered with area and production increasing at 24% and 37% respectively, as a result of favourable price signals from domestic poultry feed industry and value chain development as well as high adoption of hybrid maize seeds (Ali et al 2009; Waddington et al., 2012).

In spite of significant reductions in poverty over the past decade (percentage of the population living in poverty fell from 51% in 1995 to 40% in 2005), poverty reduction remains the central policy challenge for Bangladesh (Sen and Hulme

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2006). More than 50 million people still living in extreme poverty (BBS 2006; Quisumbing et al., 2011). The country's food grain production was approximately 28 million tons in 2006 and estimated food grain requirement is 35 million tons in 2020, of which rice comprises 94%, wheat 4-5% and maize 1-2% (DAE, 2007). Currently, the country is achieving its goal of food grain self-sufficiency status. However, there could be future challenge might be a difficult challenge to meet the food grain requirement in 2020 with available cultivable land. Bangladesh is densely populated country, since seventies on an average every year 2% of the people have been added to its total population. The estimated population in 2020 is 167 million people (BBS, 2007). Ganesh-Kumar et al. (2012) estimated that Bangladesh can face either a surplus or a deficit in rice in next 20 years, depending upon the prevailing supply and demand scenario and intermediate demand requirements. On the other hand, landholdings and land parcels in the country, as in many other parts of South Asia, are undergoing fragmentation, thereby accelerating the pace of their degradation and constraining agricultural development (Niroula and Thapa, 2005). The average farm size was declining from 1.4 ha in 1977 to 0.86 ha in 2006 (BBS, 2007). However, the development activities are taking place in all the sectors of the economy utilizing more and more agriculture land being converted to building townships, industries, educational institutions, roads and highways etc. (Ullah, 2002). However, this may be followed by a future increase in holding size, when land consolidation occurs, with more and more people moving out of primary sector. Also increased non-farm job opportunities with higher wage and migration of labour force to cities lead to a scarcity of agricultural labour (Ziauddin, 2010).

The abiotic stresses for crop production, such as land degradation, induced by both natural and human factors show an increasing trend in Bangladesh (Rahman, 2004). Natural hazards, such as sudden flash floods, tidal surges and drought, cause significant yield vulnerability (ibid). Significant land degradation processes due to soil erosion, soil salinization, continuous water logging, river bank erosion, *Jhum* (slash-and-burn) cultivation, acidification, plough-pan formation, organic matter reduction, deforestation are severe constraints to appropriate land use planning and land management practices [2]. Furthermore, poor management practices, especially those of pests and diseases, fertilizer, water and irrigation have largely contributed significant hurdles in achieving the full yield potential (Mondal, 2010). During the past decade, agricultural mechanization particularly the use of power tillers has been advancing at an

2 http://globalcommunitywebnet.com/GlobalFiles/agriculturallanduse.pdf
http://globalcommunitywebnet.com/gdufour/2004WorkHasiburrahman.htm

impressive pace in Bangladesh. However, to overcome this situation, introduction of appropriate conservation agriculture (CA) based resource conserving technologies (RCTs) could possibly enhance and sustain the productivity of limited land and other available inputs, while conserving the natural resource base of the production system.

Conventional agriculture, often involving intensive tillage, has been claimed to cause soil degradation, particularly when practiced in areas of marginal productivity. The CA technology alternatives include a set of integrated soil and crop management practices that aim to minimize the negative effects of intensive farming. The RCTs recommended within the CA framework include direct sowing, zero-tillage or minimum tillage, the establishment of cover crops help to protect organic matter, soil moisture and soil fertility, the introduction of varied and appropriate crop rotations and the retention of crop residues as mulch. The present study was developed to examine the potential of CA-based RCTs in cereal production systems of NW Bangladesh, and conducted as a part of research project namely, Cereal System Initiative for South Asia (CSISA).

This project has been implemented in four countries along the Indo-Gangetic Plains: India, Nepal, Bangladesh and Pakistan during the period of 2009-2012. The project follows a 'hub based approach' and it aims to focus in the initial phase on two hubs in entire Bangladesh that represent the key intensive cereal production systems. Given this background, the present study, builds on the comprehensive baseline household survey of NW Bangladesh. The study focuses on biophysical and socio-economic characterization of the cereal producing households of the hub domain. The rest of this document is organized as follows. Section 2 introduces the study area. In Section 3, sampling and data collection procedures are explained. Section 4 includes the socio-economic characterization of sampled households, while in Section 5, the economics of cereal production and varietal adoption are analysed and discussed. Section 6 captures the livestock productivity information and Section 7 focuses on CA-based RCTs, and details viz. information on technologies, adoption and familiarity, as well as perceived impacts of technologies on farm profitability and reasons for non-adoption are explained. In section 8 of the input and output market channels of cereal productions the study area are characterised. The final section contains the conclusions of the study.

2. Study area

The study area comprises 3 districts of NW Bangladesh: Dinajpur, Nilphamari and Rajshahi. They were selected purposively to capture the diverse cereal production systems of the study region. The share of cultivable area to the total land area in the study sites are 77% (Dinajpur), 74% (Nilphamari) and 63% (Rajshahi). The study area has a tropical monsoon climate characterized by wide seasonal variations in rainfall, high temperatures, and high humidity. Three cropping seasons are commonly recognized: a hot, humid spring (March to June); monsoon (July to October) and a cool, dry winter (November to February). The annual average rainfall in the study area ranges from 1448 mm (Rajshahi District) to 2931 mm (Nilphamari District). About 80 % of Bangladesh's rain is obtained during the 4-month monsoon season. About 80 % of total irrigated area is covered by groundwater, with shallow tube-wells being the dominant source (65% of total area irrigated). The dominant cropping patterns of NW Bangladesh are rice-rice, rice-wheat, rice/fallow-maize and potato/maize-rice (Krishna, 2011). The major CA-based RCTs in research pipeline or diffusion programmes are power tiller operated seeder (PTOS), bed planting of wheat, modern improved varieties of rice and wheat, quality seed and seed treatment and crop diversification through intercropping and rotations (ibid).

3. Data collection and sampling procedure

The primary data collection was carried out, employing three tools: (i) village survey in 18 villages, conducted with a group of respondents, documenting general village characteristics such as infrastructure, prices as well as population and land-use details (ii) village census, which covered all the households, and collected a set of basic variables that allow for efficient household sampling, and (iii) household survey among 324 cereal farmer households. Villages and households were selected according to a stratified random sampling method common across CSISA hubs of South Asia. Three districts within each hub domain were selected purposively to capture a wide variety of cropping patterns and the dynamics of RCT diffusion. Within each selected district, three sub-districts (union council in NW Bangladesh) were randomly selected from the set of sub-districts in which CSISA was active. Within each selected sub-district one village with CSISA activities and one village without CSISA activities were randomly selected from the relevant lists.

As mentioned above, the three districts were purposively selected for the study: Dinajpur, Nilphamari and Rajshahi. Subsequently and after discussing with the hub managers and national partners, 8 union councils (UCs) were selected for the study: 3 in Dinajpur, 3 in Nilphamari and 2 in Rajshahi (Appendix 1). From most of these UCs, one CSISA intervention village and one non-CSISA village were randomly selected. In Yousufpur UC of Rajshahi district, 2 CSISA and 2 non-CSISA intervention villages selected as only limited project activities are planned in this area. The selection of the non- CSISA villages was done from a complete list of villages obtained from the sub-district head offices. A total of 18 villages were covered in the survey, in 9 of which CSISA activities were started/planned to start during the time of baseline survey.

For the household survey, the sample households were randomly selected from the list of farming households drawn from the village census data. On the basis of the size of farm land owned by the households, the households were first sorted from smallest to the largest, and a systematic random sampling procedure was adopted to select households across the landholding categories for the data collection. A total of 18 cereal (rice, wheat and/or maize) growing households were selected from a ward making a total sample of size 324 (108 households per district). The household survey was conducted during August-October 2010, with the objective to create a benchmark assessment on the cereal production systems of NW Bangladesh for examining the potential of CA-based production technologies. A structured questionnaire was developed for the household survey data collection in a joint effort of socio-economists from different CGIAR-centres associated in CSISA project and agronomists, plant breeders and soil scientists. The questionnaire was pre-tested and modified before the actual survey was initiated. The enumerators involved in the data collection activities were familiar with the local-economic conditions, and they were trained with mock-interviews, and consistently monitored by CIMMYT and the hub-level socio-economist. The collected data were periodically examined by the CIMMYT socio-economist of South Asia, in order to systematic errors in data elicitation.

The secondary data used in the study in addition to the primary data, were gathered from the Bangladesh Bureau of Statistics (BBS) and the Department of Agricultural Extension (DAE). The data collected were tabulated, cleaned and subjected to statistical analysis to draw meaningful conclusions.

4. Socio-economic categorization of farming households

For analytical purpose, the farming households are categorised into “lower”, “middle” and “upper” groups based on the land cultivated. [3] Such categorisation will help to understand the role of farmer’s assets, farming behaviours like selection of crops, production technologies, market channels and specially cereal cultivation patterns. The households sampled also include landless farmers, i.e. farmers not owning land. In fact 29% and 12% of sampled farmers in the small and medium groups respectively (see Error: Reference source not found) are relying solely on rented or shared land for their cultivation. The average land cultivated by the sampled households is estimated as 1.49 acres, which is more than land owned (1.17 acres). This is also reflected by more households leasing-in/sharing-in land than leasing-out/sharing out (overall averages are 31% and 12% respectively). The fact that more small and medium farmers are leasing-in/sharing-in land than large farmers may indicate scarcity of off-farm employment opportunities. The average cost of leased-in land is BDT 14,572 per acre and leased-out land is BDT 17,264 per acre. Nevertheless, this form of temporary transfer of cultivation rights is more popular than sharing, where both land owner and cultivator agree to equally share input and output costs. The inequality between the studied farmer’s groups is high regarding land cultivated: Large farmers cultivate 6.3 times the land small farmers cultivate and 2.8 times the land cultivated by medium farmers.

The study area is known for its cereal production as rice and maize are grown during two seasons while wheat is cropped once per year. Rice is the dominant

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3 The land cultivated includes land owned, plus leased-in/shared-in minus shared/leased-out for money.

crop with aman (kharif) rice being cultivated by 90% and boro (rabi) rice being cultivated by 61% of the sampled households (Error: Reference source not found). The second most important crop is wheat, cultivated by 45% of households, followed by rabi maize with 13% and spring maize with 11%. Interestingly, wheat cultivation is relatively more attractive to small farmers while more large farmers prefer maize cultivation. More than half of the produced rice and wheat grain is consumed within the household while practically all maize grain is marketed by the sampled households. Livestock form the second most important asset of the farming households in the study area, providing food, income and draft power. The ownership of large and small ruminants[4] is common in the study area; about 78% of the households own large ruminants and 56% of the households own small ruminants. Within the household sample, livestock ownership and cultivated land are positively correlated (Error: Reference source not found). Only, 2% of sampled households are headed by females, nearly all of the small farmers. While the age of household heads does not differ greatly between farmers' groups from the overall average (44 years), large farmers have received considerably more schooling (6 years) than small farmers (3 years).

The major crop rotations in NW Bangladesh are rice-rice, rice-wheat, rice/fallow-maize and potato/maize-rice (Krishna et al., 2011). From Error: Reference source not found it is evident that rice is the only dominant crop in the kharif season, about 73% of cultivable land is occupied by rice OPVs[5] cultivated by 90% of famers; hybrid rice is cultivated only by two large farmers. About 35% of the kharif rice acreage is under irrigation is given in Error: Reference source not found15. In the kharif season, approximately one-fourth of the cultivable land is kept as fallow, mainly due to lack of irrigation facilitie

4 Large ruminants include cow local, cow crossbred, buffalo male, buffalo female and bullock; small ruminants include sheep and goat.

5 OPVs rice in the study area includes local varieties, composite varieties and high yielding varieties (HYV)