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Biophysical and socioeconomic characterization of the cereal production systems of Central Nepal

Subash Ghimire, Surya Mani Dhungana, Vijesh V. Krishna, Nils Teufel, and D.P. Sherchan

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April 2013

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Contents

Tables v

Figures vi

Acknowledgments vii

Acronyms viii

Executive Summary ix

1 Introduction 1

2 Study Area 4

3 Sampling procedure and data collection 7

4 Socio-economic characterization of farming households 8

5 Economics of cereal production in Nepal Terai region 24

- 5.1 Rice 24
- 5.2 Wheat 28
- 5.3 Maize (rabi and spring seasons) 32

6 Livestock production 41

7 Farmer perception on and farm adoption of CA technologies 43

- 7.1Conventional technology adoption in the study area 43
- 7.2 Familiarity and adoption of CA and related technologies 44
- 7.3 Sources of information on CA 45
- 7.4 Perceived impact of CA-technology 47

8 Market channels for inputs and outputs 49

- 8.1 Seeds 49
- 8.2 Fertilizers and pesticides 49
- 8.3 Marketing channels of cereal output 50

9 Conclusions 52

References 54

Appendix 1 55

Tables

1. Geographic area, population and household number of study districts 5
2. Area and productivity of different crop in the study districts 5
3. General household characterization 8
4. Cropping Pattern followed by sample farmers 20
5. Share of irrigated crop area 21
6. Sources and share of irrigation water 22
7. Cost of irrigation water 22
8. Households assets status 23
9. Income sources in households 23
10a. Varietal adoption in rice: adoption as share of farmers and area 24
10b. Varietal adoption in rice: yield, grain marketed and price 25
11. Cultivation practices in rice production 26
12. Input use in rice cultivation 26
13. Economics of rice cultivation 27
14a. Varietal adoption in wheat 28
14b. Varietal adoption in wheat: yield, grain marketed and price 29
15. Cultivation practices in wheat production 30
16. Input use in wheat cultivation 30
17. Economics of wheat cultivation 31
18a. Varietal adoption in Rabi maize 33
18b. Varietal adoption in Rabi maize: yield, grain marketed and price 33
19a. Varietal adoption in spring maize 34
19b. Varietal adoption in spring maize: yield, grain marketed and price 35
20. Cultivation practices in maize production 36
21. Input use in maize cultivation 37
22. Economics of maize cultivation 39
23. Livestock productivity 40
24. Average contribution of feeds to dairy animal ration 41
25. Value of milk sales and consumption 42
26. Milk markets 42
27. Technology adoption in cereal production 44
28. Familiarity and adoption of CA and related technologies 44
29. Source of information on CA technologies 46
30. Contact frequency with the major source of information on CA technologies 46
31. Perceived impacts of CA technology 47
32. Perceived impacts of CA on farm profitability across farmer groups 48
33. Market channels: seeds 50
34. Market channels: fertilizers and pesticides 51
35. Market channels: cereal outputs 51

Figures

Figure 1: Map of Nepal showing the study area 4

Figure 2: Distribution of annual rainfall in study districts in year 2009 6

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Acronyms

BC	Benefit-cost
CA	Conservation agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CSISA	Cereal Systems Initiative in South Asia
DSR	Direct seeded rice
GDP	Gross domestic product
IGP	Indo Gangetic Plain
NARC	Nepal Agriculture Research Council
NGO	Non-governmental organization
NRs.	Nepalese Rupees
NW IGP	North West Indo Gangetic Plain
OPV	Open pollinated variety
QPM	Quality protein maize
RCT	Resource conserving technology
SSNM	Site specific nutrient management
VDC	Village Development Committee
ZT	Zero tillage

Executive Summary

The domestic food security of Nepal is critically depended on the sustainability of the cereal production systems of Central Nepal Terai region, as the major share of nation's cereal production comes from the agro-ecological regions of this belt. The present study focusses on the biophysical and socio-economic characterization of the cereal producing farm households in this region, with special attention on the economics of crop production, and the potentials of conservation agriculture (CA) technologies. The empirical part is based on a comprehensive baseline household survey (324 households), conducted among the cereal farmers, following a cluster sampling procedure across the Terai region. Primary data required for the study was collected from the sampled households through personal interviews using a comprehensive and pre-tested questionnaire. In order to obtain a complete picture of the farm-household activities and decision-making process, the sample households were categorized in to three more or less identical-sized, mutually-exclusive groups: small (lowest 33%with respect to scale of operation), medium (middle 33%) and large (upper 33%) farmers.

The study area is dominated by small and marginal farmers, with the average size of land cultivated being 2.25 acres (0.91 ha). The mean acreage under cultivation by a large farmer is 6-times greater than that of a small farmer, showing a high inequality in distribution of land cultivated (with Gini coefficient of 0.47) existing across the farmer households. At the same time, a higher percentage of smallholders are sharing out their land, while sharing-in is done mostly by large landholders. During the Kharif (rainy) season, about 79% of the cultivated land is under rice open pollinated varieties (OPVs), while another 17% is under hybrid rice production. Wheat is a major crop of the second season (winter/Rabi), cultivated on 50% of the area by about 84% of households. The share of cultivated land under wheat is significantly higher among small farmers, while large farmers diversify the system with non-cereal crops during this season. Maize is cultivated in 9% of land during this season by about 20% of the sample farmers, and hybrid seed adoption is relatively high compared to the other two cereals. During the third season (spring/summer), land is mostly kept fallow (80%), mainly due to limited irrigation facilities, with maize being the only major crop: about 17% of the cultivable area is under spring maize cultivation, mainly with local open pollinated varieties (OPVs). The small and medium farmers are the ones mainly engaged in spring maize production.

The most important source of irrigation in the study area is diesel tube-wells, providing 41% of the total irrigation water. Most small farmers purchase irrigation water from the diesel wells, whereas large scale farmers obtain water from their own wells. Purchasing water from the tube-wells causes significant cost increase for cereal production for the small farms. Canal water is the second most important source of irrigation.

Cereal varietal diversity is limited in Nepal Terai area. The three most important varieties account for 56% of the rice, 97% of the wheat and 81% of the Rabi and spring maize acreage. The cereal production is also found highly labour intensive: 40% of the total paid-out cost is employed for

hiring out human labour in rice, 25% in wheat and 26 (45)% in Rabi (spring) maize. Rice is the most profitable cereal crop in Nepal Terai, with benefit-cost (BC) ratio of 1.42 over the paid-out costs. The BC ratio for wheat is 1.38, and lower for maize (1.10 for Rabi and 0.97 for spring maize). Nevertheless, rice production is more labour intensive than the other two cereals, and unit area under rice cultivation requires 50% more variable cost than for wheat production, mostly to hire labour. Small-scale farmers obtain relatively higher profits from rice cultivation. However, no significant relationship between scale of operation and profitability is observed for both wheat and maize. Most of the cereal produce is used for home consumption. Only 28% of the rice, 25% of the wheat and 65% (46%) of the Rabi (spring) maize grains are marketed in the study area.

Two out of three households keep large and small ruminants. Although the percentage share of livestock in household income is only about 6%, the sector's indirect contribution to rural livelihoods and crop production is highly significant. Rice straw is the main source of dry matter in animal feed, followed by collected green grass, wheat straw and concentrate. Small farmers depend mainly on collected grass, while large farmers depend more on wheat straw. The total milk produced per household per day is about 6.6 litres, of which about 48% is used for household consumption, and 44% sold raw.

The average number of tillage for rice, wheat and maize is more than three, and only a marginal share of farmers are adopting zero tillage (ZT) wheat. Custom hiring of agricultural machineries is common, except for self-owning large farmers. The study examines the awareness and adoption status of various resource conserving and yield enhancing technologies in the study area. Products of hybridization (rice and maize hybrids) are the most popular technologies as more than 75% of the respondent households are aware of them with 20-30% having adopted them. Seed treatment, relay cropping, bed planting and direct seeding in rice are the technologies moderately familiar, but rarely adopted. Most of the farmers get information on these resource conserving technologies (RCTs) from progressive farmers. Results indicate that even among those farmers, who are familiar with the technology, awareness on the impact of CA technology on irrigation, cost, yield and profitability is extremely limited. Farmers are highly unaware of the impacts of bed planting (94%), quality protein maize (QPM) (92-95%), ZT (80-85%) and rotavator (86-89%) on farm profitability. Novel technology diffusion techniques and more emphasis on solving constraints faced by small and marginal farmers in obtaining information on farming are expected to accelerate the technology diffusion and enhance cereal productivity in the study area.

In trying to understand the critical importance of value chains in increasing farm profitability and income, the study also examined the existing marketing channels for inputs (seeds, agro-chemicals and fertilizers) and outputs in the study area. Private dealers are the main suppliers of rice, wheat and maize seeds. Co-operatives also take up the role of seed providers in case of rice, although they mostly cater to the needs of medium- and large farmers. Small farmers depend mostly on private dealers within their villages, whereas large farmers depend on dealers located in the district headquarters to obtain modern seed varieties. The private dealers are also the major providers of fertilizers. The largest share of cereal produced is purchased by village- and district-level traders. The village traders are highly important for the small farmers: more than 90% of marketed rice, wheat and OPV maize are purchased by the village level traders. Linking cereal farmers with input/output markets effectively, especially for smallholders, may be considered as a major challenge in increasing farm income of Nepal.

1. Introduction

The economy of Nepal is primarily based on its agriculture sector, which constitutes about one-third of the Gross Domestic Product (GDP) and employing nearly three-fourth of the labour force (MoF, 2010; NRB, 2010). Almost 75% of the total cultivated area of the country is occupied by five major crops viz., rice, maize, wheat, millets, and barley (Prasad et al., 2011). Among them, rice alone accounted for 35% of the total cultivated area (and 46% of the cereal acreage) in year 2008/09. In the Terai region, which is also known as the "Granary of Nepal", more than 84% of farm households are actively engaged in rice production. Wheat and maize are also important crops in this region, with about 61% of households cultivating wheat and 29% spring maize (CBS, 2011). The domestic food security of Nepal is critically dependent on the sustainability of the cereal production in the Terai region (MoAC, 2009). The present study is undertaken to assess the cereal production status of this region, especially with respect to the economics of crop production and conventional technology diffusion, against which the potentials of conservation agriculture (CA) could be assessed.

As in the case of many other developing countries of South Asia, the growth rate of the agricultural sector of Nepal is too low to meet the increasing food demand. The country has registered a population growth rate of 1.40% per annum, while production growth rates of the two major cereals (rice and wheat) are either stagnant or declining during the last decade (MoAC, 2009). The trend is more evident in the case of wheat; the rate of growth in wheat production has declined from 4.2% in the 1990s to 1.7% during the 2000s. There is no perceivable change in growth rate of rice, which remains at 1.4% per annum for the last two decades. On the contrary, domestic maize production shows a 3.3% annual growth rate, due to rapid productivity growth via adoption of yield enhancing technologies like hybrid seeds.[2] Significant public and private investments are necessary in agricultural research and development (R&D) sector in order to increase the cereal productivity of Nepal.

A major share of rice, wheat and maize are being produced by the smallholders (with farm size less than 1 ha) in Nepal (CBS, 2011), and without irrigation. The Badal Commission Report showed an inverse relation between farm size and income from land, mainly due to the high cropping intensity in smallholding (Adhikari, 2008). However, even though the households increase the cropping intensity and food production per unit area as the farm size declines, the profit obtained by the farm household would still remain low. Irrespective of the size of the

[2]Almost all the maize hybrids cultivated in Nepal are developed abroad (mainly in India). The single hybrid maize developed domestically is yet to become popular among farmers. The entire hybrid maize seed trade is unofficial and unrecorded (Pullabhotla et al,2011).

land holding, farm production in Nepal remains highly dependent on weather conditions. Delay in monsoon or dry spells at planting time significantly affect the area planted under different crops and overall agricultural production. Water shortage during transplanting of rice has resulted in late planting or leaving the land fallow for the season.

In addition to the climatic vagaries, unavailability of quality production inputs limits the scope for both extensification and intensification of the domestic primary sector. Unavailability and adulteration of chemical fertilizers has impeded agricultural productivity of Nepal over years which act as a particularly critical constraint in the Terai region, where crop production is more input-intensive than in other parts of the country. Like chemical fertilizers, shortage of petroleum products also affects agriculture in this region. Lack of fuel for agricultural machineries has resulted in fallowing of the arable land in Nepal Terai, where, due to the more levelled fields, farm-mechanization is largely in place. The climatic and input market factors significantly challenge the crop production in the study area. To cite a case, according to the Ministry of Agriculture and Cooperatives, the crop yield of winter 2011/12 is expected to be limited in Nepal, due to a combination of a cold wave, petroleum shortage and unavailability of chemical fertilizer (Anonymous, 2012).

Many of the aforementioned production challenges can be addressed by limiting the dependence on external inputs, mainly through reducing the cultural practice of tillage and following more sustainable crop rotations. Although being an essential component of traditional agriculture by accounting for one-fourth of the total production cost (Behera et al, 2010), tillage and other land preparation operations critically limit the area under crop production in Nepal. This is because of the increasing scarcity of petroleum products and hired human labour. Excessive tillage has also been shown to negatively impact on farm profitability and environment, through soil carbon loss, soil erosion and greenhouse gas emissions. Soaring price of fuel and energy crisis prevailing in Nepal and increasing wage rate of hired human labour as a result of out-migration from rural areas, and the share of tillage cost to total cultivation cost of cereals may have increased significantly. Along with research findings on the potential of excessive tillage to hamper soil structure and the sustainability of production, the aforementioned scenario of increasing prices of external inputs has made the challenge faced by agricultural scientists and policy makers, in finding out alternative tillage systems that would sustain the production of cereals at a relatively lower cost, more imminent. Introduction of CA-based resource conserving technologies (RCTs) is therfore expected to generate a spectrum of opportunities as an effective alternative to cope with the problems of conventional agriculture.

Conservation Agriculture is a relatively new concept in crop production that emphasizes minimum disturbance of soil, proper management of crop residues and following crop diversification, and thus addresses the issues of environment protection and sustainability of crop production. The CA-based RCTs save both time of land preparation and cost of production so that the agricultural activities become more economic for the farm households (FAO, 2001a; FAO, 2001b). The present study is based on a comprehensive household survey of three districts of Central Nepal, and focuses primarily on the biophysical and socioeconomic characterization of the cereal producing farms. The paper details major cropping patterns followed by farm households, farmer perceptions, status of technology adoption, and the economics of production of major cereals, alongside the prevailing markets of cereal outputs and farm inputs. Some part of the study is also devoted to explaining different aspects of livestock rearing and the associated product marketing. Special mention is given to investigating the familiarity and adoption of selected CA-based RCTs, in their early stage of diffusion, information sources of these technologies and their perceived impacts. The study attempts to provide grass-root level details on cereal production process and is expected to form the basis for the further planning of dissemination of CA-based RCTs in different systems.

2 Study Area

The study is conducted in Chitwan, Bara and Rupandehi districts of Terai, coming under the purview of Cereal Systems Initiative for South Asia (CSISA) Project Nepal Hub (Figure 1). The reprentative districts lie in the southern foothills of the Himalaya, in the northeast of the Indo-Gangetic Plains (IGP).[3] Terai is a strip of land of 8 to 12 km width at an elevation of up to 330 meters above sea level, and stretches alongside the international border with India in the Far-Western Region to the Eastern Region.

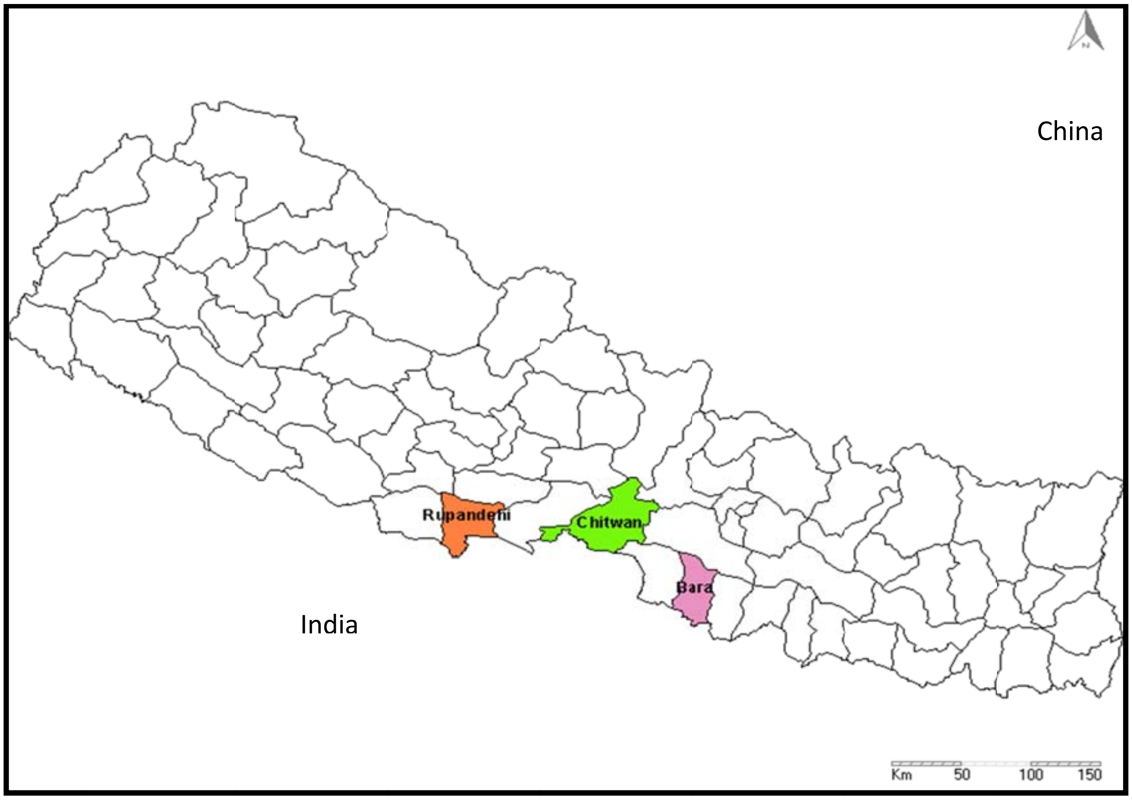

Figure 1: Map of Nepal showing the study area

There are a number of small and seasonal as well as perennial rivers in this region, most of which originate from the Himalayas. The area represents about 14% of the total geographic area of Nepal, but contributes to 72% of rice and 63% of wheat production (MoAC, 2009), having high potential for intensive agriculture boosted by the warmer temperatures and relatively better irrigation facilities, availability of inputs supplies and market opportunities compared to the hilly regions.

[3] The IGP has traditionally been the major grain producer of South Asia, stretching from Punjab of Pakistan to Bangladesh. The northwest Plains, including Indian states of Punjab and Haryana, have a relatively favorable rice-wheat environment, dominated by wheat and irrigated rice. On the other hand, the eastern IGP regions, including the Nepal Terai and Bangladesh, have a less favorable rice-wheat environment, dominated by rainfed rice and partially irrigated wheat.

Details on total geographic area and population in each of these districts are shown in Table 1. These three districts, albeit covering only 3% of the total geographical area of Nepal, comprises of 8% of population. The cereal productivity here is above the national average (Table 2)

Table I. Geographic area, population and household number of study districts.

Districts	Household Number ('000)	Population ('000)	Area in Sq. km.
Chitwan	132.84 (2.35)	566.66 (2.13)	2218 (1.51)
Bara	114.69 (2.03)	701.04 (2.63)	1190 (0.81)
Rupandehi	170.08 (3.00)	886.71 (3.33)	1360 (0.92)
Total of 3 districts	417.60 (7.38)	2154.40 (8.09)	4768 (3.24)
Nepal	5659.98	26620.80	147181

Source: CBS, 2012
Note: Figures inside the parentheses indicate percentage to column total.

Table 2. Area and productivity of different crop in the study districts.

Crops		Districts			Nepal
		Chitwan	Bara	Rupandehi	
Rice	area ('000 acre)	73.12(2.00)	129.95(3.55)	179.08(4.89)	3658.78(100.00)
	productivity (quintal/acre)	12	14	13	11
Wheat	area ('000 acre)	22.26(1.23)	71.38(3.95)	76.57(4.24)	1805.89(100.00)
	productivity (quintal/acre)	10	13	14	9
Maize	area ('000 acre)	44.58(2.06)	7.66(0.35)	5.93(0.27)	2162.88(100.00)
	productivity (quintal/acre)	10	9	10	9
Pulses	area ('000 acre)	15.71(1.99)	36.02(4.56)	17.19(2.18)	789.10(100.00)
	productivity (quintal/acre)	3	4	3	3
Vegetables	area ('000 acre)	28.17(4.85)	32.23(5.55)	29.55(5.09)	580.69(100.00)
	productivity (quintal/acre)	55	62	82	52
Oilseeds	area ('000 acre)	27.54(5.62)	6.32(1.29)	17.78(3.63)	490.39(100.00)
	productivity (quintal/acre)	3	4	4	3
Potato	area ('000 acre)	4.64(1.01)	16.06(3.51)	9.39(2.05)	457.80(100.00)
	productivity (quintal/acre)	75	82	57	55
Sugarcane	area ('000 acre)	0.04(0.03)	5.43(3.77)	2.35(1.63)	144.03(100.00)
	productivity (quintal/acre)	137	170	190	173

Source: Yearbook 2009, Ministry of Agriculture and Co-operatives Nepal.
Note: Figures in the parentheses indicate percentage to row total.1 acre = 0.405 ha; 1 quintal = 0.1 ton.

The annual rainfall recorded in Rampur (Chitwan) during 2009 (1909 mm) was the highest among the three districts. All these districts had received maximum rainfall in the month of August, and experience uni-modal rainfall distribution pattern (Figure 2). The average monthly temperature ranges from 38^0C in April to 9^0C in January. The agroclimate is hot/semi-hot moist. Soils are mostly loamy-clay. The major crop rotations in the districts are rice-wheat, rice-wheat-maize and rice-vegetables (Krishna et al., 2012). Rice is a major food crop across the study districts in terms of both area and production. Accounting for only 10% of the indicating a relatively higher productivity status. Wheat is the second most popular crop, and the three districts contribute about 14% of total national wheat production (Table 2).

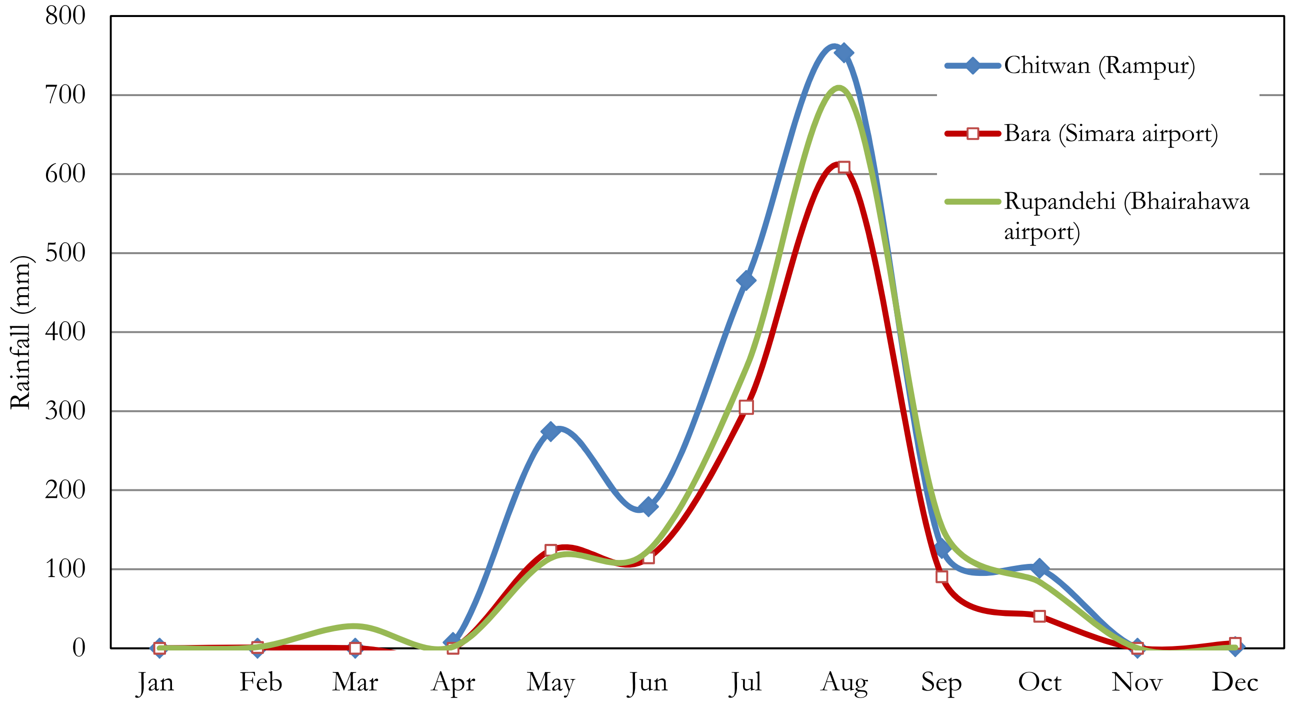

Figure 2: Distribution of annual rainfall in study districts in year 2009
Source: Yearbook 2009, Ministry of Agriculture and Co-operatives Nepal.

The focus group discussions, preceding the household survey, indicated a number of key production constraints in the locality, which include lack of irrigation facilities, inadequate infrastructure facilities, erratic electricity supply and rapidly increasing fuel prices (Krishna et al., 2012). Shortage of human labour is critically affecting most of the households in the study area, reflected in the high peak-normal wage rate ratios. Unavailability of quality fertilizer at the right time is another major constraint, as almost all of the chemical fertilizers are imported to the country. Black marketing and adulteration of fertilizers are fairly common. Pest and weed infestations, farm information inaccessibility and degraded soil condition are other major constraints prevalent in the location.

3. Sampling procedure and data collection

A cluster sampling procedure was used to select the study villages. Stratified random sampling was followed to sample households within each of the selected villages. From the Nepal hub, which consists a total of six districts, three districts, namely Rupendehi, Chitwan and Bara, were purposively selected, ensuring representation of different cropping systems. This was done after discussions with experts from fields of agronomy and plant breeding. A complete list of CSISA project intervention Village Development Committees (VDCs) - similar to the villages of India in residing population and geographical area - and wards was obtained from the project hub, from which, three CSISA intervention VDCs were randomly selected per district (nine VDCs in total). From each of these selected VDCs, one project intervention ward and one control ward were randomly selected. Cluster sampling was used to select VDCs and 18 wards (six per district) for carrying out the village and household surveys, of which, nine were intervention wards. Details of this sampling procedure are given in Appendix I.

From each of the 18 selected wards, village census datasets were collected from all the farming and non-farming households. The household details, including the name of household head, size of household, landholding and livestock ownership, acreage under different cereals as well as farmers' participation in group activities were gathered. This dataset was generated with the help of a few educated villagers residing in each of the sample wards. 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/district).

Primary data required for the study was collected from the sample households through personal interview and a comprehensively pre-tested questionnaire. The enumerators involved in the data collection were familiar with the local socioeconomic environment, trained with mock-interviews, and constantly monitored by the hub-level socioeconomist. Data was collected from the sample respondents between June and November, 2010, and was periodically examined by CIMMYT socioeconomist. In addition to the household level data, the secondary data required for the study (e.g., the location of the study area, demography, rainfall pattern, land use pattern, irrigation sources and cropping pattern etc.) was gathered from different publications of Ministry of Agriculture and Co-operatives and Central Bureau of Statistics of Government of Nepal.

4. Socioeconomic characterization of farming households

Most elements of agricultural production process, including selection of cropping patterns, production technologies, marketing channels as well as cost of production of cereals, are potentially determined by the scale of operation. For example, the scale effect may permit the large farmers to adopt mechanization or approach a distant output dealer who provides higher market price for the produce. In order to obtain a complete picture through socioeconomic characterization, the sampled households are categorized in to three mutually-exclusive groups: small, medium and large scale farmers, based on the scale of operation. In other words, stratification is done based on the relative acreage being cultivated by the household in each of the wards during the study period. Ownership of land was not used for this categorization, although it is strongly and positively correlated with the scale of operation.[4] None of the sample households in the study area were landless, and the average size of land cultivated by the sample households is 2.25 acre (0.91 ha; see Table 3).

Table 3. General household characterization (n = 324)

	Farmer groups				p-value
	Small	**Medium**	**Large**	**Overall**	
Total land owned (acres)	0.70 (0.04)	1.58(0.09)	4.20 (0.28)	2.16(0.13)	0.00[a]
Cultivated land-leased in (%)	0.93	2.70	4.43	3.69	na
Cultivable land-leased out (%)	1.04	4.00	3.73	3.49	na
Cultivated land-shared in (%)	5.66	7.71	8.29	7.90	na
Cultivable land-shared out (%)	10.36	5.90	1.28	3.40	na
Total land cultivated (acres)	0.66(0.02)	1.57(0.03)	4.51 (0.24)	2.25 (0.12)	0.00[a]
Households cultivating rice (%)	100.00	100.00	100.00	100.00	na
Households cultivating wheat(%)	78.90	85.85	88.07	84.25	0.06[b]
Households cultivating maize(%)					
Kharif (rainy)	0.00	0.94	0.92	0.61	na
Rabi (winter)	11.01	19.81	29.36	20.06	0.00[b]
Spring	24.77	30.19	29.35	28.08	0.45[b]
Households with large ruminants* (%)	65.14	77.36	77.98	74.07	0.03[b]
Household with small ruminants*(%)	65.14	70.75	67.89	68.83	0.66[b]
Female-headed households(%)	16.51	9.43	11.93	12.65	0.30[b]
Age (years) of household-head	47.00 (1.29)	47.99 (1.25)	48.29 (1.19)	47.75 (0.72)	0.67[a]
Education (years of schooling) of household head	6.02 (0.52)	6.59 (0.47)	6.88 (0.45)	6.49 (0.28)	0.29[a]

Notes: Figures in parentheses indicate standard errors of sample means; [a]shows p-values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; [b]shows p-values derived from Chi-square test with trend; na refers to non-applicability of test; *includes both adult and young animals.
1 acre = 0.405 ha.

[4]Correlation coefficient between owned land and land cultivated is positive and statistically significant (+0.91), indicating that the scale of operation is strongly related with the asset status of the farm-household.

An interesting relationship was observed between size of landholding and the practice of sharing in/out of land: a large share of small farmers share out their land, while sharing-in is done mostly by the large farmers.[5] This is reflected in the difference between land cultivated and land owned across the farmer categories. Large farmers have higher portions of their land under cultivation. The average acreage under cultivation by a large farmer is 6-times that of a smallscale farmer, showing a relatively high inequality in distribution of land cultivated (Gini coefficient of 0.47) in the study area, whereas the inequality in land owned is slightly more (Gini coefficient of 0.49).

Since the sample includes only the cereal farmers (cultivating at least rice/wheat/maize), it is unsurprising that all the sample households are engaged in rice production, while 84% are involved in wheat, and 20 and 28% in Rabi and spring maize production respectively. Wheat and Rabi maize are cultivated more frequently by the large farmers (Table 3). Livestock rearing is also very common: about four-fifths of the households have large ruminants, with 69% having small ruminants. Ownership of large ruminants is found to be positively associated with the size of operation. About 13% of the sample households are female-headed. No significant differences were observed across the farmer categories with respect to age (48 years) or education status (6.5 years of schooling) of head of household.

Rice forms the most important crop in the study area, as all sample farmers grow it during the Kharif (rainy) season. About 79% of the cultivated land is under non-hybrid rice, while another 17% is under hybrid rice production (Table 4). Unlike in many other rice production belts of Eastern IGP, winter rice is not popular in Nepal. The total area under winter (Boro) rice is limited to about 2500 ha (reported by K.P. Bhurer; personal communication). Rice production is carried out mostly with irrigation (95% on average; Table 5).

The major cereal crop of the second (winter/Rabi) season is wheat, cultivated on 50% of the cultivable area by 84% of sample households. The percentage of cultivable land under wheat is significantly higher among small farmers (60%, against 40% in large farms), while significant crop diversification occurs in the larger farms during this season (Table 5). Crops, like maize, lentil, mustard and vegetables are increasingly cultivated by the large farmers during the Rabi season. About 84% of the wheat production is carried out with at least one irrigation (Table 5), and significantly higher proportion of large farmers (88%) provides irrigation for wheat, compared to their small farmer counterparts (74%).

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[5] Correlation coefficient between size of land owned and that of "net shared-in" land (shared-in *minus* shared-out) is negative and significant (-0.27), showing that smallholders share-out land, while large landholders share-in land for cultivation.

Table 4. Cropping Pattern followed by sample farmers.

Season	Crops	% cultivable area under the crop				p-value	% farmers engaged in cultivation				p-value
		Small	Medium	Large	Overall		Small	Medium	Large	Overall	
Kharif	Rice (Hybrid)	23.15	12.92	14.43	16.87	0.14[a]	23.85	21.70	28.44	24.69	0.11[b]
	Rice (OPV)	74.83	83.58	78.58	78.95	0.00[a]	83.49	91.51	93.58	89.51	0.02[b]
	Maize	0.00	0.25	0.34	0.20	na	0.00	0.94	0.92	0.62	0.38[b]
	Fallow	2.03	3.25	6.65	3.98	0.04[a]	4.59	11.32	11.93	9.26	0.06[b]
	Total	100.00	100.00	100.00	100.00		111.93	125.47	134.86	124.07	
Rabi	Wheat	60.13	50.33	40.17	50.21	0.00[a]	78.90	85.85	88.07	84.26	0.06[b]
	Maize	6.89	9.11	10.68	8.89	0.00[a]	11.01	20.75	29.36	20.37	0.00[b]
	Buckwheat	1.39	3.00	0.78	1.71	na	1.83	6.60	5.50	4.63	0.19[b]
	Lentil	13.43	15.60	19.05	16.03	0.00[a]	31.19	52.83	78.90	54.32	0.00[b]
	Mustard	6.25	8.26	9.24	7.91	0.00[a]	11.93	22.64	40.37	25.23	0.00[b]
	Linseed	2.08	3.36	5.34	3.59	0.03	6.42	12.26	25.69	14.81	0.00[b]
	Vegetables	5.44	4.11	3.57	4.38	0.07[a]	6.42	17.92	29.36	17.90	0.00[b]
	Others	3.18	3.88	3.18	3.41	0.00[a]	9.17	33.96	21.10	18.83	0.00[b]
	Fallow	10.24	12.24	16.26	12.92	0.06[a]	15.60	31.13	34.86	27.16	0.00[b]
	Total	109.03*	109.89*	108.28*	109.06*		172.47	283.96	353.21	269.75	
Summer	Maize	21.47	23.03	7.57	17.31	0.13[a]	24.77	35.85	25.69	28.70	0.88[b]
	Sesame	1.22	0.25	0.32	0.60	na	2.75	0.94	2.75	2.16	0.97[b]
	Vegetables	1.39	0.95	0.31	0.88	na	2.75	3.77	1.83	2.78	0.68[b]
	Others	1.74	1.15	0.93	1.28	na	2.75	3.77	1.83	2.78	0.68[b]
	Fallow	74.19	74.61	90.87	79.94	0.08[a]	71.56	60.38	71.56	67.90	0.99[b]
	Total	100.00	100.00	100.00	100.00		104.59	104.72	103.67	104.32	

Note: [a] shows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; [b] shows p-values derived from Chi-square test with trend; na refers to non-applicability of test; *Total exceed 100 due to intercropping.

Table 5. Share of irrigated crop area.

Season	Crop	% of crop area irrigated by				p-value[a]
		Small	Medium	Large	Overall	
Kharif	Rice	96.61	95.95	94.47	95.22	0.24
	Maize	na	0*	100*	80	na
Rabi	Wheat	73.92	77.31	88.29	83.53	0.05
	Maize	93.28	72.53	59.94	64.84	0.14
	Lentil	26.72	34.35	37.61	36.15	0.00
	Mustard	51.85	67.88	44.24	49.12	0.32
	Linseed	33.33	38.78	40.38	39.84	na
	Vegetables	100.00	76.83	79.57	81.74	na
	Others	27.45	9.47	54.40	38.44	na
Summer**	Maize	21.02	1.30	10.96	7.78	0.00
	Sesamum	38.10	0.00	0.00	11.59	na
	Vegetables	100.00	84.21	100.00	94.23	na
	Others	0.00	0.00	0.00	0.00	na

Note: [a]p-values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom; na refers to non-applicability of the test; *single sample farmer only cultivated Kharif maize in each of these groups; ** no cultivation in Rupendehi district.

Rabi maize is also popular, cultivated on 9% of the land by 20% of households. About 65% of maize cultivation is done with irrigation in this season (Table 5).

Cultivable land is mostly kept fallow (80%) during the spring season, mainly due to limited irrigation facilities, with maize being the only major crop: about 17% of the cultivable land is under spring maize cultivation, by 29% of the farmers. Small and medium farmers are mainly engaged in spring maize cultivation. Adaptability of this crop to the rainfed production conditions could be one of the factors behind its popularity; only 8% of area under this crop is with irrigation (Table 5).

Details of sources and cost of irrigation provided in Tables 6 and 7. The most important source of irrigation is diesel tube-wells, providing 41% of the total irrigation water in the study area. Diesel tube-well irrigation is carried out either from the farmers' own wells (17% of water obtained in this manner) or water is purchased from the wells owned by other farmers (24% of total irrigation water). However, the scale of operation has a significant influence in terms of owning/purchasing irrigation water. It is the small farmers who have to purchase irrigation water from the diesel wells, whereas the large farmers obtain water mainly from their own wells. About 37% of irrigation water for small-scale farmers is purchased from diesel wells, compared to 15% for the large-scale farmers.

Table 6. Sources and share of irrigation water.

Sources	share % among				p-value[a]
	small	medium	large	overall	
Electric tube-well, purchased	1.19(0.70)	2.45(1.23)	4.40(1.71)	2.69(0.74)	0.37
Diesel tube-well, purchased	36.54(3.29)	21.18(3.66)	14.77(3.11)	24.18(2.21)	0.00
Canal	34.54(3.29)	35.75(3.66)	33.03(3.11)	34.43(2.21)	0.89
River	0.69(0.51)	1.42(0.88)	0.69(0.39)	0.92(0.36)	na
Electric tube-well, owned	0.92(0.92)	3.68(1.71)	2.39(1.10)	2.31(0.73)	0.22
Diesel tube-well, owned	9.91(2.67)	13.35(3.21)	28.07(3.99)	17.15(1.97)	0.00
Others	16.24(2.02)	22.17(2.50)	16.65(2.17)	18.32(1.29)	0.21
Total	100.00	100.00	100.00	100.00	

Note: Figures in parentheses indicate standard error; [a]shows p-values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; na indicates non-applicability of test.

Table 7. Cost of irrigation water.

	Unit	Farmer group				p-value[a]
		Small	Medium	Large	Overall	
Purchased water						
Tube-well	NRs/hour	224.89(7.48)	217.79(8.53)	195.32(8.80)	215.27(4.81)	0.06
Canal	NRs/acre/year	342.26(67.46)	286.65(14.12)	263.71(13.00)	296.90(22.18)	0.58
Own tube well						
Using electricity	NRs/hour	100.00(0.00)	118.00(7.18)	92.86(29.84)	103.80(16.07)	na
Using diesel	NRs/hour	75.06(3.80)	74.33(4.63)	88.63(4.57)	81.78(2.85)	0.12

Note: Figures in parentheses indicate standard error, [a]shows p-values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; na indicates non-applicability of test; There is no tank irrigation and no cost is incurred for irrigation from river; 1 US$ = NRs. 84.14 (in May 2012).

Again, only about 10% of total irrigation water is obtained from diesel wells owned by the small-scale farmers, while 28% of irrigation for large-scale farmers is from this source. The difference in irrigation infrastructure with scale of operation causes significant cost increase for the small farm-households. On average, purchased water costs 163% more than that extracted from owned tube-wells. In addition, there is a significant disparity in the price of purchased irrigation water between small-scale farmers (NRs. 225/hour of water pumping) and large-scale farmers (NRs. 195/hour). In other words, small-scale farmers pay 15% more for same unit of irrigation than their large-scale counterparts. This difference could probably be attributed to the bargaining power associated with scale of operation.

Canal water is the second most important source of irrigation water with about 34% of irrigation water derived from this source (Table 6). The pricing is done based on the size of land unit cultivated over one year. At the time of survey, the sample farmers were paying NRs. 297/acre/year for canal water, on average (Table 7). Electric tube-wells are seldom found in the study area (about 5% of sample farmers using them), which could be attributed to the significant capital requirement for initial investment as well as the intermittent and inadequate power supply in the study area, although 87% of the households are having electricity connection (Table 8).

Table 8. Household's assets status.

	Farmer group				p-value
	Small	Medium	Large	Overall	
Households with electricity connection (%)	83.49	91.51	86.24	87.04	0.54[b]
Households with piped water connection (%)	4.59	15.09	14.68	11.42	0.02[b]
Livestock assets (number)					
Cattle (crossbreed, adult female)	0.09(0.03)	0.09(0.03)	0.15(0.05)	0.11(0.02)	0.77[a]
Buffalo (adult female)	0.37(0.05)	0.60(0.07)	0.71(0.09)	0.56(0.04)	0.02[a]
Draft animal (adult male)	0.23(0.07)	0.34(0.08)	0.55(0.11)	0.37(0.05)	0.04[a]
Goats & sheep (adult)	1.65(0.20)	2.52(0.27)	1.99(0.25)	2.04(0.14)	0.04[a]
Poultry					
Commercial	0.00(0.00)	59.43(33.13)	30.27(19.53)	29.63(12.70)	0.08[a]
Local/backyard	1.03(0.28)	1.42(0.28)	1.60(0.35)	1.35(0.18)	0.33[a]

Note: Figures in parentheses indicate standard error; [a]shows p-values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; [b]shows p-values derived from Chi-square test with trend.

Along with cultivable land and irrigation infrastructure, livestock form an important component of the household asset profile of farming systems in South Asia. As observed previously in Table 3, a majority of the sample households are engaged in livestock production. The details of livestock assets of sample households are provided in Table 8. Number of large ruminants is found to be higher among the large farmers, than with small and medium groups. In contrast, goat and sheep are more popular among the medium-scale farmers. Altogether, livestock production contributes about 6.5% of the annual income for the households, against 23% from crop production (Table 9). Unsurprisingly, the share of crop income is significantly high for the large farmers (31%) than small (15%) and medium (24%) farmers. On the other hand, agricultural and non-agricultural labour activities are the other major sources of income for the small farmers.

Table 9. Income sources in households

	Farmer group				p-value[a]
	Small	Medium	Large	Overall	
Crops	15.23(2.13)	23.57(2.10)	31.01(2.61)	23.36(1.37)	0.00
Livestock	5.87(0.96)	7.05(0.93)	6.47(0.74)	6.46(0.50)	0.19
Other farm activities	2.61(0.86)	1.84(0.67)	1.20(0.70)	1.89(0.43)	0.33
Agricultural labour	17.94(2.31)	10.86(1.90)	13.80(2.42)	14.23(1.29)	0.07
Non-agricultural labour	21.88(2.39)	17.26(2.37)	13.94(1.96)	17.70(1.31)	0.08
Services	15.73(2.61)	13.73(2.68)	14.81(2.38)	14.77(1.47)	0.61
Business	7.71(1.92)	9.09(2.20)	7.16(1.82)	7.97(1.14)	0.86
Remittances	13.03(2.54)	16.60(2.62)	11.61(2.31)	13.71(1.44)	0.28
Total	100.00	100.00	100.00	100.00	

Note: Figures in parentheses indicate standard error; [a]shows p- values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom

5 Economics of cereal production in Nepal Terai region

Cereals are major component of both subsistence and commercial Nepalese agriculture. Consequently, the economics of cereal production has a very important role in determining the food security and the financial sustainability of farm-households, the region and the nation in general. In the study area, the popular prevailing cropping systems contain at least two cereal crops (rice with wheat or maize).

5.1 Rice

Rice is the main crop in Terai region, contributing about 70% of the rice production of Nepal.[6] In the study area, all the sample farmers are involved in rice cultivation. In the Kharif season, 96% of cultivable land is under rice cultivation, out of which around 17% is hybrid rice. Surprisingly, adoption of hybrid rice is highest among small farmers (23% by acreage) compared to the medium (13%) and large (14%) groups (Table 4). With respect to area under hybrid rice, partial adoption of the technology is more common amongst large farmers, as 28% them cultivate hybrid rice, while 94% are engaged in non-hybrid cultivation. There are identifiable varietal preference patterns existing among farmers for varieties, with three varieties, Sona Mansuli (Masuri), Sabitri and Gorakhnath, accounting for 56% of the acreage under rice (Table 10a).

Table 10a. Varietal adoption in rice: adoption as share of farmers and area.

Variety	% of rice farmer cultivating				% of crop area cultivated			
	Small	Medium	Large	overall	Small	Medium	Large	Overall
Sona Mansuli	35.78	26.41	32.11	31.48	29.44	22.14	28.39	27.11
Sabitri	22.01	33.02	29.36	28.08	19.63	25.22	13.80	17.07
Gorakhnath	18.34	16.03	24.77	19.75	16.24	10.41	11.47	11.75
Radha4	6.42	12.26	21.10	13.27	3.10	8.63	7.28	7.16
Ramdhan	7.34	12.26	11.00	10.18	6.54	7.48	4.23	5.23
Mansuli	2.75	12.26	13.76	9.57	1.69	7.69	9.83	8.48
Saro(early maturing varieties)	0.91	8.49	14.68	8.02	0.23	3.77	6.47	5.19
Sama Mansuli	7.33	5.66	9.17	7.40	7.33	5.02	3.95	4.56
Loknath	0.92	2.83	2.75	2.16	1.12	1.25	1.00	1.07
Hardinath	3.67	4.71	7.34	5.24	1.92	1.67	1.57	2.30
Others	12.84	13.21	27.52	17.90	12.75	6.70	11.03	10.23
Total	118.31*	147.14*	193.56*	153.06	100.00	100.00	100.00	100.00

*total percentage exceeds 100 because some farmers are cultivating multiple varieties.

Sona Mansuli is the most preferred rice variety, cultivated by 32% of farmers in 27% of area under rice. Other popular varieties existing in the study area are Radha 4, Ramdhan, Mansuli and Saro. The top seven varieties cover about 82% of the rice acreage in the study area.

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[6] www.archieve.irri.org

Among different varieties grown by farmers, Loknath is the highest yielding (16.75 quintal/acre, although cultivated by only seven sample farmers), followed by Gorakhnath (hybrid rice; yielding 16.12 quintals/acre) (Table 10b). Radha 4 is the lowest yielder among the popular seven varieties (10.88 quintal/acre), but at par with the national average of 11 quintals/acre. Overall, small farmers are reaping slightly higher grain yield (14.60 quintal/acre) in comparisons to those in medium and large farmer groups. However, this difference is not statistically significant.

Table 10b. Varietal adoption in rice: Yield, grain marketed and price.

Variety	Yield (qtl/acre)obtained by				% grain marketed				Price (NRs./qtl) obtained by			
	Small	**Med.**	**Large**	**Overall**	**Small**	**Med.**	**Large**	**Overall**	**Small**	**Med.**	**Large**	**Overall**
Sona Mansuli	15.26	14.77	16.09	15.41	4.31	24.82	47.49	24.76	1350.00	1541.00	1650.00	1616.00
	(0.61)	(0.65)	(1.52)	(0.59)	(1.99)	(5.31)	(4.42)	(2.87)	(272.95)	(57.87)	(34.90)	(27.90)
Sabitri	14.40	12.73	14.36	13.74	3.54	29.29	45.47	28.18	2100.00	1764.00	1859.00	1839.00
	(0.61)	(0.63)	(0.83)	(0.41)	(2.09)	(5.80)	(5.52)	(3.44)	(57.74)	(44.06)	(36.79)	(28.88)
Gorakhnath	16.37	15.88	16.09	16.12	10.00	18.82	46.67	27.81	1967.00	1981.00	1934.00	1948.00
	(0.65)	(0.53)	(1.18)	(0.80)	(5.85)	(5.53)	(5.96)	(3.97)	(33.33)	(33.98)	(25.14)	(18.91)
Radha4	8.62	10.59	11.74	10.88	17.86	36.15	33.70	31.86	1717.00	1669.00	1694.00	1688.00
	(0.99)	(0.58)	(0.62)	(0.44)	(8.99)	(9.09)	(6.60)	(4.70)	(60.09)	(41.11)	(49.23)	(31.16)
Ramdhan	16.38	12.73	12.46	13.52	7.50	15.00	40.42	22.42	2100.00	1950.00	2050.00	2013.00
	(1.96)	(1.17)	(0.58)	(0.73)	(7.50)	(5.77)	(9.34)	(4.99)	(0.00)	(125.83)	(80.17)	(64.64)
Mansuli	14.16	12.88	13.37	13.24	30.00	28.08	52.33	40.00	1450.00	1843.00	2173.00	2003.00
	(1.21)	(0.85)	(1.01)	(0.60)	(15.28)	(8.39)	(8.48)	(5.86)	(50.00)	(134.27)	(74.81)	(77.88)
Saro (early	15.44	14.56	13.78	14.11	25.00	7.78	42.81	30.00	1500.00	1475.00	1303.00	1342.00
maturing)	(0.00)	(0.94)	(1.18)	(0.79)	(0.00)	(5.72)	(10.19)	(7.27)	(0.00)	(175.00)	(150.79)	(120.42)
Sama Mansuli	13.09	12.47	9.46	11.42	0.00	3.33	40.00	17.50	na	1900.00	1950.00	1943.00
	(0.62)	(1.24)	(1.04)	(0.65)	(0.00)	(3.33)	(14.06)	(6.97)		(0.00)	(81.65)	(69.38)
Loknath	11.97	17.96	17.16	16.75	0.00	0.00	41.67	17.86	na	na	1950.00	1950.00
	(0.00)	(1.83)	(1.44)	(1.19)	(0.00)	(0.00)	(8.33)	(8.99)			(28.87)	(28.87)
Hardinath	15.66	12.94	10.63	11.85	0.00	0.00	48.13	34.68	na	na	1769.00	1769.00
	(3.48)	(0.59)	(3.24)	(2.66)	(0.00)	(0.00)	(13.44)	(16.85)			(146.31)	(146.31)
Other	13.25	11.28	13.02	12.66	9.29	15.36	40.28	26.54	1925.00	1750.00	1721.00	1742.00
	(0.80)	(0.70)	(1.15)	(0.65)	(6.50)	(7.49)	(6.63)	(4.52)	(275.00)	(189.29)	(152.53)	(119.81)
Total	14.60	13.35	13.58	13.66	6.90	22.16	43.53	27.56	1557.00	1747.00	1797.00	1768.00
	(0.33)	(0.28)	(0.39)	(0.19)	(1.59)	(2.30)	(2.23)	(1.44)	(137.75)	(31.57)	(29.17)	(23.28)

Note: Figures in parentheses indicate standard error; na refers to non-applicability. The inter-group comparison was not carried out due to small number of observation in most of the cells. However, the difference across groups for average varietal yield and price is not statistically significant at 0.10 level. There is a strong association of scale of operation with percentage grain marketed ($p < 0.01$); 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

Unsurprisingly, there is a significant difference across farmer groups with respect to percentage of grain marketed. Nepal's agriculture is dominated by subsistence farming systems with about 72% of total rice production being produced for home consumption only (Table 10b). However, there is a significant difference across the farmer categories with respect to share of rice marketed. The marketed grain share is lowest among small farmers (7%), compared to medium (22%) or large (44%) farmers. The average price received by farmer for rice grains is more or less equal (difference being statistically insignificant) across the farmer groups, average, NRs.1768 per quintal. Amongst the different rice varieties, Ramdhan and Mansuli are highest priced (about NRs. 2000 per quintal), with Saro the lowest priced (NRs. 1342/quintal). The significantly large inter-varietal price difference could be indicative of a clear consumer preference for quality in the rice grain markets.

Further to the varietal adoption, and preceding economics of rice production, details on cultivation practices and input usage are examined in detail (Tables 11 & 12). Rice is being cultivated only in the Kharif season, sown in the second half of June or first half of July (depending mainly on the availability of irrigation water), and harvested in first half of November (Table 11).

Table 11. Cultivation practices in rice production

Operation	Farmer group				p-value
	Small	Medium	Large	Overall	
Average number of tillage operations	3.44(0.08)	2.90(0.13)	3.70(0.11)	3.36(0.06)	0.00[a]
Farmers following no till (%)	0.95	0.00	0.00	0.32	na
Farmer following seeding as (%):					
Manual broadcast	0.00	1.01	0.00	0.32	na
Seed drill	2.02	0.00	0.00	0.65	na
Transplanting	97.14	98.99	100.00	99.03	0.60[b]
Seed treatment (% of farmers)	0.95	1.89	0.98	1.30	na
Median date of sowing	28 Jun	24 Jun	1 Jul	27 Jun	
Mode date(s) of sowing	15 Jun	20 Jun	15 Jun; 2 Jul; 3 Jul; 15Jul	15 Jun	
Farmers sowing on mode date(%)	6.67	5.77	6.06	5.48	
Median date of harvesting	10 Nov	10Nov	13 Nov	10Nov	
Mode date(s) of harvesting	1 Nov; 5 Nov; 10Nov	10Nov	15Nov	10Nov	
Farmers harvesting on mode date (%)	6.86	8.74	9.18	7.28	
Mode of harvesting (% of farmers)					
Manual	100.00	100.00	100.00	100.00	
Machine	0.00	0.00	0.00	0.00	

Note: Figures in parenthesis indicate the standard error of sample mean; ashows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; b shows p-value derived from Chi-square test with trend; na refers to non-applicability of the statistical tests.

Table 12. Input use in rice cultivation.

	Farmer groups				p-value
	Small	Medium	Large	Overall	
Seed rate (kg/acre)	20.88(2.06)	21.35(0.94)	19.69(1.63)	20.64(0.94)	0.01[a]
FYM and other manures (qtl/acre)	15.75(1.24)	18.25(1.32)	18.41(1.48)	17.52(0.78)	0.24[a]
Fertilizers (qtl/acre)					
Nitrogen	0.28 (0.01)	0.27 (0.01)	0.31 (0.02)	0.29 (0.01)	0.35[a]
Phosphorus	0.17 (0.01)	0.18 (0.01)	0.19 (0.02)	0.18 (0.01)	0.91[a]
Potash	0.12 (0.02)	0.09 (0.01)	0.20 (0.06)	0.14 (0.02)	0.01[a]
Zinc	0.02 (0.00)	0.02 (0.00)	0.02 (0.00)	0.02 (0.00)	0.13[a]
Others	na	na	0.14	0.14	na
Herbicide (litre/acre)	0.13 (0.04)	0.30 (0.06)	0.48 (0.15)	0.36 (0.09)	0.01[a]
Fungicide (litre/acre)	0.12 (0.08)	0.11 (0.04)	0.20 (0.14)	0.15 (0.06)	0.38[a]
Human labour (work-days/acre)	77.60 (2.64)	67.19 (1.98)	64.83 (2.01)	70.95 (1.31)	0.00[a]
%of hired labour to total labour	58.04	63.36	69.50	63.64	0.16[b]
% of female labour to total labour	55.58	56.40	57.36	56.45	0.83[b]
Animal labour (NRs/acre)	1022.89 (141.04)	663.34 (98.87)	1241.88 (435.28)	993.33 (124.15)	0.20[a]
Machine labour (NRs/acre)	3206.93 (282.19)	3637.71 (631.37)	4452.06 (707.14)	3794.17 (333.75)	0.87[a]

Note: Figures in parenthesis indicate the standard error of sample mean; ashows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; b shows p-value derived from Chi-square test with trend; na refers to non-applicability of the statistical tests; 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

About 20 kg seed is used per acre of rice crop, slightly below the national average of 22 kg/acre, and seed treatment is rarely done (only 1% farmers adopting it). Transplanting of seedlings is commonly practiced. The small farmers use a higher seed rate (Table 12). On an average, farmers were tilling the land 3-4 times and spending NRs. 4727 per acre for animal and machine labour alone (26% of total paid-out cost). Human labour is hired in addition for tillage operations. On average, farmers use 29 kg of nitrogen, 18 kg phosphorus and 14 kg for potash in rice production. Herbicides are used in limited quantities (360 ml/acre), mainly by the medium and large farmers. Altogether, 71 labour days are required for carrying out rice cultivation per acre, more than half of which is female, and family labour is commonly used (36% of total labour use). Harvesting is done manually, as machine (combine) harvesters were not available in the study area at the time of the survey.

The cost-return analysis of rice production is carried out for the main plot of rice production and is furnished in Table 13.

Table 13. Economics of rice cultivation

Cost component (NRs/acre)	Farmer groups				p-value
	Small	Medium	Large	Overall	
Seed	1559.85(177.16)	1610.56(188.67)	1971.54(582.05)	1713.49(211.85)	0.64[a]
Seed treatment	10.26(10.26)	6.05(6.05)	14.08(14.08)	10.17(6.16)	0.99[a]
FYM and other manures	1809.24(214.96)	2631.35(252.95)	2356.89(277.43)	2257.77(144.70)	0.03[a]
Chemical fertilizer	2734.86(156.33)	2667.85(161.79)	3660.72(458.17)	3021.80(171.53)	0.27[a]
Herbicides	13.76(5.45)	24.62(6.82)	55.95(16.33)	31.34(6.23)	0.00[a]
Fungicides and insecticides	15.60(8.64)	79.20(54.22)	70.02(46.98)	54.32(23.68)	0.02[a]
Animal labour	107.16(33.82)	26.80(13.64)	48.70(28.21)	61.68(15.65)	0.07[a]
Machine custom hiring	3115.30(279.05)	3884.93(458.39)	4348.56(703.93)	3775.38(294.13)	0.50[a]
Hired human labour	6555.58(382.74)	7206.70(438.75)	7121.86(387.65)	6954.99(232.41)	0.64[a]
Total paid-out cost	15921.61(561.95)	18138.05(716.66)	19648.33(1177.62)	17880.93(501.22)	0.07[a]
Total Paid out cost +family labour cost	22148.48(589.62)	22654.12(995.87)	23465.35(1137.53)	22751.03(492.77)	0.94[a]
Gross revenue	26871.25(754.69)	23459.11(995.87)	25587.12(1137.53)	25339.28(492.77)	0.01[a]
Net revenue (excluding family labour)	10949.64(858.33)	5321.06(1290.22)	5938.79(1337.67)	7458.34(691.27)	0.00[a]
Net revenue (including family labour)	4722.77(873.24)	805.00(1270.18)	2121.75(1307.75)	2588.25(674.13)	0.10[a]
Output price (NRs/quintal)	1827.88(30.06)	1783.14(64.23)	1802.49(19.23)	1804.94(24.01)	0.54[a]
Cost of production (NRs/quintal)	1124.78(42.24)	1502.78(93.56)	1471.89(109.31)	1362.78(50.35)	0.00[a]
Return to labour (NRs/day)*	393.94(39.03)	209.33(72.27)	234.99(114.89)	281.23(46.90)	0.16[a]

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom, *calculated using net revenue excluding family labour/number of family labour days. This could be compared against the existing wage rate of hired human labour (NRs 173/day); 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

The cost structure reveals the labour-intensive nature of rice cultivation: 40% of the total paid-out cost is used for hiring human labour. Machine cost associated with tillage and land preparation accounts for 20% of the paid-out cost, while chemical fertilizers are the third largest cost component (17%). Cost of manures and plant protection chemicals (including herbicides) incurred are significantly higher in the large farm category. For tillage, many of the small farmers still use animal traction, while large farmers depend more on machines. There is a significant difference across farmer groups with respect to the total paid-out cost of cultivation: large farmers spend 23% more to cultivate an acre of rice compared to the small farmers. However, when the family labour cost is imputed, this difference gets reduced, and the average cost of rice cultivation with imputed family labour cost is about NRs. 22,751 per acre (US$ 668/ha). Against this, the gross revenue from rice cultivation is NRs. 25,339 per acre (US$ 744/ha), making rice a profitable crop (with a benefit-cost ratio of 1.42 before and 1.11 after imputing the family labour component). Due to a higher crop productivity and slightly lower cost of production, net revenue becomes significantly high for the small farmer group. The net revenue is 84% (123%) higher among small farmers compared to large farmers without (with) the family labour component.

5.2 Wheat

Wheat is the third most important cereal crop of Nepal after rice and maize, with respect to acreage and production. The crop occupies 22% of total cereal area and contributes to 25% of the total cereal production of the country. The crop is cultivated in the Rabi (winter) season by about 84% of sample farmers in 50% of their cultivable area, mostly under irrigation (Table 4). It is the large farmers who are mostly involved in wheat cultivation, but the per-farm area-share under the crop is significantly high for the small farmers. In some parts of the study area, it is grown in the mixed cropping system, along with mustard, lentil, peas, etc.

Wheat farming in the Terai is dominated by improved varieties, but varietal diversity is rather limited, with two varieties (NL 297 and Gautam) being cultivated in about 90% of wheat acreage (Table 14a).

Table 14a. Varietal adoption in wheat

Variety	% of wheat farmer cultivating				% of crop area cultivated by			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
NL 297	77.91	80.22	85.42	82.83	72.86	79.80	80.52	79.33
Gautam	13.95	17.58	11.46	14.55	17.90	16.32	7.69	11.26
Bhrikuti	3.49	2.20	9.38	5.23	3.85	2.69	8.83	6.59
Local	4.65	2.20	2.08	2.98	5.39	1.19	2.54	2.56
BL 28	na	na	1.04	0.37	na	na	0.42	0.42
Total	100.00	102.20	109.38	105.96	100.00	100.00	100.00	100.00

The local varieties are cultivated only by about 3% of the sample farmers. However, the productivity of the local varieties is more or less at par with the improved varieties found in the study area. Out of the different improved varieties, the cultivar NL 297 is preferred by most of the farmers (83%), with about 80% of their wheat area devoted to this variety.

A CIMMYT-led field study revealed that about 30% of the wheat area during 1999/2000 crop season was under NL 297, and the increase in its popularity over time could be attributed partly to its relatively higher yield (10 quintals/acre; Table 14b).[7] Other than NL 297 and Gautam (cultivated in about 15 % of wheat area), Bhrikuti (in 5%) is an important improved variety with respect to both farmer adoption and acreage. There are no significant differences across farmer groups with respect to wheat yield (indicating that the wheat farming is scale-neutral), and the market price obtained.

Table 14b. Varietal adoption in wheat: Yield, grain marketed and price

Variety	Yield (qtl/acre) obtained by				% grain marketed by				Price (NRs./qt) obtained by			
	Small	Med.	Large	Ov'll	Small	Med.	Large	Ov'll	Small	Med	Large	Overall
NL 297	10.12	9.36	10.54	10.03	9.38	26.03	38.45	25.59	1625.00	1678.00	1661.00	1662.00
	(0.75)	(0.40)	(1.05)	(0.47)	(2.39)	(3.65)	(3.60)	(2.08)	(46.80)	(31.10)	(20.81)	(16.38)
Gautam	8.93	9.39	8.60	9.06	14.17	20.31	46.36	33.17	1567.00	1729.00	1663.00	1672.00
	(0.63)	(0.76)	(0.59)	(0.41)	(7.53)	(6.60)	(10.62)	(3.07)	(233.33)	(82.99)	(95.78)	(62.26)
Bhrikuti	6.38	10.17	7.66	7.75	0.00	30.00	25.00	20.36	na	1550.00	1726.00	1676.00
	(1.06)	(4.19)	(1.03)	(0.87)	(0.00)	(10.00)	(9.43)	(6.72)		(50.00)	(66.15)	(57.07)
Local	9.88	5.39	9.88	8.75	12.50	0.00	40.00	16.25	1100.00	na	1600.00	1350.00
	(0.75)	(2.99)	(5.09)	(1.38)	(12.50)	(0.00)	(40.00)	(11.01)	(0.00)		(0.00)	(250.00)
BL 28			10.77	10.77			100.00	100.00			1700.00	1700.00
			(0.00)	(0.00)			(0.00)	(0.00)			(0.00)	(0.00)
Total	9.81	9.31	10.08	9.75	9.87	24.57	38.57	25.36	1586.00	1680.00	1665.00	1660.00
	(0.60)	(0.35)	(0.83)	(0.37)	(2.19)	(3.10)	(3.23)	(1.84)	(56.71)	(28.10)	(19.89)	(16.15)

Note: Figures in parentheses indicate standard error; na refers to non-applicability. The inter-group comparison was not carried out due to small number of observation in most of the cells. However, the difference across groups for average varietal yield and price is not statistically significant at 0.10 level. There is a strong association of scale of operation with percentage grain marketed ($p < 0.01$); 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

Most of the wheat produced in the samples farms is used for household consumption (Table 14b). On average, only 25% of the total grain produced is found to be marketed. Not surprisingly, the proportion of marketed surplus is highest (39%) for large farmers followed by medium (25%) and small farmers (10%). The average market price obtained is NRs. 1660/quintal.

Details of cultivation practices followed for wheat production in the farmers' main plot is shown in Table 15, from which it can be deduced that the crop is mainly cultivated with thorough tillage (average of 3 tillage operations), and that there is only a marginal adoption of ZT wheat in the study area (5% of farmers). The crop is sown mostly via manual broadcasting in the second half of November. Harvest takes place in March-April months, also done mostly manually. There is a slight delay in harvesting of wheat for small farmers. Machine/combine harvesting is rarely employed, except by about 3% of the large farmers.

[7] http://apps.cimmyt.org/research/wheat/map/research_results/reshighlights/pdfs/resHigh_FarmParticip.pdf

Table 15. Cultivation practices in wheat production.

Operation	Farmer group				p-value
	Small	Medium	Large	Overall	
Average No. of tillage operations	3.05 (0.16)	2.89(0.08)	3.07(0.13)	3.00(0.07)	0.68[a]
Farmers following no-till (%)	6.17	1.30	7.89	5.13	0.62[b]
Farmers following seeding (%) as:					
Manual broadcast	93.83	97.40	92.11	94.44	0.02[b]
Seed drill	6.17	2.60	7.89	5.56	0.95[b]
Drum seeder	0.00	0.00	1.32	0.43	na
Seed treatment (% of farmers)	0.00	0.00	0.00	0.00	na
Median date of sowing	20Nov	22 Nov	21 Nov	21 Nov	
Mode date(s) of sowing	15 Nov	15 Nov	21 Nov	15 Nov	
Farmer sowing on mode date(%)	6.17	11.69	9.09	8.41	0.52[b]
Median date of harvesting	14 Apr	7 Apr	28 Mar	8 Apr	
Mode date(s) of harvesting	22nd Apr	26 Mar; 17 Apr; 25 Apr	12th Apr	20th Mar	
Farmers harvesting on mode date(%)	8.64	5.56	9.72	5.38	0.79[b]
Mode of harvesting (% of farmers)					
Manual	100.00	100.00	97.33	99.15	na
Machine (combine)	0.00	0.00	2.67	0.85	na

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; [b]shows p-value derived from chi-square test with trend; na refers non-applicability of the test. *Farmers are not using seeding type like power tiller operated seeder, roto-seeder and turbo-seeder.

Unlike in the case of rice, there are no significant differences across the farmer groups with respect to input use (Table 16), with the exception of human labour. The figures represent the input used in the farmers' main wheat plot alone. The seed rate followed is 55kg/acre. On average, about 31 work-days are required to produce wheat from an acre, making it the least labour-intensive cereal crop in the study area (rice production employs more than double the amount of labour days).

Table 16. Input use in wheat cultivation.

	Farmer group				p-value
	Small	Medium	Large	Overall	
Seed rate (kg/acre)	56.37 (2.08)	52.70 (1.75)	56.70 (1.58)	55.27 (1.06)	0.28[a]
FYM and other manures use (qtl/acre)	17.83 (2.24)	13.79 (1.76)	15.31 (1.83)	15.54 (1.05)	0.33[a]
Fertilizers (qtl/acre)					
Nitrogen	0.36(0.03)	0.35(0.02)	0.37(0.02)	0.36(0.02)	0.50[a]
Phosphorus	0.28(0.04)	0.24(0.02)	0.30(0.04)	0.27(0.01)	0.43[a]
Potash	0.45(0.06)	0.43(0.04)	0.43(0.04)	0.44(0.03)	0.96[a]
Zinc	0.46(0.06)	0.46(0.06)	0.35(0.07)	0.43(0.04)	0.36[a]
Others	0.00	0.50(0.00)	0.00	0.50(0.00)	na
Herbicide (litre/acre)	0.46(0.09)	0.46(0.08)	0.29(0.05)	0.40(0.05)	0.13[a]
Fungicide (litre/acre)	0.23(0.03)	0.18(0.02)	0.36(0.10)	0.25(0.03)	0.43[a]
Human labour use (workdays/acre)	37.04(1.68)	27.89(1.50)	27.69(1.11)	31.00(0.89)	0.00[a]
% hired labour to total labour	46.41	51.30	58.70	53.14	0.33[b]
% female labour to total labour	42.41	41.95	42.92	42.48	0.97[b]
Animal labour (NRs/acre)	920.79(324.65)	1177.05(618.45)	1316.70(598.50)	1013.96(249.07)	0.18[a]
Machine labour (NRs/acre)	2164.16(113.68)	2066.42(88.16)	1982.47(117.80)	2073.15(61.82)	0.47[a]

Note: Figures in parenthesis indicate the standard error of sample mean; [a]show p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom, [b]show p-values derived from chi-square test with trend; na refers non-applicability of test; 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

Small farmers are using about 37 labour days for cultivation of one acre of wheat, which is 9 days more than in case of medium and large farmers. Significant share (54%) of the total labour requirement for small farmers is met by family members (41% for the large farmers). The contribution of female labour to total labour used is almost consistent (about 42%) across the farmer groups. In addition, animal and machine labour, costing about NRs. 3087/acre, is used in wheat production and spent mainly for tillage and land preparation activities.

Wheat production in the study area is found to be more fertilizer-intensive than rice. Manures are applied at time of land preparation at the rate of 16 quintal per acre. In addition, 36 kg nitrogen, 27 kg phosphorus and 44 kg potash is used per acre. Other fertilizers (including Zinc) amount to 93 kg per acre. Fewer farmers use pesticides in their wheat field (Table 16).

The economic sustainability of cereal production, especially in the marginal and small farms, depends upon the extent and stability of farm income generated from a unit of land under cultivation. The cost and return structure of wheat production in farmers' main wheat plot is presented in Table 17.

Table 17. Economics of wheat cultivation

Cost component (NRs/acre)	Farmer group				p-value
	Small	Medium	Large	Overall	
Seed	2052.63(87.69)	1822.32(94.09)	2044.98(94.03)	1974.02(53.28)	0.18[a]
Seed treatment	0.00	0.00	0.00	0.00	na
FYM and other manures	2254.27(491.44)	2615.57(1033.16)	1454.88(295.53)	2113.53(391.60)	0.58[a]
Chemical fertilizer	3078.12(436.10)	2248.49(116.91)	2848.87(241.77)	2730.67(175.24)	0.19[a]
Herbicides	1.73(1.13)	1.54(1.20)	6.19(3.19)	3.12(1.18)	0.36[a]
Fungicides and insecticides	17.53(6.95)	14.27(4.96)	33.65(14.67)	21.69(5.58)	0.52[a]
Animal labour cost	158.12(56.18)	30.57(24.33)	34.65(26.79)	76.05(23.00)	0.01[a]
Machine custom hiring cost	2125.19(122.86)	2049.51(94.72)	1941.94(130.42)	2040.77(67.53)	0.37[a]
Hired labour cost	3618.65(193.28)	2763.16(211.49)	2534.22(167.73)	2984.94(114.59)	0.00[a]
Total paid-out cost	13280.91(666.85)	11545.44(1063.45)	10899.40(428.88)	11936.35(444.82)	0.00[a]
Total paid out cost +family labour cost	16997.81(746.16)	14300.93(1114.08)	13298.77(445.73)	14908.98(480.40)	0.00[a]
Gross revenue	19180.52(2379.39)	15582.41(624.19)	16589.35(1520.59)	16456.70(684.63)	0.82[a]
Net revenue (excluding family labour)	3882.44(1390.16)	3828.29(1324.14)	5689.90(1584.09)	4451.67(826.67)	0.39[a]
Net revenue (including family labour)	165.54(1383.86)	1072.80(1354.31)	3290.58(1585.46)	1479.05(833.45)	0.06[a]
Market price of grains(NRs/quintal)	1929.22(153.91)	1667.88(11.16)	1674.26(13.50)	1760.41(53.97)	0.00[a]
Cost of production (NRs/quintal)	1683.81(164.06)	1332.07(117.07)	1501.84(14.21)	1508.97(88.82)	0.09[a]
Return to family labour (NRs/day)*	212.97(109.86)	305.63(69.69)	383.09(151.92)	285.90(67.39)	0.00[a]

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom, *calculated using net revenue excluding family labour/number of family labour days. This could be compared against the existing wage rate of hired human labour (NRs 173/day); 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

Manures and fertilizers account for the maximum cost in wheat production: 41% of the total paid-out cost; 23% to purchase chemical fertilizers alone. About one-fourth of the total paid-out cost is incurred for hired labour, in addition to which an almost equal share of family labour is employed. There is a significant difference across farmer categories with respect to animal and human labour cost. Although the mean values are very low, the small-scale farmers incur 3.5 times more cost of hiring in animal labour, compared to the large-scale farmers, which is a clear indication that adoption of mechanization for tillage operations in wheat in Nepal may not be scale neutral. The scale of operation also affects the labour-intensive nature of wheat production. Small farmers, despite involving more family labour per acre, have to spent more money on hiring labour activities also. Hence, any labour-saving technology innovation in wheat would disproportionately benefit small farmers in Nepal. Due to the high labour cost, in particular, the total cost of wheat cultivation is 22% higher for small-scale farmers in comparison to their large-scale counterparts.

The total cost of wheat production is at the highest for small-scale farmers (NRs. 1683/quintal), followed by large-scale farmers (NRs. 1501/quintal) and medium-scale farmers (NRs. 1332/quintal) (Table 17). The grain price obtained is significantly high for small-scale farmers.[8] However, small-scale farmers get lowest net return (NRs. 166/acre), due to higher cost of production. The net return achieved by large-scale farmers is highest. It is observed that small-scale farmers are getting very less net return, often bear financial losses, from the wheat cultivation and its sustainability is at a critical stage. Scale neutral technologies that would cut down the cost of wheat production are expected to have high significance in this juncture.

5.3 Maize (Rabi and spring seasons)

In the Terai region, it is possible to cultivate maize throughout the year, due to favourable agro-climatic conditions. Maize ranks as the second most important staple food crop in Nepal, covering 2.2 million acres with an average productivity of 9 quintals/acre (MoAC, 2009). The warm temperatures and better irrigation facilities in Terai agro-ecology provide congenial production environment for maize (Paudyal et al., 2001). It is the only cereal crop that is cultivated in more than one season in the study area. District Chitwan is one of the major maize producers of Terai region, having a national acreage share of 2.06%. Other two districts, Bara and Rupandehi, contribute only to 0.35% and 0.27% (Appendix II). As provided in Table 4, around 20% of sample farmers cultivate maize during the Rabi season, while 29% follow spring maize production in the study area. Percentage of farmers' land covered by maize in the Rabi (spring) seasons is 8.89 (17.31).

[8] The price and yield figures corresponds to the main wheat plot alone, and hence deviated from Tables 12a&b, where whole-farm data is considered.

Kharif maize is rarely in the field, as the cultivable area is devoted entirely for rice cultivation during this season.

There is a significant adoption of hybrid and improved variety maize seeds, although the extent of adoption varies across cropping seasons. There is no hybrid variety of maize formally recognized by the Government of Nepal. Nevertheless, a strong trade of maize seeds through the Indian border markets is observed, which is unofficial and unrecorded (Pullabhotla et al., 2011). Most of the farmers' fields in Rabi season are under hybrid maize cultivation, similar to the bordering Indian state of Bihar (Raghu et al., n.d.). Information on maize varieties being cultivated in the study area during Rabi season is shown in Tables 18a&b.

Table 18a. Varietal adoption in Rabi maize.

Variety	% of maize farmer cultivating				% of crop area cultivated by			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
PV92	58.33	54.54	62.50	60.00	57.98	60.98	50.10	52.90
Pinnacle	8.33	4.55	9.37	7.69	6.72	2.20	7.31	6.20
Rampur Local	0.00	4.55	9.37	6.15	0.00	5.49	23.85	18.38
Rampur Composite	8.33	4.55	9.37	7.69	6.72	5.49	11.45	9.88
Rampur Yellow	0.00	9.09	3.13	4.61	0.00	7.14	1.91	2.87
Local	25.00	22.72	12.50	18.46	28.57	18.68	4.45	9.07
CB 950	0.00	0.00	3.13	3.13	0.00	0.00	0.95	0.95
Total	100.00	100.00	109.37	107.73	100.00	100.00	100.00	100.00

Table 18b. Varietal adoption in Rabi maize: Yield, grain marketed and price

Variety	Yield (qtl/acre) obtained by				% of grain marketed by				Price (NRs./qt) obtained by			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall	Small	Medium	Large	Overall
PV 92	10.62	8.18	11.61	10.37	55.71	66.67	84.00	73.59	1163.00	1289.00	1367.00	1316.00
	(1.70)	(0.98)	(1.44)	(0.86)	(19.74)	(13.33)	(8.15)	(6.88)	(368.20)	(38.89)	(32.96)	(50.01)
Pinnacle	14.96	9.58	15.76	14.36	100.00	100.00	100.00	100.00	1400.00	1200.00	1383.00	1350.00
	(0.00)	(0.00)	(1.11)	(1.35)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(66.67)	(52.44)
Rampur	na	3.35	3.79	3.68	na	0.00	35.00	26.55	na	na	1400.00	1400.00
Local		(0.00)	(0.53)	(0.39)		(0.00)	(23.63)	(18.86)			(100.00)	(100.00)
Rampur	17.96	5.98	6.32	8.58	30.00	40.00	63.33	52.00	1600.00	1400.00	1300.00	1400.00
Composite	(0.00)	(0.00)	(2.88)	(2.83)	(0.00)	(0.00)	(31.80)	(18.81)	(0.00)	(0.00)	(100.00)	(81.65)
Rampur	na	8.37	7.78	8.18	na	70.00	50.00	63.33	na	1600.00	1800.00	1667.00
Yellow		(3.59)	(0.00)	(2.08)		(20.00)	(0.00)	(13.33)		(200.00)	(0.00)	(133.33)
Local	15.36	9.70	7.48	10.37	0.00	28.00	68.75	34.58	na	1350.00	1400.00	1383.00
	(0.72)	(0.82)	(1.98)	(1.15)		(19.60)	(18.75)	(12.42)		(50.00)	(70.71)	(47.73)
CB950	na	na	4.78	4.78	na	na	100.00	100.00	na	na	1400.00	1400.00
			(0.00)	(0.00)			(0.00)	(0.00)			(0.00)	(0.00)
Total	12.77	10.25	10.07	9.97	43.33	55.45	77.14	64.35	1275.00	1340.00	1386.00	1346.00
	(1.26)	(1.90)	(1.03)	(0.62)	(14.16)	(9.64)	(6.41)	(5.22)	(244.86)	(42.31)	(26.61)	(22.08)

Note: Figures in parentheses indicate standard error; na refers to non-applicability; The inter-group comparison was not carried out due to small number of observation in most of the individual cells. 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

PV 92 (hybrid released by Pioneer) is the most popular variety, cultivated by 60% of maize farmers in 53% of the maize acreage (Table 18a). Pinnacle is another popularly sown hybrid and also the highest yielder (14 quintals/acre). However, its solely commercial as it, not used for home consumption (Table 18b). Along with these hybrids, improved open pollinated varieties (OPVs) released by the public sector (Nepal Agricultural Research Council, NARC), viz. Rampur Local, Rampur Composite, and Rampur Yellow, are also popular among farmers. Rampur local is cultivated mainly by the large-scale farmers, despite being low yielding (less than 4 quintals/acre). This variety is highly preferred for home consumption (74%). (The overall figure for Rabi maize is 36%). Some cultivars of unknown progeny are also in use, cultivated mainly by the small-scale farmers. However, these cultivars have similar yield with the hybrids. On average, the market price obtained by the maize farmers in study area is NRs. 1346/quintal with small-scale farmers receiving a relatively lower price, possibly due to the transportation and information constraints associated with their scale of operation.

The varietal adoption during spring season shows a sharp contrast to that of Rabi season maize. As Table 19a shows, Rampur Local is the single most popular variety, adopted by 42% of the farmers and sown in 47% of acreage under spring maize. Its yield is 100% more during the spring season compared to in Rabi.

Table 19a. Varietal adoption in spring maize.

Variety	% of maize farmer cultivating				% of crop area cultivated by			
	Small	Medium	Large	Overall	Small	Medium	Large	Overall
GK	0.00	2.63	0.00	1.07	0.00	1.30	0.00	0.55
Bioseed	0.00	2.63	0.00	1.07	0.00	4.35	0.00	1.83
Rajkumar	3.70	0.00	7.14	3.22	2.70	0.00	4.93	2.47
Pioneer	0.00	2.63	3.57	2.15	0.00	1.30	2.69	1.65
Rampur Local	40.74	34.21	53.57	41.93	38.27	34.78	63.88	47.26
Rampur Composite	22.22	31.58	10.71	22.58	21.02	36.96	6.95	22.00
Rampur Yellow	7.40	13.15	14.28	11.82	10.24	9.34	14.79	11.72
Arun	22.22	10.53	3.57	11.82	16.98	8.47	1.12	6.91
Khumal Yellow*	3.70	2.63	na	2.15	10.78	1.74	0.00	2.60
Local**	0.00	2.63	7.14	3.22	0.00	1.74	5.38	2.93
Total	100.00	102.62	100.00	101.00	100.00	100.00	100.00	100.00

*According to the experts, the variety Khumal Yellow is recommended for hilly environment and can be grown in the Terai region during winter season, however three famers have replied that they had cultivated the variety in spring season. **Generally in survey area if farmers saved seed of improved varieties then in next generation they call it also as a local variety.

The other public sector OPVs, namely Rampur Composite, Rampur Yellow and Arun, are also highly popular among farmers, altogether covering 41% of maize acreage. Adoption of private hybrids is limited during the spring season, even as their grain yield is much higher than that of the OPVs and local varieties (Table 19b). The output from the low-yielding OPVs, however, is used mainly for home consumption; their output share marketed is less than 50%, with the exception of Rampur Yellow (for hybrid maize, this figure ranges from 55 to 80%). Overall market price received by the maize farmers of study area is estimated at NRs. 1429/quintal, and, as in the case of Rabi maize, small-scale farmers are getting lower price for their produce.

Table 19b. Varietal adoption in spring maize: Yield, grain marketed and price.

Variety	Yield (qtl/acre) obtained by				% of grain marketed by				Price (NRs./qt) obtained by			
	Small	**Medium**	**Large**	**Overall**	**Small**	**Medium**	**Large**	**Overall**	**Small**	**Medium**	**Large**	**Overall**
GK	na	11.97	na	11.97	na	80.00	na	80.00	na	1500.00	na	1500.00
		(0.00)		(0.00)		(0.00)		(0.00)		(0.00)		(0.00)
Bioseed	na	11.97	na	11.97	na	80.00	na	80.00	na	1400.00	na	1400.00
		(0.00)		(0.00)		(0.00)		(0.00)		(0.00)		(0.00)
Rajkumar	11.97	na	18.55	16.36	50.00	Na	57.50	55.00	1400.00	na	1250.00	1300.00
	(0.00)		(0.59)	(2.22)	(0.00)		(32.50)	(18.93)	(0.00)		(150.00)	(100.00)
Pioneer	na	11.97	11.97	11.97	na	50.00	100.00	75.00	na	1400.00	1500.00	1450.00
		(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(25.00)		(0.00)	(0.00)	(50.00)
Rampur	5.53	7.11	9.28	7.48	15.00	46.92	60.67	43.94	1350.00	1480.00	1404.00	1431.00
Local	(0.84)	(0.77)	(2.12)	(0.90)	(10.67)	(10.15)	(9.33)	(6.38)	(50.00)	(66.33)	(17.90)	(29.77)
Rampur	9.78	7.39	8.38	8.22	32.50	50.00	41.67	43.81	1225.00	1467.00	1400.00	1405.00
Composite	(1.09)	(0.88)	(2.49)	(0.69)	(10.31)	(5.37)	(8.33)	(4.54)	(25.00)	(49.75)	(57.74)	(39.35)
Rampur	6.58	10.77	5.45	6.98	45.00	52.00	75.00	59.09	1550.00	1420.00	1475.00	1464.00
Yellow	(2.39)	(1.85)	(1.69)	(0.83)	(5.00)	(16.55)	(9.57)	(8.68)	(250.00)	(58.31)	(25.00)	(45.27)
Arun	8.58	6.31	11.97	8.06	25.00	37.50	60.00	32.73	1467.00	1467.00	1400.00	1457.00
	(0.84)	(1.11)	(0.00)	(0.77)	(11.18)	(12.50)	(0.00)	(7.87)	(66.67)	(88.19)	(0.00)	(42.86)
Khumal	1.19	14.96	na	8.08	0.00	0.00	na	0.00	na	na	na	na
Yellow	(0.00)	(0.00)		(6.88)								
Local	na	5.99	5.38	5.59	na	100.00	30.00	53.33	na	1400.00	1550.00	1500.00
		(0.00)	(0.60)	(0.40)		(0.00)	(10.00)	(24.04)		(0.00)	(50.00)	(57.73)
Total	7.31	7.82	8.92	8.04	22.50	49.49	61.03	45.54	1375.00	1459.00	1417.00	1429.00
	(0.64)	(0.48)	(1.29)	(0.48)	(5.61)	(4.85)	(5.98)	(3.51)	(50.94)	(27.72)	(19.00)	(17.39)

Note: Figures in parentheses indicate standard error, na refers non-applicability. The inter-group comparison was not carried out due to small number of observation in most of the cells. However, the difference across groups for average varietal yield is not statistically significant at 0.10 level. There is a strong association of scale of operation with percentage grain marketed ($p < 0.01$) and the market price obtained ($p = 0.09$).1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

Details on cultivation practices followed for Rabi and spring maize in the study area are presented in Table 20 and input use in Table 21. Rabi season starts by November and ends in April. Spring maize is grown between February and June. Manual broadcasting is popularly followed in both seasons, with no seed treatment (Table 20). The seed rate is low in Rabi season (15 kg/acre), compared to spring (26kg/acre) (Table 21), possibly due to intercropping, higher soil moisture (which ensures higher seed germination) and greater adoption of hybrid seeds during the formal season. All the sample farmers are growing maize in thoroughly tilled land, with an average of 3-4 tills in both the seasons. There is a significant difference in cost of machine use for tillage across farmer groups in both Rabi and summer seasons. Small-scale farmers incur 163% (75%) above that of large-scale farmers on machine labour, during the Rabi (spring) season, mainly due to their need of hiring in machines rather than having and using their own machines. Regarding soil nutrient consumption, which is associated with a significantly high adoption rate of hybrid seeds and assured irrigation, Rabi maize is expected to have a higher uptake of fertilizer than spring maize. However, this insight is found true only in the case of nitrogen and non-NPK fertilizers. About 48 kg (25 kg) of nitrogen is applied per acre of Rabi (spring) maize, 54 kg of non-NPK fertilizers are applied in Rabi, and none for spring maize production. Phosphorus is used almost equally across the seasons (about 28-kg/acre), while spring maize consumes more potash (54 kg, against 39 kg in Rabi).

Table 20. Cultivation practices in maize production

	Rabi Season					Spring Season				
	Farmer group				p-value	Farmer group				p-value
	Small	**Medium**	**Large**	**Overall**		**Small**	**Medium**	**Large**	**Overall**	
Average number of tillage operations	3.63(0.18)	3.55(0.41)	3.79(0.35)	3.67(0.21)	0.67[a]	2.57(0.15)	2.61(0.15)	3.38(0.34)	2.86(0.14)	0.43[a]
Farmer following no-till	0.00	0.00	0.00	0.00	na	0.00	9.09	0.00	3.04	na
Farmers following seeding as (%):										
Manual broadcast	100.00	100.00	100.00	100.00	na	100.00	95.23	100.00	98.41	0.96[b]
Seed drill	0.00	0.00	0.00	0.00	na	0.00	4.76	0.00	1.59	na
Seed treatment (% of farmers)	0.00	0.00	0.00	0.00	na	0.00	0.00	0.00	0.00	na
Median date of sowing	21Nov	20 Nov	15 Nov	20 Nov		1 Mar	18 Feb	20 Feb	21 Feb	
Mode date(s) of sowing	12 Nov			1Nov		20 Feb	12 Feb	15 Feb	15 Feb; 20 Feb	
Farmer sowing on mode date(%)	25.00			9.09		14.28	9.52	14.28	12.70	
Median date(s) of harvesting	14 Apr	20 Apr	25 Apr	22 Apr		5 Jun	6 Jun	1 Jun	3 Jun	
Mode date of harvesting	27 Apr	20 Apr	1 May	20 Apr; 28 Apr; 1 May		15 Jun	10 Jun	1 Jun; 3 Jun	1 Jun	
Farmers harvesting on mode date(%)	25.00	18.18	21.42	9.09		16.67	10.00	14.29	8.47	
Mode of harvesting (% of farmers)										
Manual	100.00	100.00	100.00	100.00	na	100.00	100.00	100.00	100.00	na
Machine	0.00	0.00	0.00	0.00	na	0.00	0.00	0.00	0.00	na

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom; [b] shows p-value derived from chi-square test with trend; na refers to non-applicability.

Table 21. Input use in maize cultivation.

	Rabi Season					Spring Season				
	Farmer group				p-value	Farmer group				p-value
	Small	Medium	Large	Overall		Small	Medium	Large	Overall	
Seed rate (kg/acre)	14.21	14.69	14.45	14.47	0.85[a]	22.89	27.08	27.36	25.77	0.83[a]
	(3.14)	(2.57)	(3.00)	(1.66)		(2.46)	(4.40)	(4.30)	(2.19)	
FYM and other manure use (qtl/acre)	7.91	23.00	16.76	16.22	0.00[a]	22.21	22.92	23.81	22.99	0.78[a]
	(1.00)	(0.09)	(2.32	1.95		(2.65)	(3.47)	(5.74)	(2.38)	
Nitrogen	0.27	0.46	0.58	0.48	0.00[a]	0.23	0.27	0.27	0.25	0.98[a]
	(0.03)	(0.09)	(0.07)	(0.04)		(0.03)	(0.08)	(0.07)	(0.04)	
Phosphorus	0.13	0.29	0.34	0.28	0.00[a]	0.19	0.47	0.20	0.29	na
	(0.01)	(0.04)	(0.06)	(0.03)		(0.05)	(0.11)	(0.08)	(0.05)	
Potash	0.10	0.37	0.34	0.39	0.02[a]	0.54	0.48	0.60	0.54	na
	(0.05)	(0.14)	(0.08)	(0.05)		(0.10)	(0.12)	(0.12)	(0.06)	
Other	na	0.48	0.34	0.40	na	na	na	na	na	na
		(0.16)	(0.09)	(0.08)						
Herbicide (litre/acre)	na	0.59	1.05	0.96	na	na	na	na	na	na
		(0.00)	(0.84)	(0.66)						
Fungicides (litre/acre)	0.12	0.24	0.87	0.57	na	0.12	0.30	na	0.21	na
	(0.00)	(0.06)	(0.40)	(0.24)		(0.00)	(0.00)		(0.09)	
Human labour use (work-days/acre)	38.19	42.80	35.58	36.19	0.82[a]	42.12	27.04	30.70	33.29	0.00[a]
	(4.28)	(6.96)	(3.89)	(3.28)		(3.71)	(3.29)	(3.72)	(2.19)	
% of hired labour to total labour	50.41	39.03	60.67	53.96	0.39[b]	53.59	65.49	66.29	61.71	0.25[b]
% of female labour to total labour	49.42	39.03	37.79	40.76	0.31[b]	47.58	54.85	52.71	51.16	0.64[b]
Animal labour use (NRs./acre)	na	na	na	na	na	153.90	42.49	281.05	175.69	na
						(0.00)	(18.98)	(207.00)	(104.75)	
Machine labour use (NRs./acre)	517.28	382.43	195.76	297.91	0.00[a]	398.20	239.18	227.25	288.21	0.00[a]
	(89.27)	(62.41)	(46.03)	(36.71)		(51.16)	(34.16)	(64.62)	(30.94)	

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom; [b]shows p-value derived from chi-square test with trend; na refers non-applicability.1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.29

Across the farmers groups, fertilizer and manure use rates are the highest for large farmers during Rabi season. The requirement of human labour is observed slightly higher for Rabi (36 labour days), as compared to the spring maize (33 labour days). All sample farmers are opted harvesting the crop manually.

The cost-return structure of maize production (Table 22) clearly shows that the two most important categories of inputs (manures and fertilizers, and labour) account for 74% (87%) of cultivation cost in Rabi (spring) seasons. In the case of Rabi maize, seed is also a major cost component (22% of total paid-out cost), due to high adoption of hybrid seeds. Average labour required to cultivate an acre is around 33-36 days, making up one-fourth of the total paid-out cost for Rabi and 45% for spring maize. When all the labour components (including family labour) are valued at the market wage rates, the cost of production often exceeds the gross revenue. On average, a maize farmer loses about NRs. 2287 per acre for Rabi and NRs. 4113 for spring maize cultivation. However, small farmers make a profit by lowering the cost of maize production, especially by cutting down the cost of chemical fertilizers. If only paid-out costs are accounted for, the farmer spends NRs.1516 for producing one quintal of maize during Rabi season, for which he fetches only NRs. 1299 as grain price. Maize crop residues are rarely marketed. The situation is similar in the case of spring maize, making maize one of the least sustainable crops of the study area from a financial point of view. Technological interventions, that not only increase productivity but also save nutrients and labour, are urgently required to make Terai maize sustainable. Despite the fact that maize registers a higher rate of growth in Nepal, this crop should receive a priority treatment in agricultural research and development over rice and wheat being a financial inferior alternative for the farmer.

Table 22. Economics of maize cultivation

Cost component (NRs/acre)	Farmer group (Rabi)					Farmer group (Spring)				
	Small	**Medium**	**Large**	**Overall**	**p-value**	**Small**	**Medium**	**Large**	**Overall**	**p-value**
Seed	1245.68	2209.01	3569.62	2552.69	0.00[a]	894.46	1436.69	1087.56	1143.52	0.60[a]
	(239.26)	(556.99)	(496.99)	(325.28)		(124.89)	(337.29)	(321.35)	(162.76)	
FYM and other manures	1961.69	2484.32	1581.75	1974.78	0.52[a]	4099.73	4121.81	3358.72	3856.22	0.57[a]
	(380.23)	(681.81)	(467.74)	(313.86)		(981.68)	(613.79)	(610.79)	(426.82)	
Chemical fertilizer	2316.94	3013.17	4664.97	3545.15	0.07[a]	842.69	502.74	715.35	684.41	0.68[a]
	(141.86)	(706.62)	(1448.61)	(667.65)		(251.47)	(154.87)	(217.92)	(120.88)	
Herbicides	0.00	27.20	83.15	44.34	na	0.00	0.00	0.00	0.00	na
	(0.00)	(27.20)	(64.29)	(28.76)		(0.00)	(0.00)	(0.00)	(0.00)	
Fungicides and insecticides	65.46	39.45	209.48	117.89	0.22[a]	0.00	0.43	0.00	0.14	na
	(27.95)	(20.79)	(118.06)	(51.81)		(0.00)	(0.43)	(0.00)	(0.14)	
Animal labour cost	0.00	0.00	0.00	0.00	na	7.69	10.36	53.53	24.12	0.42[a]
	(0.00)	(0.00)	(0.00)	(0.00)		(7.69)	(6.29)	(42.82)	(14.87)	
Machine custom hiring cost	517.28	347.57	208.62	329.76	0.00[a]	416.99	232.05	242.56	295.27	0.00[a]
	(89.27)	(66.26)	(44.22)	(41.00)		(49.66)	(33.36)	(62.56)	(30.37)	
Hired labour cost	3756.39	2347.82	3056.80	2990.07	0.13[a]	5341.56	4806.27	4508.67	4878.15	0.42[a]
	(583.29)	(605.22)	(317.60)	(287.03)		(637.77)	(449.89)	(470.69)	(299.79)	
Total paid out cost	9863.65	10468.54	13374.39	11554.69	0.21[a]	11603.12	11110.34	9966.39	10881.84	0.44[a]
	(932.56)	(1598.99)	(1906.42)	(995.89)		(909.08)	(796.20)	(858.39)	(492.89)	
Total Paid out cost +family labour cost	13966.59	15042.58	15493.19	14972.90	0.75[a]	16625.67	14244.48	13164.35	14646.76	0.05[a]
	(617.24)	(1593.37)	(1906.23)	(960.33)		(882.23)	(871.28)	(997.64)	(553.94)	
Gross revenue	15426.65	10038.61	13199.58	12685.81	0.16[a]	9576.53	10763.18	11215.55	10533..61	0.77[a]
	(2185.58)	(1191.03)	(1987.77)	(1102.49)		(1022.69)	(1032.23)	(1316.36)	(650.82)	
Net revenue (excluding family labour)	5562.99	-429.49	-174.82	1131.13	0.15[a]	-2026.59	-347.16	1249.15	-348.22	0.55[a]
	(2546.06)	(1941.93)	(2244.25)	(1342.18)		(1588.55)	(1472.78)	(1605.75)	(899.91)	
Net revenue (including family labour)	1460.06	-5003.98	-2293.61	-2287.09	0.15[a]	-7049.14	-3481.30	-1948.90	-4113.15	0.12[a]
	(2248.56)	(1795.99)	(2199.76)	(1273.33)		(1482.25)	(1510.28)	(1547.39)	(902.09)	
Market price (NRs/quintal)	1507.72	1206.88	1252.43	1299.15	0.99[a]	1430.02	1726.42	1490.61	1552.92	0.52[a]
	(364.60)	(54.64)	(36.38)	(86.64)		(32.22)	(305.91)	(97.56)	(110.46)	
Cost of production (NRs/quintal)	929.62	1388.36	1951.22	1515.94	0.52[a]	2924.34	1924.42	1701.57	2171.49	0.77[a]
	(159.05)	(271.76)	(573.37)	(266.42)		(796.26)	(330.60)	(243.49)	(294.94)	
Return to labour (NRs/day)*	876.21	-5.87	-186.01	135.46	0.37[a]	-199.99	-44.10	39.32	-66.13	0.55[a]
	(409.22)	(95.49)	(1772.46)	(746.32)		(142.83)	(137.05)	(168.72)	(86.35)	

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom; na refers to non-applicability, *calculated using net revenue excluding family labour/number of family labour days. This could be compared against the existing wage rate of hired human labour (NRs 173/day). 1 US$ = NRs. 84.14 (in May 2012); 1 acre = 0.405 ha; 1 quintal = 0.1 ton.

Table 23. Livestock productivity

	Cattle (local)				p-value	Cattle (crossbred)				p-value	Buffalo				p-value
	Small	**Medium**	**Large**	**Overall**		**Small**	**Medium**	**Large**	**Overall**		**Small**	**Medium**	**Large**	**Ov'll**	
Age at first calving (month)	34.85	34.33	36.00	35.20	0.57[a]	33.57	34.44	35.40	34.58	0.59[a]	38.41	39.53	41.02	39.79	0.03[a]
	(0.86)	(2.79)	(1.09)	(1.07)		(3.77)	(3.14)	(0.85)	(1.46)		(1.23)	(0.98)	(0.79)	(0.57)	
Maximum milk yield (liters) per day	3.71	3.50	3.97	3.75	0.25[a]	6.71	7.06	6.60	6.80	0.92[a]	6.08	7.67	7.55	7.05	0.04[a]
	(0.64)	(0.68)	(0.35)	(0.31)		(0.80)	(0.60)	(0.28)	(0.29)		(0.28)	(0.54)	(0.80)	(0.31)	
Lactation length (month)	8.29	6.17	6.72	6.48	0.02[a]	7.86	8.00	9.82	8.76	018[a]	9.08	10.70	9.32	9.69	0.21[a]
	(0.75)	(0.89)	(0.53)	(0.42)		(1.12)	(0.79)	(0.83)	(0.54)		(0.23)	(2.13)	(0.34)	(0.68)	
Inter-calving period (months)	12.43	14.83	11.93	13.02	0.10[a]	12.86	12.33	13.00	12.74	0.33[a]	13.28	15.55	14.85	14.76	0.01[a]
	(0.43)	(2.00)	(0.39)	(0.73)		(0.59)	(0.68)	(0.47)	(0.32)		(0.38)	(0.59)	(0.55)	(0.32)	
Total calves (number)	0.03	0.05	0.06	0.05	0.45[a]	0.06	0.03	0.07	0.05	0.45[a]	0.09	0.08	0.11	0.09	0.68[a]
	(0.02)	(0.02)	(0.02)	(0.01)		(0.02)	(0.02)	(0.02)	(0.01)		(0.03)	(0.03)	(0.03)	(0.02)	
Average annual milk yields (liters)	1173.21	1186.25	1216.67	1197.00	0.92[a]	1877.14	2502.86	2754.09	2438.20	0.12[a]	1858.62	2129.87	2074.09	2038.75	0.18[a]
	(194.52)	(162.67)	(140.99)	(90.90)		(231.24)	(312.86)	(349.28)	(196.24)		(98.52)	(92.55)	(94.94)	(55.71)	
Replacement rate (%)*	6.59	5.70	5.02	5.68	0.46[a]	4.96	5.04	5.34	5.14	0.61[a]	5.71	5.18	5.42	5.27	0.46[a]
	(0.80)	(0.89)	(0.46)	(0.44)		(0.82)	(0.53)	(0.48)	(0.34)		(0.89)	(0.26)	(0.28)	(0.16)	

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom,*replacement rate is calculated as [1/(expected life- age at first calving)]*100.

6 Livestock production

Livestock rearing is an integral part of the farming systems of South Asia. In Nepal, it provides 23%of the agrarian GDP and remains as a substantial income source for rural poor. Nepalese farming takes place predominantly in a mixed crop-livestock system, in which livestock play an important source of food, power (draft), fuel (dung for cooking) and manure for crop cultivation, and as a hedge against production and price shocks from crop production. In the study area, two out of three households have large ruminants and about the same percentage of households keep small ruminants in their herd (cf. Table 3). In total household income, percentage share of livestock is only about 6% (Table 9), but the sector's indirect contribution to rural livelihoods and crop production is highly significant. Due to its potential and relevance, the feed and productivity aspects of livestock in the sample farms are elicited, and the results are provided in Tables 23-26.

Livestock productivity, regarding dairy animals, depends upon a number of factors, viz. age of animal at the first calving, average milk yield per day, length of lactation period and the calving interval. Age of the first calving or beginning of productive life of the animal is found to be about 35 months for local as well as cross breed cow, and 40 months for buffalo (Table 23). Maximum milk yield per day is highest for buffalos and crossbreed cattle (about 7 liters/day), against the local cattle (4 liters/day). Although similar to crossbred cows in maximum milk yield per day, the average figures show that the annual milk yield from buffalos is relatively lower than the crossbred cows, but much higher than that from the local cattle. The total milk yield of a local cow is 50% lower than that of a crossbred. Crossbred and local cows have lower dry period, due to short inter-calving periods (13 months), in comparison with buffalo (15 months). Replacement rate, which is an important factor for maintaining the productivity of herd, is slightly lower for crossbred cows (5.1%), in comparison with buffalos (5.3%) and local cows (5.7%).

The study further analyses the feeding pattern of dairy animals, as it has a significant role not only in milk production, but also the adoption of cropping practices involving residue utilization or mulching (Table 24).

Table 24. Average contribution of feeds to dairy animal ration

% dry matter	Farmer group				p-value
	Small	Medium	Large	Overall	
Wheat straw	16.27(2.63)	14.19(2.44)	23.96(2.50)	18.58(1.49)	0.00[a]
Rice straw	39.65(2.29)	40.23(2.08)	41.02(1.85)	40.35(1.18)	0.93[a]
Maize straw	1.05(0.63)	0.68(0.49)	0.98(0.49)	0.90(0.31)	0.79[a]
Green fodder crops	1.80(0.74)	1.55(0.56)	1.06(0.46)	1.43(0.33)	0.52[a]
Green grass collected	27.42(2.74)	25.40(1.37)	19.86(1.36)	23.82(1.06)	0.01[a]
Concentrates	13.46(1.82)	17.36(2.04)	12.78(1.67)	14.47(1.07)	0.12[a]

Notes: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom

Total nutrient availability for livestock production depends on the total dry matter intake, and also its source. Rice straw is the main source of the dry matter in animal rations in the surveyed farms, followed by collected green grass, wheat straw and concentrate. The Terai region is an exception in the Indo-Gangetic Plain, where both rice and wheat straw are used for livestock feeding (in western IGP only wheat straw is used as fodder, whereas in eastern IGP only rice straw). Wheat straw is used mainly on the large farms but, on average, its contribution in terms of total dry matter is only 50% of that of rice straw. Contribution in total dry matter intake from fodder crops and maize stover is insignificant. Around 40% of the dry matter is being covered by rice residues, while 24% is gained from the collected green grasses. Small farmers are mainly involved in gathering of green grass for livestock feeding.

Tables 25 and 26 depict the uses of milk with market price and milk marketing channels, respectively. Total milk produced per household per day is estimated as 6.6 litres. About 31% of the daily milk production is used for household consumption, and 44% is sold without processing. The rest (24 %) is processed for household consumption or sale. The market price of unprocessed milk is NRs. 30/litre, which is traded through formal established milk market or through informal channels. About 75% of the milk producing households sell their product through the formal milk market, like dairy co-operatives, with one-fifth of households trading with informal buyers. Only 6% are selling directly to the consumers (Table 26).

Table 25. Value of milk sales and consumption

	Farmer group				
	Small	**Medium**	**Large**	**Overall**	**p-value**
Milk price (NRs/litre)	30.69(0.81)	30.51(0.62)	30.07(0.92)	30.41(0.45)	0.93[a]
Milk sold (litre/day)	2.64(0.31)	3.56(0.39)	2.59(0.38)	2.93(0.22)	0.02[a]
Milk consumed (litre/day)	1.84(0.17)	2.21(0.31)	2.11(0.14)	2.07(0.13)	0.30[a]
Milk processed for consumption (litre/day)	1.12(0.26)	0.92(0.21)	1.29(0.16)	1.12(0.12)	0.22[a]
Milk processed for sale (litre/day)	na	0.79(0.50)	0.61(0.29)	0.51(0.26)	na
Total unit	5.60(0.27)	7.48(0.63)	6.60(0.41)	6.63(0.28)	0.29[a]

Note: Figures in parenthesis indicate the standard error of sample mean; [a]shows p values derived from Kruskal-Wallis equality of population rank test with 2 degrees of freedom. 1 US$ = NRs. 84.14 (in May 2012).

Table 26. Milk markets

Main outlet	% of households				**p-value**
	Small	**Medium**	**Large**	**Overall**	
Formal	69.23	64.29	82.52	74.75	0.09[b]
Informal	15.38	25.00	17.48	19.19	0.83[b]
Consumer	15.38	10.71	0.00	6.06	na

Note: [b] shows p-values derived for chi-square test with linear trend;na refers to non-applicability.

7 Farmer perceptions on and farm adoption of conservation agriculture technologies

Conservation agriculture (CA) is a relatively novel concept in the field of agricultural research and development that emphasizes minimum soil disturbance, crop residue retention, and crop diversification, thereby addressing the environmental externalities of crop production; it also sustains or increases crop productivity while reducing the cost of cultivation. The individual technologies are aimed at minimizing or avoiding soil-damaging effects of conventional tillage-based crop production in the tropical zones (FAO, 2001a). There are a few CA-based resource conserving technologies that have been initiated and promoted in the Terai region of Nepal, which includes direct seeded rice (DSR) and zero-or reduced-tillage wheat. Since the time of introduction, these technologies are slowly but steadily gaining popularity among farmers due to the multiple production advantages over conventional practices. CA has the potential to save both time/labour and cost of cultivation, making agricultural activities and production more economical and sustainable. Adoption of CA-based technologies could potentially ensure environment-friendly production practices and conserve the natural resource base (soil, water, bio-diversity, soil organisms etc.). Since farmer dependability on external inputs can be reduced, the cost of production becomes lower and farming becomes financially appealing. However, the awareness of farmers on different CA techniques is rather limited in many parts of the study area. In this section, the current adoption of different conventional technologies, familiarity toward CA and related technologies, sources of information, and perceived impacts are examined among the sampled farmers.

7.1 Conventional cereal production technology adoption in the study area

An examination of cultural practices indicated that the average number of tillage passes for rice, wheat, and maize is more than three; and only a small percentage of farmers are found to be adopting zero tillage (Table 27). Farmers use 2-wheel or 4-wheel tractors (with cultivator and disc harrow) for ploughing operations. Farmer adoption of conventional production technologies and machineries in study area is given in Table 28. The most popular technologies are diesel pumps for irrigation (51% adoption), 4-wheel tractors (98%), tine cultivator (98%), power thresher (86%), knap-sack sprayer (56%) and disc harrow (49%). Many technologies popular in other parts of the IGP, like the rotavator, combine harvester, seed drill, etc., are adopted only by a marginal share of households. Adoption of the disc harrow, power thresher, and fodder chopper are positively associated with the size of the land cultivated, while 2-wheel tractor is more popular amongst the small-scale farmers. Hiring of the agricultural machineries is common among farmers. For example, about 3% of the sample farmers (mostly large) possess 4-wheel tractors, and 2% do not use them in cereal cultivation, while the rest (95%) of the households hire them for the farming operations. Across the farmer groups, unsurprisingly, it is the large farmers who own most of the machineries.

Table 27.Technology adoption in cereal production.

Technology	% farmer adoption				p-value	% of ownership of equipment				p-value
	Small	Medium	Large	Overall		Small	Medium	Large	Overall	
1. Submergible Pump	3.67	8.49	9.17	7.10	0.11[b]	0.92	4.72	3.67	3.09	na
2. Diesel Pump	52.29	45.28	55.05	50.62	0.68[b]	11.92	15.09	30.28	19.14	0.00[b]
3. Diesel generator	6.42	2.83	0.00	3.09	na	0.00	0.00	0.00	0.00	na
4.4-Wheel tractor	98.17	100.00	96.33	98.14	na	0.00	1.89	8.26	3.40	na
5. 2-Wheel tractor	25.69	18.87	15.60	20.37	0.06[b]	0.00	0.00	1.83	0.62	na
6. Tine cultivator	98.17	100.00	96.33	98.15	na	0.00	0.94	2.75	1.23	na
7. Disc harrow	39.45	56.60	52.29	49.38	0.06[b]	0.00	0.94	2.75	1.23	na
8. Rotavator	0.92	3.77	4.59	3.09	na	0.00	0.00	0.92	0.31	na
9. Seed drill	8.26	10.38	9.17	9.26	0.81[b]	0.00	0.00	0.92	0.31	na
10. Mechanical sprayer	0.92	0.00	0.92	0.62	na	0.92	0.00	0.92	0.62	na
11. Knapsack sprayer	57.80	47.17	62.39	55.86	0.49[b]	8.26	16.04	17.43	13.89	0.05[b]
12. Power Thresher	79.82	89.62	89.91	86.42	0.03[b]	0.00	0.00	3.67	1.23	na
13.Maize dehusker	13.76	18.87	19.27	17.28	0.28[b]	0.00	0.00	0.00	0.00	na
14. Combine harvestor	0.00	3.77	3.67	2.47	na	0.00	0.00	0.00	0.00	na
15. Fodder Chopper	18.35	27.36	48.62	31.48	0.00[b]	6.42	14.15	31.19	17.28	0.00[b]

Note: [b]shows p-value derived from chi-square test with trend; na indicates non-applicability.

Table 28. Familiarity and adoption of CA and related technologies

Technology	Familiarity (% farmers)			% adoption			
	Heard	Seen	Adopted	Small	Medium	Large	Overall
1. Laser land leveler	0.31	0.00	0.00	0.00	0.00	0.00	0.00
2. Bed planting	1.23	34.57	23.15	24.77	16.04	28.44	23.15
3. Zero tillage (no till)	20.06	34.57	9.57	6.42	5.66	16.51	9.57
4. Rotavator	6.79	18.21	3.70	1.83	3.77	5.50	3.70
5. DSR	19.75	25.30	20.37	20.18	18.87	22.02	20.37
6. Double no till	0.31	0.00	0.00	0.00	0.00	0.00	0.00
7.Hybrid rice	26.23	24.38	32.72	33.03	26.42	38.53	32.72
8.Hybrid maize	23.46	34.26	18.83	13.76	15.09	27.52	18.83
9.QPM	11.42	1.54	0.31	0.00	0.94	0.00	0.31
10.Seed treatment/priming	14.20	7.10	40.12	39.45	33.02	47.71	40.12
11. SSNM	0.92	0.00	1.23	1.83	0.94	0.92	1.23
12. Relay cropping	1.85	8.33	33.64	33.94	27.36	39.44	33.64

The inter-group comparison was not carried out due to small number of observation in most of the cells.

7.2 Familiarity and adoption of CA and related RCTs

An innovation is an idea, practice, or object perceived as novel by an individual, which may be or may not be a result of recent research (Van Den Ban and Hawkins, 1996). Adoption is the degree to which the innovation is used in long run equilibrium when farmers have complete information about the technology and its potential. It is the mental process through which an individual passes from the first stage of awareness or knowledge of an innovation to a final decision to adopt or reject and to conformation of this decision (Rogers & Shoemaker, 1971; Dasgupta, 1989). The rate of adoption is the relative speed with which an innovation is adopted by members of a social system.

It is usually measured by the length of time required for a certain percentage of the members of a social system to adopt an innovation. The rate of adoption depends upon several factors such as personal, social, cultural and economic factors. Personal factors include age, education, motivation, attitudes, beliefs, and needs of clients. Social factors include social structure, community or group participation, and contact with extension worker and so on. Economic factors include tenure status, family size, farm size, resource availability, price of input and product etc., while cultural factors include norms, local tradition and religion (Lionberger, 1960).

The study further examines the awareness and adoption status of various RCTs, and the associated innovations in the study area, across farmer groups. Products of hybridization (hybrid rice and hybrid maize) are found to be the most popular technologies in the study area, as more than 75% of the respondent households are familiar with (at least heard or seen, if not adopted) them. About 33% (19%) have adopted hybrid rice (maize) on their farm. Laser land levelling, double no-till, and site-specific nutrient management (SSNM) are the least familiar technologies (<2% households) in the study area. Seed treatment is adopted by a fairly large number of respondents, as more than 40% of farmers reported they had adopted the technology sometime in their own field. However, as observed in Tables 11, 13 and 20, most of the farmers do not follow priming for rice, wheat or maize, grown in their main plots during the study year, indicating a significant dis-adoption of the technology. Following seed treatment, relay cropping, bed planting and DSR are found to be moderately familiar and adopted technologies. Rotavators, a shallow-tillage technique adopted by a significant share of the NW IGP farmers, is found to be less prevalent in the study region. Quality protein maize (QPM) is also moderately familiar for farmers (13%), although the adoption is negligible (only one out of 324 sample farmers ever cultivated the variety). Among the farmer groups, the percentage share adopting these technologies is found to be highest among the large farmers. However, the relation between adoption and scale of operation is not necessarily linear, as in many instances, the rate of adoption is lower with medium-scale farmers than in the small farmer.

7.3 Sources of information on CA

Sources of information, and their perceived reliability, play a crucial role in diffusion of improved practices. The relationship between extension contact and level of adoption of improved farm practices was studied widely in the literature. Most of the farmers sampled obtain information on CA-based RCTs through other progressive farmers in the village, which is also the case in other parts of South Asia (Mittal et al., 2010). Information on production technologies, like ZT wheat, rotavators, new varieties etc., is obtained from this informal source for half of the farmers familiar with these technologies (Table 29). The Cereal Systems Initiative for South Asia (CSISA) project is one source of information for technologies like bed planting, ZT, DSR, and QPM for some of the farmers. Government extension workers are cited as one of the major sources of information on ZT wheat, rotavators, hybrid rice and bed planting. Regarding hybrid rice and hybrid maize, private dealers are the major source. Mass media also contributes to the diffusion of information on some of these technologies, especially QPM.

Table 29. Source of information on CA technologies.

CA technologies	No.	Source of information (% of farmers who are familiar with the technology)									
		CSISA	Gov. extens	Coop	NGO	Private dealers	Exhibition & Melas	Mass media	Other farmers	Relatives	Others
1. Laser land leveler	2							100.0			
2. Bed Planting	98	1.02	3.06					1.02	15.31	5.1	74.49
3. Zero tillage	208	5.77	12.5	0.48	0.48		2.4	4.33	62.5	11.54	
4. Rotavator	93	1.08	9.68			1.08	3.22	2.15	58.06	22.58	
5. DSR	212	3.30	2.36				0.94	5.19	45.28	14.62	28.3
6. Double no-till	1									100.00	
7. Hybrid Rice	270		3.70	0.74	0.37	27.41	0.37	2.59	56.67	7.78	0.37
8. Hybrid Maize	248		2.82	0.40	0.4	23.39		4.44	50.81	16.53	1.21
9. QPM	43	2.32	2.32		2.32			16.28	62.79	11.63	2.32
10. Seed treatment	197	0.51	1.01		0.51	1.01	0.51	4.57	25.38	11.68	54.82
11. SSNM	7				100.0						
12. Reply cropping	141	0.71	2.13					2.13	24.11	27.65	43.26

The study also sought information on contact frequency of farmers with the main source of information, other than informal sources (e.g., other farmers)(Table 30). For ease of analysis, the average frequency of contact is estimated by assigning the value of 3 for weekly contact, 2 for monthly contact, 1 for quarterly contact and 0 for no contact. Overall, contact frequency with the main source is highest for hybrid rice (2.38, indicating mostly weekly contacts; and the major source is private dealers) followed by ZT (2.01; government extension), hybrid maize (1.90; private dealers), and rotavator (1.62; government extension). Amongst the farmer groups, for four technologies (namely rotavator, DSR, seed treatment and relay cropping) the calculated values for contact frequency are the maximum for large farmers.

Table 30. Contact frequency with the major source of information on CA technologies.

	Contact frequency with main source			
	Small	Medium	Large	Overall
1. Laser land leveler	na	na	na	na
2. Bed Planting	1.00	0.00	0.00	0.67
3. Zero tillage (no till)	2.14	2.71	2.16	2.01
4. Rotavator	1.67	1.50	1.67	1.62
5. DSR	0.00	1.50	2.00	1.58
6. Double no till	na	na	na	na
7. Hybrid Rice	2.66	2.21	2.29	2.38
8. Hybrid Maize	2.14	1.87	1.23	1.90
9. QPM	1.50	1.00	na	1.00
10. Seed treatment/ priming	1.50	1.00	2.33	1.58
11. SSNM	0.00	0.00	na	0.00
12. Reply cropping	0.00	0.00	1.33	0.80

Note: Average values are calculated by assigning 3 for weekly contact, 2 for monthly contact, 1 for quarterly contact and 0 for no contact; na refers to non-applicability

For technologies like hybrid rice and maize, the frequency of contact is highest for the small farmer group. No relation on scale of operation and contact frequency is observed for ZT technology. The low number of observations for many technologies prevents running statistical tests of significance across farmer groups.

7.4 Perceived impacts of CA-technology

One of the most noticeable changes for the farmer by introducing CA is the reduced requirement for farm power and labour. The cost of cultivation is expected to be lower, and adoption is expected to have a direct impact on farm profitability. However, due to a multitude of agro-ecological, farming system, and socio-economic factors, all farmers are unlikely to realize the positive impacts of the technology. Information obtained from sources that become the basis for farmer perceptions and adoption may not always be objective and/or complete. In this section, we examine the perceived impact of CA-based RCTs and other related technologies on irrigation, cost, yield and profit. The results, shown in Table 31, clearly indicate that even among the farmers who are familiar with the technology, their awareness on its impacts on irrigation, cost, yield and profitability is largely limited.

Table 31. Perceived impacts of CA technology

CA name	Number	perceived impact (% farmer)	% of farmers familiar with the technology			
			Irrigation	Cost	Yield	Profit
Bed planting	98	positive	2.04	3.06	3.06	4.08
		negative	3.06	2.04	0.00	0.00
		no impact	1.02	1.02	2.04	2.04
		no idea	93.88	93.88	94.90	94.90
Zero tillage	198	positive	2.53	5.56	7.58	4.55
		negative	5.56	11.11	10.10	4.04
		no impact	7.07	2.02	1.52	7.58
		no idea	84.85	80.81	80.30	82.83
Rotavator	88	positive	2.27	3.41	3.41	6.82
		negative	9.09	10.23	4.55	2.27
		no impact	0.00	0.00	5.68	3.41
		no idea	88.64	86.36	86.36	87.50
DSR	206	positive	2.43	2.43	2.43	2.91
		negative	3.40	15.05	16.99	16.02
		no impact	18.93	2.91	2.91	3.88
		no idea	75.24	79.61	77.67	77.18
Hybrid Rice	251	positive	9.16	42.63	46.22	46.22
		negative	1.59	0.80	1.59	1.20
		no impact	38.25	7.97	3.98	3.98
		no idea	51.00	48.61	48.21	48.61
Hybrid Maize	223	positive	13.45	21.08	26.46	25.56
		negative	1.35	2.24	0.90	1.35
		no impact	13.45	6.73	2.69	2.24
		no idea	71.75	69.96	69.96	70.85
QPM	42	positive	2.38	2.38	7.14	7.14
		negative	0.00	0.00	0.00	0.00
		no impact	2.38	4.76	0.00	0.00
		no idea	95.24	92.86	92.86	92.86
Seed treatment	186	positive	2.15	7.53	15.05	16.67
		negative	7.53	7.53	2.69	2.15
		no impact	9.68	9.14	8.06	6.99
		no idea	80.65	75.81	74.19	74.19
Relay cropping	130	positive	7.86	5.71	32.14	40.00
		negative	24.29	35.00	8.57	7.14
		no impact	27.86	25.71	27.14	23.57
		no idea	40.00	32.86	32.14	29.29

Relay cropping is the technology on which the sub-sample (those who have heard of the technology, at least) of farmers indicated the highest impact awareness (30-40% indicated "no idea" against different impacts of this technology). Farmers were largely unaware of the impacts of bed planting (94% unaware), QPM (92-95%), ZT wheat (80-85%) and the use of rotavators (86-89%).

Unless farmer awareness on potential positive impacts of these technologies is increased, diffusion will be extremely challenging for extension workers and projects promoting CA and other appropriate agricultural technologies. For most of the technologies that were directly employed by the respondents, however, the percentage of farmers indicating benefits is greater than those perceiving negative impacts. For example, although 71% of farmers were unaware of the impact of hybrid maize on farm profitability, 26% indicated a positive impact in contrast to only 1% perceiving it as causing loss to the adopting farmer. The only exception is DSR, which, according to 16%of farmers, causes negative impacts on profitability; only 3% reported it to be profit-enhancing in rice farming. However, it should be noted that DSR technology is understood by the sample farmers to be a traditional practice of direct sowing of rice in study area, rather than an improved package of agronomic practices that follow CA principles.

The perceived impact of CA and related technologies in farm profitability across farmer categories is presented in Table 32. A small number of observations in most of the cells prevented statistical testing of differences across categories. However, tests were conducted for hybrid rice, seed treatment, hybrid maize and relay cropping. The former two do not indicate any specific pattern of association of scale of operation and perceived impact of technology on profitability, but hybrid maize has a more positive impact for large famers and relay cropping is fruitful for medium farmers.

Table 32. Perceived impacts of CA on farm profitability across farmer groups.

CA technology	Number of Farmers Familiar				% of farmers familiar with technology and with positive attitudes				p-value
	Small	Medium	Large	Overall	Small	Medium	Large	Overall	
Bed planting	34	23	41	98	5.88	0.00	4.88	4.08	
Zero tillage	63	64	81	208	4.76	3.13	4.94	4.33	
Rotavator	28	31	34	93	7.14	6.45	5.88	6.45	
DSR	69	68	75	212	1.45	2.94	4.00	2.83	
Hybrid rice	93	87	90	270	40.86	37.93	50.00	42.96	0.23[b]
Hybrid maize	80	86	82	248	22.50	15.12	31.71	22.98	0.04[b]
QPM	12	25	0	37	8.33	8.00	0.00	8.11	
Seed treatment	63	65	71	199	11.11	15.38	19.72	15.58	0.39[b]
Relay cropping	46	37	59	142	39.13	59.46	27.12	39.44	0.00[b]

8 Market channels for inputs and outputs

8.1 Seeds

In modern agriculture, seed is an important vehicle to deliver many of the agriculture-based technological innovations to farmers. The timely availability and access to seed of adaptable and high-yielding varieties are determinants of the efficiency and productivity of other production inputs such as irrigation, fertilizers, and pesticides. Availability and accessibility in turn depend upon the locally existing marketing channels. This sub-section examines the marketing channels of seeds and other inputs for cereal production in the Terai region. The results show that private dealers are the main suppliers of rice, wheat, and maize seeds in the study area. In the case of rice, co-operatives also bear a role as seed providers. However, it is mostly medium and large farmers who depend on the co-operatives and public sector sources. There is a distinct pattern of dealer selection among farmers: small farmers depend mostly on dealers within their villages, whereas large farmers depend on dealers outside the village, including those in the district headquarters. For example, similar to rice, the main source of wheat seed is private dealers: approximately 85% of total wheat seed is purchased through this source. With nearly 64% of small farmers, but only 45% of large farmers, depending on village-level seed dealers, there exists a significant difference across the farmer groups with respect to the location of seed market selection. Similarly, about 28% of small farmers only purchase wheat seed from outside of their village, while 36% of large farmers obtain their seed from outside the village. However, as we have observed in the cost of cultivation tables, there are no significant differences across the farmer groups with respect to the cost of seed. On the other hand, there exists a distinct pattern with respect to varietal adoption. Hence, it may be understood that the large farmers depend on the private dealers outside the village, mainly to ensure supply of novel varieties and hybrids.

8.2 Fertilizers and pesticides

Similar to the marketing channels for seed, private dealers form the major sources for both fertilizers and pesticides, while the government, co-operatives, and others (mainly input markets of Indian border) supply a significant share of farmers in the study area. Despite the government's plan and policy to increase chemical fertilizer usage to stimulate higher crop production, only a small amount of this key input is supplied through government outlets. The majority share of fertilizer is being sold by private dealers at the district level, followed by village-level traders, and suppliers in border markets. As in the case of seed, village-level private dealers are more popular among the small and medium farmer groups, while the large farmers prefer district-level dealers. For example, 41% of small farmers obtain fertilizers from village dealers, while 62% of large farmers buy from the dealers located at the district headquarters. A similar situation prevails for pesticides, where more than 60% of the requirement is fulfilled through the private dealers. Government-based supply is also significant, but only the large farmers (40%) are availing pesticides from this source. Indian border markets are a popular source among the small farmers, especially of Bara and Rupandehi districts. The institutional factors that facilitate farmer selection across the different markets in South Asia are inadequately examined in the literature, and need to be studied further for effective dissemination of production technologies.

Table 33. Market channels: Fertilizer and pesticides.

Source	% of products from the sources				p-value
	Small	Medium	Large	Overall	
Fertilizers					
Government supply	0.31	0.97	0.00	0.21	na
Co-operative	6.37	5.56	6.58	6.37	0.18[a]
Private dealer (village)	41.28	38.83	15.62	22.29	0.09[a]
Private dealer (district)	32.63	37.34	61.75	54.53	0.07[a]
Others	19.41	17.31	16.06	16.60	0.13[a]
Pesticides:					
Government supply	0.00	0.00	40.33	34.82	na
Co-operative	0.00	0.00	2.45	2.11	na
Private dealer (village)	21.25	51.02	40.33	40.54	0.00[a]
Private dealer (district)	62.08	46.74	14.59	19.64	0.01[a]
Others	16.67	2.23	2.29	2.89	0.08[a]

Note: [a]shows p-values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom; na refers to non-applicability.

8.3 Marketing channels of cereal output

In the study area, 28% of rice, 25% of wheat and 65% (46%) of Rabi (spring) maize produced is marketed, while the rest is mainly used for home consumption (Tables 10b, 14b, 18b and 19b). As crop production is an important source of income for the farmers, the selection of appropriate marketing channels by farmers is expected to generate significant income for them. Details on the destination of the marketed surplus are provided in Tables 34 and 35. Government *mandi* (market), village traders, traders at district- and even the state-level are the main buyers of the produce. A major share of the cereal produced is purchased by the village and district-level traders, while only insignificant amounts are procured by the government. Among the farmer groups of the study, more than 90% of the marketed rice, wheat, and OPV maize from small farmers' field are purchased by the village-level traders. Government *mandi* and cooperatives mainly help medium and large farmers sell their cereal products. An exception is the case of rice (OPV), for which cooperatives purchase 11% of the produce from the small farmer group.

Table 34. Market channels: seeds.

Source of seed	% products purchased from the source				p-value
	Small	Medium	Large	Overall	
Rice (OPV)					
Government supply	0.00	0.42	0.97	0.72	na
Cooperative	10.94	3.57	12.28	9.67	0.00[a]
Private dealer (village)	65.10	59.75	32.12	43.23	0.00[a]
Private dealer (district)	23.96	28.28	41.51	36.01	0.41[a]
Others	0.00	7.98	13.13	10.37	na
Rice (hybrids)					
Government supply	0.00	0.00	0.00	0.00	na
Cooperative	0.00	1.44	5.08	3.16	0.00[a]
Private dealer (village)	71.52	47.37	27.78	41.31	0.00[a]
Private dealer (district)	28.48	49.51	49.35	45.34	0.00[a]
Others	0.00	1.68	17.79	10.19	Na
Wheat					
Government supply	0.00	0.73	0.25	0.34	na
Cooperative	2.02	1.10	7.08	4.73	na
Private dealer (village)	63.84	56.16	44.65	50.61	0.00a
Private dealer (district)	28.13	34.95	36.38	34.77	0.00a
Others	6.00	7.07	11.64	9.58	0.15a
Maize (OPV)					
Government supply	0.00	1.34	0.00	0.70	na
Cooperative	0.00	15.25	1.19	8.41	na
Private dealer (village)	22.93	69.69	77.43	68.65	0.00a
Private dealer (district)	61.03	13.72	21.39	20.84	0.00a
Others	16.04	0.00	0.00	1.40	na
Maize (hybrids)					
Government supply	0.00	3.95	1.65	1.92	na
Cooperative	0.00	0.00	0.00	0.00	na
Private dealer (village)	43.05	48.68	69.83	63.55	0.00a
Private dealer (district)	56.95	47.37	27.61	33.86	0.00a
Others	0.00	0.00	0.93	0.67	na

Table 35. Market channels: Cereal outputs.

Outlet	% of output traded				p-value
	Small	Medium	Large	Overall	
Rice (OPV)					
Government mandi	0.00	0.00	3.95	3.30	na
Co-operative	0.00	0.00	0.00	0.00	na
Trader (village)	95.57	77.26	71.24	72.53	0.02[a]
Trader (district)	4.43	22.74	24.80	24.17	na
Trader (State)	0.00	0.00	0.00	0.00	na
Rice (hybrid)					
Government mandi	0.00	0.00	0.00	0.00	na
Co-operative	0.00	0.00	0.00	0.00	na
Trader (village)	100.00	100.00	67.74	73.44	0.12[a]
Trader (district)	0.00	0.00	32.26	26.56	na
Trader (State)	0.00	0.00	0.00	0.00	na
Wheat					
Government mandi	0.00	0.00	5.48	4.07	na
Co-operative	0.00	0.00	2.50	1.86	na
Trader (village)	96.75	80.39	59.56	65.50	0.08[a]
Trader (district)	3.25	19.61	32.46	28.57	na
Trader (State)	0.00	0.00	0.00	0.00	na
Maize (OPV)					
Government mandi	0.00	0.00	0.00	0.00	na
Co-operative	0.00	0.00	0.00	0.00	na
Trader (village)	100.00	89.14	88.28	89.04	0.09[a]
Trader (district)	0.00	10.86	11.72	10.96	na
Trader (State)	0.00	0.00	0.00	0.00	na
Maize (hybrid)					
Government mandi	0.00	3.95	1.65	1.92	na
Co-operative	0.00	0.00	0.00	0.00	na
Trader (village)	43.05	48.68	69.82	63.55	0.03[a]
Trader (district)	56.95	47.37	27.61	33.86	na
Trader (State)	0.00	0.00	0.93	0.67	na

Note:[a]shows p values derived from Kruskal- Wallis equality of population rank test with 2 degrees of freedom; na refers to non-applicability.

9 Conclusion

The present study is developed from a comprehensive socio-economic household survey, aimed to provide important baseline indicators for CSISA project. Under this project, improved cereal production technologies that are economically sustainable, and conserve the natural resource base, are expected to be developed and disseminated. Information gathered from 324 cereal producer households, from three different districts of Nepal's Terai region, was synthesized. Details on the general characterization of farming households in the study area focusing on cropping patterns, varietal adaptation, productivity and economics of cereal production, details on livestock production, level of adoption and perceived impact of conservation agriculture and related production technologies, and existing marketing channels - are provided under the various sections of this report. Only a few attempts have been made to characterize the cereal production sector of the Terai region, against which the present study gains special relevance. The findings - separately provided for small, medium and large farmer groups - are concluded in this section.

The study area is dominated by small and marginal farmers. There exists significant inequality in land ownership. Most of the sample farmers cultivate more than one cereal crop in a year, in addition to many other food crops. Crop diversity varies significantly across the cropping seasons: Kharif is dominated by rice, but a number of crops are cultivated during winter (Rabi) season, mainly on the larger farms. Rice is the most important cereal crop, as almost all of farmers are engaged in its cultivation, and they keep a major share of the produce for home consumption. Adoption of hybrid seeds is frequently observed, although the majority of the rice area is still under OPVs and local varieties. However, rice productivity in the sample farms is observed to be significantly higher than the national average. For wheat and maize, yields are more or less equal to the national average of 9.21 and 9.23 quintals/acre, respectively. Only a few varieties dominate the production of cereals in the Terai, especially with respect to wheat (with three varieties comprising 97% of wheat acreage), and this could well be one of the major hurdles that prevent higher levels of productivity.

The farming sector of Central Nepal is dominated by subsistence farming. Only about a quarter of rice and wheat grain production is marketed, and this share is even much lower among small farmers. Rice and wheat are observed to be relatively remunerative crops to the farming community. In contrast, maize (produced mainly for markets in the Rabi and spring seasons) does not provide a promising economic picture. Many of the maize cultivators face financial losses, as the cost of production exceeds sales. Stagnating rice and wheat productivity and an economically unviable maize cultivation regime, pose significant challenges to the national agricultural research system to develop effective cultivation practices and policies, in the backdrop of existing supply constraints in fertilizers, fuel and labour markets. Another major challenge is to effectively link cereal farmers with input/output markets, especially the smallholders. In terms of inputs like seed and fertilizer, village- and district-level dealers were observed to be the main suppliers, and in many cases the quality of these inputs are questionable. Only a small share of inputs comes through the government supply channel. Finally, high prices of fertilizers in the private markets reduce the profits of cereal farmers.

In order to limit the dependence of farmers on external inputs, reduce the total cost of production, and achieve the goal of sustainable production of cereals, CA technologies are being developed and disseminated in half of the study villages under the CSISA project. At the time of the baseline survey, the diffusion of these technologies is, unsurprisingly, found to be marginal. Relay cropping, bed planting, ZT and DSR are the technologies being adopted in the farmers' fields. Nevertheless, the farmers are largely unaware of the technology impacts on cost, input use or profitability, which could pose a significant challenge to promotional programs seeking to inform a wider audience of farmers about these promising technologies/practices. Government extension officers, in collaboration with project personnel and NGOs, should have a significant cumulative effect on diffusion of such resource conserving technologies over time, given the constraint of information unavailability (and unsuitability of some CA-related technologies) that small-scale farmers need to overcome. Development of novel technology diffusion models—and more emphasis on addressing constraints faced by small and marginal farmers in obtaining information on farming—are expected to accelerate RCT diffusion and enhance cereal productivity in the study area.

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Appendix I: Schematic representation of sampling plan for the study