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Crop–livestock interactions and livelihoods in the Trans-Gangetic Plains, India

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Crop–livestock interactions and livelihoods in the Trans-Gangetic Plains, India

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Acronyms

AI	artificial insemination
asl	above sea level
CIBR	Central Institute on Buffalo Research (Hisar, Haryana)
CIMMYT	International Wheat and Maize Improvement Centre (Texcoco, Mexico)
FYM	farm yard manure
GCA	Gross cropped area
HAU	Haryana Agricultural University
hh	household
IGP	Indo-Gangetic Plains, South Asia
ILRI	International Livestock Research Institute (Nairobi, Kenya)
KVK	Krishi Vigyan Kendra (Extension outreach program, India)
LGP	Lower-Gangetic Plains (Subregion of the IGP, comprising the downstream plains in Eastern India [West Bengal], Ganges basin)
MGP	Middle-Gangetic Plain (Subregion of the IGP, comprising the midstream plains in eastern India [Eastern UP and Bihar], Ganges basin)
MSP	minimum support price
n	number of observations
NCA	Net cropped area
NGO	non-governmental organization
ns	non-significant
p.	probability
PAU	Punjab Agricultural University
RCTs	resource-conserving technologies
RWC	Rice–wheat Consortium of the Indo-Gangetic Plains (New Delhi, India)
s.d.	standard deviation
SLP	CGIAR Systemwide Livestock Programme
TGP	Trans-Gangetic Plain (Subregion of the IGP, comprising the plains in North-western India [Punjab, Haryana], straddling Ganges and Indus basin)
TW	tubewell
UGP	Upper-Gangetic Plain (Subregion of the IGP, comprising the upstream plains in North-central India [Western U.P.], Ganges basin)
U.P.	Uttar Pradesh
ZT	zero tillage

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Foreword

The present study is the first in a series of five reports for the crop–livestock interactions scoping study. The first four reports each describe a particular subregion of the Indo-Gangetic Plains in India: the Trans-Gangetic Plains (TGP, Punjab and Haryana—this report), Uttar Pradesh (Singh et al. 2007), Bihar (Thorpe et al. 2007) and West Bengal (Varma et al. 2007). The fifth report synthesizes across the four subregions (Erenstein et al. 2007). To facilitate write-up, synthesis and future reference, the reports all follow a similar outline and table format. This implies some repetition between reports, but this was still preferred over a single bulky report in view of the richness and diversity of the information and so as not to lose the local insights and relevance. Chapter 1 (Introduction), chapter 2 (Methodology), the action research needs for the IGP (part of 7.3) and most of the annexes are largely identical in each of the reports. Each of the reports can be read as a standalone report.

Executive summary

The research and development community faces the challenge of sustaining crop productivity gains, improving rural livelihoods and securing environmental sustainability in the Indo-Gangetic Plains (IGP). This calls for a better understanding of farming systems and of rural livelihoods, particularly with the advent of, and strong advocacy for, conservation farming and resource-conserving technologies. This scoping study presents an assessment of crop–livestock interactions and rural livelihoods in the Trans-Gangetic Plains of Punjab and Haryana, drawing from a village survey in three districts (Patiala, Kurukshetra and Hisar) and secondary data.

Widespread irrigation and the Green Revolution have transformed the semi-arid Trans-Gangetic Plains into India's granary, producing 21% of the nation's food grains on only 3% of its area. The subregion is characterized by rural livelihoods based on wheat–buffalo farming systems. Over the last 30 years there has been widespread adoption of rice, making rice–wheat the predominant cropping system (35% of system area in IGP). Farm size is relatively high and the area has witnessed a rapid mechanization. Buffalo (dairy) increasingly dominate the bovine population, making the TGP the most densely buffalo populated area of India. There has been a sharp decline in draught animals, small ruminants and in Punjab, of poultry. Agricultural growth was accompanied by steady reductions in poverty, resulting in the lowest rural poverty rates in India (6.4–8.3%). Punjab and Haryana are the prime beneficiaries of the Minimum Support Price (MSP) schemes for rice and wheat, removing market risk from these crops. Bio-physical consequences, however, are the declining groundwater table and the degrading of soils, contributing to a stagnation of agricultural growth in the 1990s.

Livelihood platforms

Land is the central asset for the livelihoods in the surveyed communities, with 72% of households having access to land and with an average landholding of 3.7 ha per farm household. The physical capital asset base is very developed, particularly in terms of irrigation and mechanization. Only the Hisar cluster was relatively less mechanized and had limited groundwater irrigation development, with profound consequences for the corresponding cropping intensity and productivity. Human capital in Haryana clusters was limited by illiteracy, with 40% of the household heads in the surveyed villages having no formal education, as against 16% for the Patiala cluster. Rural population density is relatively low compared to the remainder of the IGP.

Land use is intensive and land value correspondingly high, particularly when irrigation is secure. Although credit markets are relatively developed, capital remains the most limiting production factor. Informal sources meet the bulk of credit demand with interest rates averaging 1.75–2% per month. Daily wage rates (India Rupees (INR)[1] 87) are relatively high compared to other IGP states. In view of seasonal labour shortages and large farm size, the rice–wheat clusters are net-users of agricultural labour, particularly seasonal migrants for wheat and rice harvest and rice transplanting. Gender inequity still plays a key role, reflected inter alia by gendered wage rates. Women were typically less involved in crop activities and more in livestock activities.

Livelihood strategies

Livelihood strategies in the surveyed communities predominantly revolved around crop–livestock systems and agricultural labour. Wheat dominates the cropping pattern in winter (all clusters) and rice during the monsoon (the Patiala and Kurukshetra clusters). In the Hisar cluster, irrigation constraints imply a more diverse cropping pattern during the monsoon and winter. All systems however have approximately 10% of the cultivated area devoted to fodder crops in both seasons. Rice and wheat yields are high, particularly compared to the other IGP states. Rice is primarily produced for the market (95%). While wheat is mainly produced for the market (68%), a significant share is retained for own consumption reflecting traditional food preferences.

Buffalo ownership is widespread and complements the rice–wheat based cropping systems as the basis of rural livelihoods. The aggregate livestock herd averaged 4.6 cow equivalents per household, the highest amongst the IGP subregions surveyed. The preference for dairy buffalo over cattle reflected owners' decision-making based on: (i) their observations of buffalo's production being less risky and more stable relative to crossbreds; (ii) the assured market in which the milk price was based on composition therefore favouring buffalo's high fat milk; and, (iii) the possibility of selling male calves and older culls (in contrast with cattle). Extracted milk yields were generally low and only about half of the milk was marketed. Backyard poultry is markedly absent.

For landed households, crop production appeared as the main livelihood source, with livestock typically complementary and to a large extent dependent on the crop enterprise. Landless households depend primarily on their labour asset, with livestock providing an important contribution.

Crop–livestock interactions

The TGP is characterized by the prevalence of wheat as the traditional food and feed crop. Wheat residues have scarcity value and are intensively collected, stored and used as the basal animal feed and surpluses traded (INR 1.4 per kg). In contrast, the prevailing coarse

1. India Rupees (INR). In May 2008, USD 1 = INR 40.542.

rice residues have marginal value and are largely burned *in situ*. Only rice residues from fine grain rice varieties (particularly Basmati) are more widely appreciated and used as animal feed. Particularly striking is the widespread mechanization of harvest and residue management practices. Compared to other IGP states, the livestock pressure on crop and cereal residues in the TGP is relatively low, a reflection of its large farm size. The practice of stubble grazing is uncommon and non-feed use of residues is relatively limited.

The buffalo are stallfed throughout the year on a basal diet mainly of wheat *bhusa* (chopped straw). The basal diet, particularly of lactating animals, was supplemented with green fodder and the use of other crop by-products. Compared to the other IGP states, the reliance on grazing and collected grasses for feed was limited. Although feeding practices compare favourably to other IGP states, milk yields were still low and the role of bovines was not perceived as primary income earners.

The buffalo depend on the wheat residues with limited flow back from the livestock component to the crop component in terms of dung or traction. At household level more interdependency between crop and livestock components is apparent in view of complementary labour needs and internal non-monetary services.

Based on these findings the study goes on to explore the effects on livelihood security and environmental sustainability and provides an outlook and agenda for action for the TGP clusters as well as the generic action research needs that emerge from all the IGP clusters.

1 Introduction

The outstanding contribution of agricultural research towards improving the livelihoods of poor farmers on the Indo-Gangetic Plain (IGP) through the Green Revolution technologies is well documented (Evenson and Gollin 2003; Frankel 1971; Hazell et al. 1991; Lipton and Longhurst 1989; Pinstrup-Andersen and Hazell 1985; Rosegrant and Hazell 2001). During the 1960s to 1980s, the planting in the irrigated fields of the IGP of high-yielding wheat and rice varieties, combined with the application of fertilizer, gave much improved cereal production. As a result India moved from a deficit in the staple grains, wheat and rice, to a secure self-sufficiency. Now, in the face of diminishing groundwater supplies and degrading soils (Kumar et al. 1999; Pingali and Shah 1999), the challenge is to sustain crop productivity gains, while supporting the millions of families on the IGP—most of whom are resource-poor—to diversify their farming systems in order to secure and improve their livelihoods.

Central to this challenge of ensuring improved livelihoods and environmental sustainability are the ruminant livestock—particularly buffalo, cattle and goats—that are an integral part of the IGP's farming systems. For decades beneficial interactions between rice and wheat cropping and ruminant livestock have underpinned the livelihood systems of the IGP. Yet until recently there has been little systematic research to assess the benefits of these interactions, or to evaluate the potential for improvement. Based on a review of over 3000 papers from S Asia, Devendra et al. (2000) reported a paucity of research that incorporates livestock interactively with cropping, and a woeful neglect of social, economic and policy issues. Bio-physical commodity-based crop or livestock research had dominated, a systems perspective was lacking and many of technologies which were developed were not adopted. More recently broad classifications of crop–livestock systems in S Asia and their component technologies have been documented (Paris 2002; Parthasarathy Rao et al. 2004; Parthasarathy Rao and Hall 2003; Thomas et al. 2002). However, it is clear that a better understanding of farming systems and of the livelihood objectives of landed and landless families, including how they exploit crop–livestock interactions, will be required if we are to be successful in improving rural livelihoods and securing environmental sustainability in the IGP.

Taking a systems approach and applying a livelihoods perspective (Ellis 2000) are particularly important because of the dynamics and diversity of the IGP's social geography, its agriculture and the complexity of the crop–livestock interactions. Current understanding of the interactions is only partial; hence the need to update our knowledge and to assess the implications for agricultural R&D—particularly with the advent of, and strong advocacy for, conservation farming and resource-conserving technologies (RCTs, e.g. zero-tillage, permanent beds and mulching). The RCTs are having some success in improving resource use efficiency for crop production (RWC 2005; Singh et al. 2005), but there is a lack of information about their impacts on overall farm productivity and its livestock components (Seth et al. 2003). Improving our understanding of crop–livestock interactions and their contributions to rural livelihoods will better position the R&D community to be more effective in addressing the major challenges of improving livelihoods while ensuring environmental sustainability.

It was against this background that the Rice–Wheat Consortium designed a scoping study with the following objectives:

- To assess rural livelihoods and crop–livestock interactions in the IGP.
- To understand the spatial and seasonal diversity and dynamics of livelihoods and crop–livestock interactions, particularly in terms of the underlying drivers and modifiers.
- To assess the corresponding implications for R&D programs.

The study was carried out across the Indo-Gangetic Plains of India, comprising the states of Punjab, Haryana, Uttar Pradesh (U.P.), Bihar and West Bengal. For the purpose of this study we grouped the Indian IGP into four subregions: the Trans-Gangetic Plains (TGP: Punjab and Haryana) and the Gangetic Plains of U.P., Bihar and West Bengal. The Gangetic Plains of U.P. thereby comprise the Upper-Gangetic Plains and part of the Middle-Gangetic Plains, Bihar comprises most of the Middle-Gangetic Plains and West Bengal the Lower-Gangetic Plains (Figure 1). This report describes the study carried out in Trans-Gangetic Plains (TGP). It's results and those from the other three subregion reports (U.P.—Singh et al. 2007; Bihar—Thorpe et al. 2007; and West Bengal—Varma et al. 2007) are drawn together in the main synthesis report (Erenstein et al. 2007).

The study reports are structured as follows. The second chapter presents the overall methodology followed and details about the specific survey locations. The third chapter presents the study area drawing primarily from secondary data and available literature. The fourth chapter analyses the livelihood platforms in the surveyed communities, distinguishing between the livelihood assets, access modifiers and trends and shocks. The fifth chapter describes the livelihood strategies in the surveyed communities, with particular attention for crop and livestock production. The sixth chapter assesses the crop–livestock interactions in the surveyed communities, with a particular emphasis on crop residue management and livestock feeding practices. The seventh chapter first discusses the effects on livelihood security and environmental sustainability and subsequently dwells on the outlook for the surveyed communities and draws together an agenda for action.

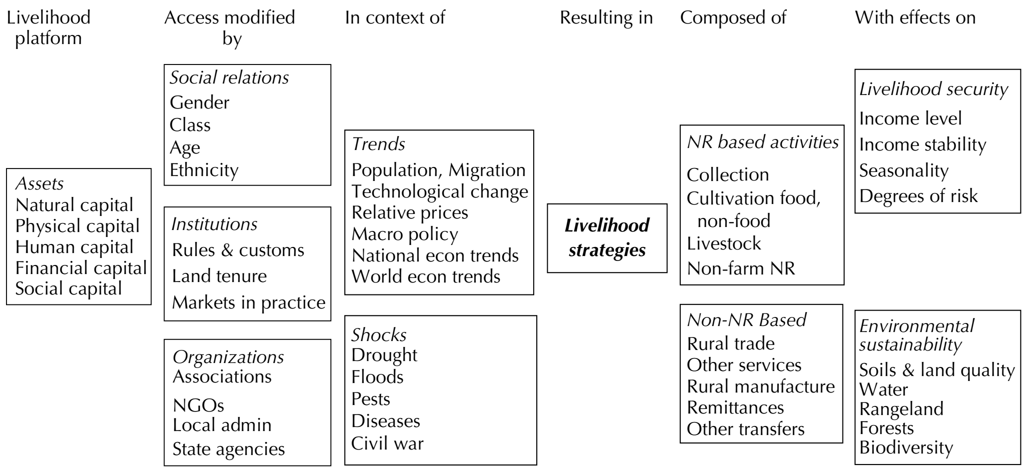
Legend: 1. Indus Plains; 2. Trans-Gangetic Plains [TGP]; 3. Upper Gangetic Plains [UGP]; 4. Middle Gangetic Plains [MGP]; 5. Lower Gangetic Plains [LGP].

Figure 1. *The Indo-Gangetic Plains and its five subregions.*

2 Methodology

Conceptual framework

The scoping study set out to assess rural livelihoods and crop–livestock interactions in the Indo-Gangetic Plains (IGP) through the combined use of secondary information and village-level surveys. In order to better dissect and understand livelihoods and the contributions of crops, livestock and interactions of the sample village communities, the scoping study took as its analytical framework the 'assets-mediating processes-activities' model presented by Ellis (2000, Figure 2).



Source: Ellis (2000).

Figure 2. *A framework for the analysis of rural livelihoods.*

The framework provides a systematic way of (i) evaluating the assets of households and communities and the factors (e.g., social relations or droughts) that modify access to these assets; (ii) describing and understanding current livelihood strategies; and then (iii) exploring the options for reducing poverty and addressing issues of sustainability. Of particular interest in our scoping study was to understand the dynamics of the livelihood systems and how these influenced decisions on the management of rice–wheat cropping and of livestock and their interactions, e.g. the trade-offs between RCTs (resource-conservation technologies) and the use of crop residues to feed buffalo for milk production. Taking this livelihoods approach ensured that natural resource-based and other activities were addressed and that their effects on livelihood security and environmental sustainability were assessed.

Figure 3 schematically presents the linkages between crop and livestock systems in the IGP that further guided the study. The scoping study did not intend a comprehensive assessment of the crop and livestock subsectors of India's IGP. Instead emphasis was on the linkages—the crop–livestock interactions—at the farm and village level between the two subsectors. The study therefore focused on the dynamics at the interface of the crop and livestock subsectors. Within that dynamics a further focus was the management of crop residues because of their importance as ruminant livestock feeds and their role in natural resources management.

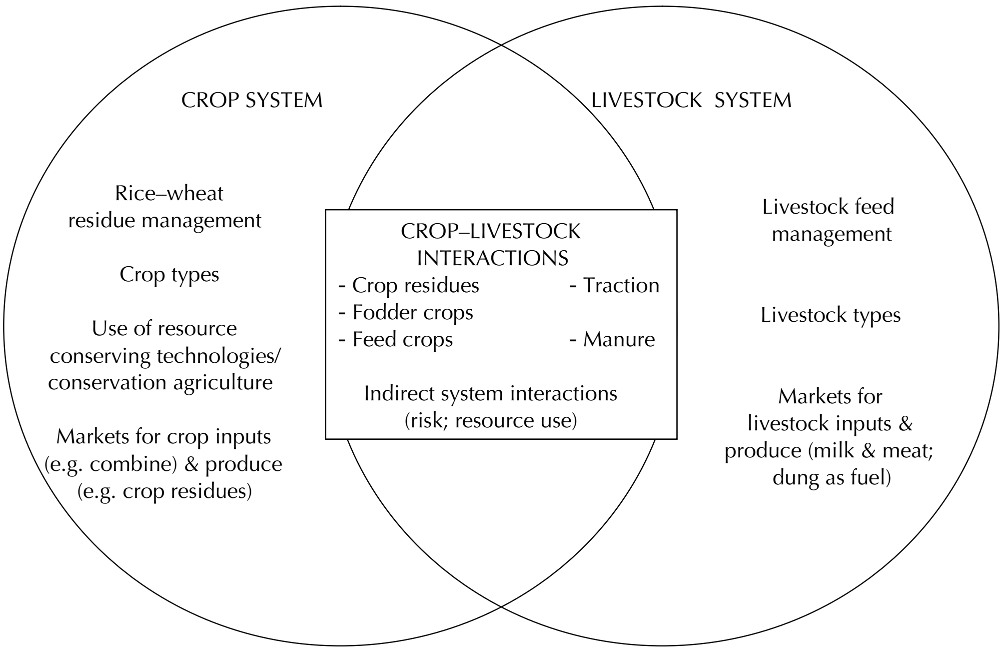
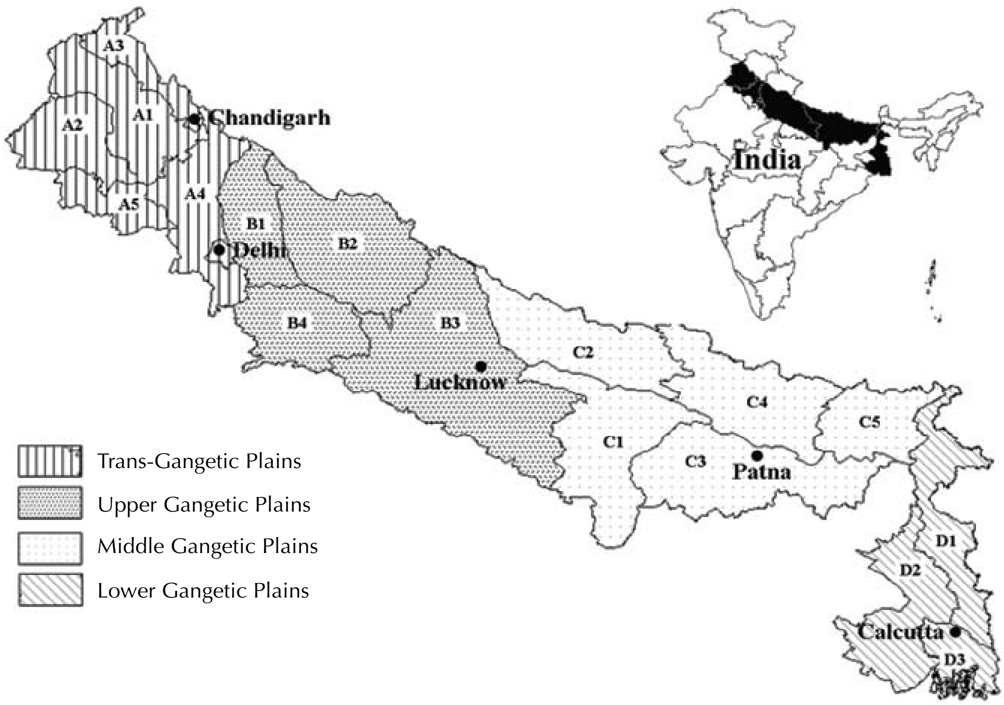


Figure 3. *A schematic representation of crop–livestock interactions in the Indo-Gangetic Plains.*

Village-level survey

The main data source for the scoping study was a village level survey covering a total of 72 communities from April to June 2005. The communities were randomly selected using a stratified cluster approach. At the first level, we grouped the Indian IGP into four subregions: the Trans-Gangetic Plains (TGP: Punjab and Haryana) and the Gangetic Plains of UP, Bihar and West Bengal. Each subregion comprises various agro-ecological subzones as described in the classification by Narang and Virmani (2001, Figure 4) and Kumar et al. 2002. At the second level, we purposively selected a representative district from each of the 3 main IGP agro-ecological subzones within the subregions. These locations were selected to reflect the range of agro-ecological conditions in the IGP and to capture the expected variation in farming systems, including level of access to irrigation services. At the third and final cluster level, we randomly selected 6 villages around a central point, typically the district headquarters. The villages were randomly selected by taking two villages off the main road along three opposing directions, one village typically relatively close (generally within 5 km) and the second further away (generally more than 15 km). Table 1 shows the name, cluster and agro-ecological classification of each village in the TGP for which a survey was carried out. Figure 5 shows the location of the 18 villages (based on readings from GPS units) within the three TGP clusters.



Source: Adapted from Narang and Virmani (2001).

Figure 4. *Subregions and agro-ecological subzones of the Indo-Gangetic Plains.*

Table 1. *Name, cluster and zone of the 18 surveyed villages in the Trans-Gangetic Plains*

Cluster (State)	Patiala (Punjab)	Kurukshetra (Haryana)	Hisar (Haryana)
Village	Danouri	Koulapur	Harikot
	Ramgarh	Kandoli	Barhi
	Mandaur	Mukimpura	Basra
	Babarpur	Bakhli	Gorchhi
	Saini majra	Antehri	Kirtan
	Kala Jhar	Jogimajra	Ramayan
Zone*	Central plain zone (A1)	Eastern zone (A4)	Western zone (A5)

*Following Narang and Virmani (2001, 6).
Source: Adapted from Narang and Virmani (2001). Figure 4 maps the coded subzones.

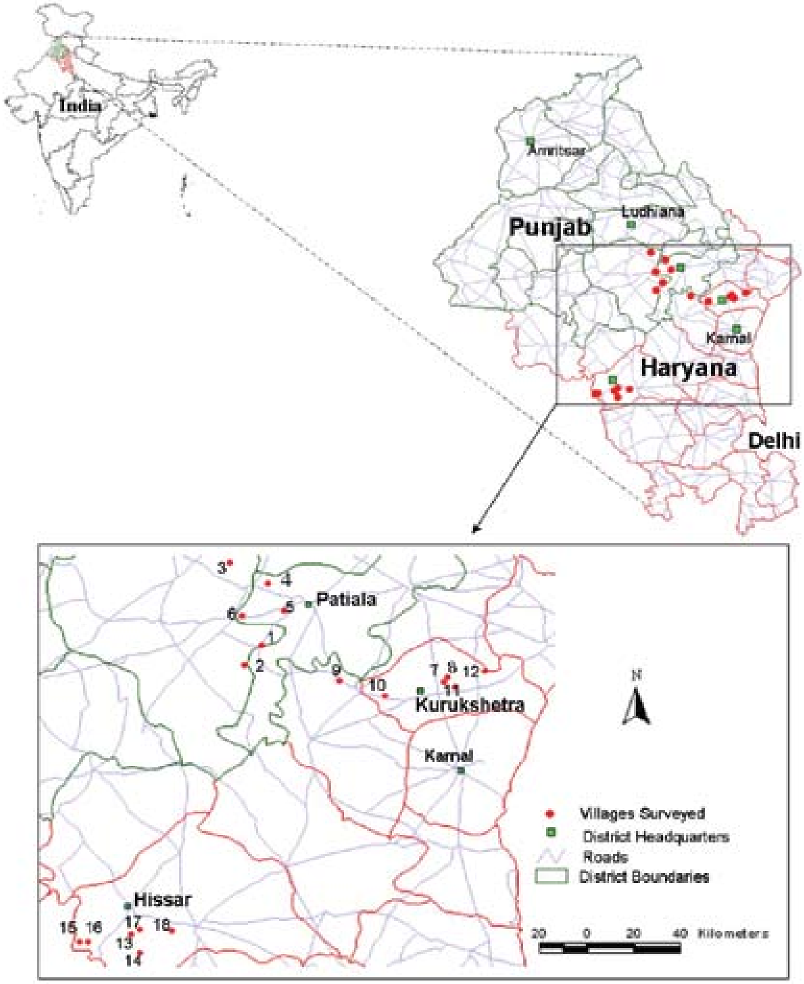


Figure 5. *Location of the 18 surveyed villages within the Patiala cluster (Punjab State) and the Kurukshetra and Hisar clusters (Haryana State) in the Trans-Gangetic Plains.*

Within each village we interacted with self-selected groups of key-informants. We thereby attempted to include a representative range of village stakeholders during a half-day village visit, covering the diverse spectra of gender, social and wealth categories (including landed and landless). The half-day visit thereby typically included a briefing with key informants of the village, a larger group meeting with villagers (mainly landed), a separate smaller group meeting with landless, and a visual survey by walking through and around the village.
The separate meeting with the landless was deemed necessary to enable their more active participation. However, we were less successful in involving women who were virtually excluded from the group discussions in the TGP (Table 2). In part, this was dictated by the prevailing social norms and definitely not aided by the male-biased team composition. Team

members were thereby requested to be assertive and pay particular attention to gender issues in an attempt to readdress the imbalance.

Table 2. *Median number and gender of participants in the village group discussions in each cluster in the Trans-Gangetic Plains*

Cluster	Village group discussion		Landless group discussion	
	# of participants	# of female participants	# of participants	# of female participants
Patiala	11	0	6	1
Kurukshetra	10	0	5	0
Hisar	15	0	5	0
Overall	11	0	5	0

The village survey used semi-structured interviews using a survey instrument (Annex 4). A village leader was generally first asked to provide quantitative descriptors of the village (people, resources, and infrastructure). Then group discussions described the crop and livestock subsystems practised in the village and other significant aspects of village livelihoods. Particular attention was given to the management of crop residues and to livestock feed resources. Data were collected on the expected drivers of crop–livestock interactions, like the cost of daily-hired labour and the level of access to irrigation.

At each stage of the survey process, respondents were asked to identify and discuss the critical issues that affected their living standards and the constraints to, and the opportunities for, improving their livelihoods and that of the village. In this way, the discussions attempted to provide a sound understanding of the opinions and perspectives of each village community and of its major social groupings regarding policy issues and policy making, i.e. to gain a ‘user’ or bottom-up perspective and to avoid being prescriptive.

At each location within each region, three teams completed the survey instrument for two villages within a day. Members of a core team participated in the surveys in each of the four regions and in each of the three locations which constituted the subregion of each region. This gave continuity and consistency of research approach and ensured that the core team members absorbed and analysed the survey and related information from the village studies across the Indian IGP from Punjab in the NW to West Bengal in the east (Figure 1). Within each survey team at each cluster, the core members were joined by staff from the local Krishi Vigyan Kendra (Extension outreach program, India) or other State Agricultural University Departments and/or their counterparts in the Departments of Agriculture and Animal Husbandry of the State Government (Annex 3).

Analysis and integration of information

The quantitative primary data from the village surveys were summarized using descriptive statistics. These results were complemented by the information and statistics gathered from secondary sources. The descriptive statistics not only helped gain a better understanding of the type and extent of crop–livestock interactions within each subregion but also showed the variation within and across the four major regions. The descriptive statistics were also useful in examining informal hypotheses about the possible drivers of interactions between crops and livestock and in helping to identify the key modifiers of the effects of the drivers.

It should be noted that the nature of the survey method of collecting data dictates that each quantitative observation (e.g. area of irrigated land in the village or the number of buffalo) is a guesstimate from a respondent or group of respondents. As such, estimates of variables (e.g. mean number of buffalo for the TGP subregion sample of villages) calculated from these guesstimates are indicative, not definitive, results and are therefore presented in the results section at an appropriate level of rounding (e.g. village population to the nearest 100).

The nature of the data and study also implies that the analysis is mainly descriptive. All the tables in the present report refer to village level survey data unless otherwise mentioned. The tables typically present unweighted averages across surveyed villages (i.e. the average of the 6 surveyed villages in each cluster and 18 villages in case of the overall mean for the subregion). This applies to both absolute and relative values (i.e. in the case of % of households [hh] the % was estimated at the village level and subsequently averaged across villages). These tables also present measures of variability and the significance of differences between clusters. However, with 6 villages per cluster and a total of 18 villages for the subregion, the likelihood of finding significant cluster effects is somewhat limited and some measures like Chi-square cannot be interpreted.

The livelihood framework can be applied at different scales. Our focus here is on the village and household levels. At the household level, we will often distinguish between farm households (with land access and crop production activities), landless households (no access to agricultural land [owned or rented] or crop production activities) and village households (includes both farm and landless). Finally, in applying the livelihood framework in this study, we use the principle of 'optimal ignorance,' seeking out what is necessary to know in order for informed action to proceed (Scoones as cited in Ellis 2000, 47).

It is important to remember that a scoping study, by its very nature, is not designed to provide definitive answers, but rather to flag issues for subsequent in-depth research. Therefore, the emphasis of the study methods was learning through drawing on available information and current knowledge from secondary sources and from the village surveys, interpreting and synthesizing the data from these sources and finally identifying gaps both in the information and our knowledge and in its application.

3 Study area[1]

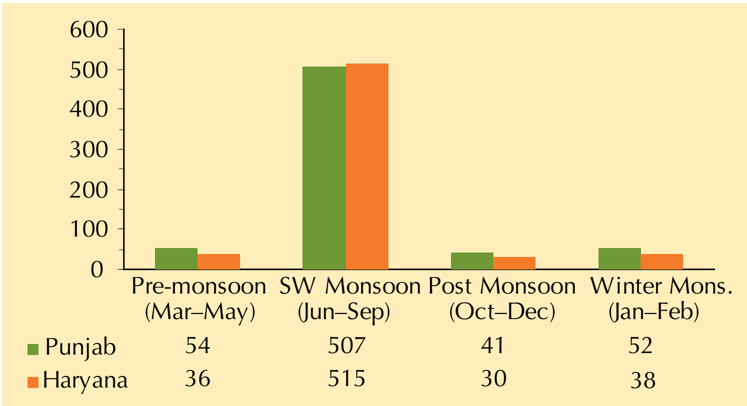
The Indo-Gangetic Plain (Figure 1) can be divided broadly into eastern and western subregions. The eastern subregion has problems of poor water control and flooding; rainfed (monsoon/*kharif*) lowland rice is the traditional cereal staple and the mainstay of food security. Only in recent decades have wheat and other cool season crops been introduced on a large scale in the East, north of the Tropic of Cancer. By contrast the western subregion, including the Trans-Gangetic Plain (TGP) subregion, is mainly semi-arid and would be water scarce were it not for an excellent irrigation infrastructure of canals and groundwater tube wells. In the TGP winter/*rabi* wheat has traditionally been, and continues to be the mainstay of food security, aided by good winter rains (100–110 mm) and low temperatures appropriate for vernalization and good seed set in wheat (Narang and Virmani 2001). In recent decades there has been a major increase in the area of rice grown in the monsoon/*kharif* season. Another important contrast is that whereas in the eastern IGP cattle are the predominant livestock, in the western IGP, including the TGP, buffalo dominate. In broad terms, therefore, the eastern IGP is characterized by rural livelihoods based on rice–cattle farming systems, while rural livelihoods in the western IGP, including the TGP subregion, are based on wheat–buffalo farming systems.

The Trans-Gangetic Plain subregion primarily encompasses the States of Punjab and Haryana and one district of Rajasthan (Sri Ganganagar District). For practical purposes we therefore consider the TGP as synonymous with Punjab and Haryana combined. Broadly three agro-climatic subregions are recognized by Kumar et al. (2002): the Foothills of Shivalik, the Plains and the Arid/Semi-arid zone (Table 3). These are classified as zones A3 (SubMontane), A1 and A4 (Central Plains and Eastern Zone), and A2 and A5 (Western Plains and Western zone), respectively, by Narang and Virmani (2001) in their report on spatial variability in rice–wheat systems (Figure 4). Our three research clusters encompass the Central Plains (A1), the Eastern zone (A4) and the Western zone (A5—Table 1).

The subregion has a semi-arid climate and a sauce-shaped topography with generally gently sloping, well-drained land. Most soils are alluvial and ground water is of low quality. Annual rainfall ranges from 400 to 700 mm in surveyed zones (Table 3), with a marked seasonality (some 80% falling in June–September, Figure 6). Irrigation infrastructure is so extensive that in 2000–2001 the irrigated area of Punjab was 95% and of Haryana 84% (Annex 1). The extent of surface irrigation canals is such that Punjab has the highest density of rivers and canals in the IGP (30.3 km length per km^2 geographical area as against an IGP average of 11.0 and Haryana 11.3, derived from Minhas and Samra 2003). The semi-arid climate implies that

1. The chapter presents background information for the study area drawing primarily from secondary data and available literature. Results from the village survey are presented in subsequent chapters.

the extent of other water bodies is limited in both the TGP states (primarily limited to tanks/ ponds), comprising less than 0.5% of the geographical area (as against an IGP average of 2%, derived from Minhas and Samra 2003).



Source: IASRI (2005, 17).

Figure 6. *Season-wise normal rainfall (mm) in the Trans-Gangetic Plains (Punjab 654 mm p.a., Haryana 619 mm p.a.).*

Table 3. *Rice, wheat and irrigated area, mean annual rainfall and prevalent soils in the Trans-Gangetic Plains*

Zone *	Rice–wheat area (million ha)	Area (% of GCA) 1996		Irrigated area (% of GCA)	Mean Rainfall, mm/year	Soil Type
		Rice	Wheat			
Plains (Patiala, Kurukshetra)	1.68	29	42	98	674	Calcareous and fine textured
Arid (Hisar)	1.26	16	37	98	385	Desert Soil
Foothills of Shivalik	0.46	27	42	78	880	Sandy loam to clay loam
TGP	3.40					

Source: Sharma et al. (2004) (RW area); and Kumar et al. (2002, 24) (other indicators).
*In '( )' survey cluster names for current study.

The widespread availability of irrigation has made rice and wheat the dominant crops (Table 3). With an estimated 3.4 million ha of rice–wheat system area, the TGP comprises 35% of the rice–wheat system area of the IGP in India (Sharma et al. 2004), with Punjab alone contributing 26.5% and Haryana 8.7%. The rice–wheat system particularly prevails in the plain zone (1.68 million ha) followed by the arid zone (1.26 million ha—Table 3). The intensity of wheat and rice cropping is such that with a combined geographical area of 95,000 km^2 (3% of India total), Punjab and Haryana produce 21% of national food grains from 9% of the national food grain area (Annex 1; MoA 2004a, 42). Bio-physical consequences are the declining groundwater table and the degrading of soils (Fujisaka et al. 1994; Harrington et al. 1993; Kumar et al. 1999; Narang and Virmani 2001; Pingali and Shah 1999; Singh and Sidhu 2005). Particularly water consuming are the cultivation of rice on relatively light sandy loam/loam soils and during the hot summer before the onset of the monsoon. In the central areas of Punjab, for example, the groundwater table shows a decline of 20 cm per year, with some places reaching a decline of 100 cm per year (Narang and Virmani 2001).

The people of the TGP have a distinct personality: rugged, brave, physically strong and willing to adopt change, characteristics forged by a history spent facing invaders from the North West: Greeks, Turks, Mongols, Persians and Afghanis. The partitioning and subsequent population fluxes in 1947 had further profound effects on the heritage. When in the 1960s to 1980s high-yielding wheat and rice varieties and the matching input supplies (including irrigation) were made available to these energetic and resourceful people, it was a potent mix that resulted in the Trans-Gangetic Plains becoming the heartland of India's Green Revolution.

While the farming systems of the TGP are primarily rice–wheat (RW) cropping with buffalo, the subregion also has significant areas of cropping systems of: RW–sunflower, RW–Mungbean, R–potato–W, R–Sugarcane–Ratoon Sugarcane–W, Pigeonpea–W and Cotton–W (Narang and Virmani 2001). Nevertheless it is the adoption of rice, which has mainly been at the expense of pulses and cereals other than wheat (Annex 2) that is the most striking change in the choice of crops in the farming systems of the TGP during the last 30 years. The adoption of monsoon/*kharif* rice, other examples of crop diversification and the resultant increase in cropping intensity during the 1980s and 1990s owe much to the increases in access to irrigation and use of fertilizers (Table 4).

Table 4. *Changes in input use and cropping intensity in the Trans-Gangetic Plains*

Zone *	Year	Irrigated area (% of GCA)	Fertilizer (NPK kg/ha cropped)	Cropping Intensity (%)	Rural literacy (%)
Plains (Patiala, Kurukshetra)	1982	83	109	160	35
	1996	98	154	182	49
Arid (Hisar)	1982	77	80	159	28
	1996	98	153	177	41
Foothills of Shivalik	1982	56	109	155	43
	1996	78	151	69	56

Source: Kumar et al. (2002, 29).
*In '( )' survey cluster names for current study.

Concomitant with these changes in choices of crops in the TGP has been the rapid mechanization of the land preparation and the combine harvesting of wheat and rice (Sidhu and Singh 2004). In recent years there has also been increasing tractor substitution from small to larger tractors, with the smaller tractors shifting to other states like Madhya Pradesh. Driving the tractor upgrade is the perceived need for more tractor power (associated with the perception amongst some farmers that soils are getting 'heavier' over time) and widespread availability of formal credit. As a result of mechanization, draught animal numbers have declined; for example in Haryana draught animals declined from 27.6 per 100 ha NSA (net sown area) in 1972 to 21 in 1992 and 13 in 2003 (Table 6). On the other hand, the buffalo population has increased, particularly over the last 10 years in Haryana (Table 5). As a result buffalo increasingly dominate the bovine population in the TGP. These trends have made the TGP the most densely buffalo populated area of India, with 13% of the nation's buffalo population on only 3% its total geographic area.

Table 5. *Livestock populations in the Trans-Gangetic Plain states in 1992 and 2003*

	1992					2003				
	Punjab		Haryana		India	Punjab		Haryana		India
	('000)	%	('000)	%	('000)	('000)	%	('000)	%	('000)
Crossbred cattle	1,628	10.7	417	2.7	15,215	1,531	6.9	573	2.6	22,073
Desi cattle	1,281	0.7	1,719	0.9	189,369	508	0.3	966	0.6	156,865
Buffaloes	6,008	7.1	4,372	5.2	84,206	5,995	6.4	6,035	6.5	93,225
Small ruminants	1,071	0.6	1,843	1.1	166,062	498	0.3	1,093	0.6	176,101
Pigs	101	0.8	516	4.0	12,788	29	0.2	120	0.9	13,571
Poultry	18,331	6.0	8,578	2.8	307,069	10,779	2.2	13,619	2.8	489,012

Source: MoA (2004b).
% reflects the state's share of the national herd.

Concurrent with these changes in the bovine population has been a sharp decline in the small ruminants numbers (sheep and goats) and in poultry in Punjab (but not in Haryana where commercial chicken production is being adopted), while the pig population has also fallen (Table 5). As a result the density of small stock has halved during the last decade with a proportionally greater decline per human capita (Table 6).

The average farm size of 4.0 and 2.3 ha in Punjab and Haryana, respectively, is relatively high compared to the national average of 1.3 ha (MoA 2006). The difference in land base per farm is even more pronounced if we take into account the irrigation base, which allows for widespread double cropping in the TGP. The relatively high average farm size in Punjab reflects the relatively even distribution over farm size classes. Indeed, only 12% of Punjab farms were classified as marginal (< 1 ha) in 2000–01, as compared to 46% in Haryana and 63% for India as a whole (Table 7). This is associated with a higher degree of consolidation in Punjab, particularly in view of the rampant subdivision of landholdings over time.

In Punjab and Haryana 32 and 46% of rural households are cultivators, whereas agricultural labour comprises 22 and 19%, respectively. Household industry workers comprise a fraction

(3 and 2%, respectively), and other occupations make up the remainder (43 and 33%, respectively—Business World 2005, 92). No scheduled tribes are reported, and scheduled castes make up 33 and 21% of the rural population, respectively (Census India 2005).

Table 6. *Density of livestock in the Trans-Gangetic Plain states in 1992 and 2003*

Indicator	State	Year	Bovines	Draught animals	Small ruminants	Pigs	Poultry
Per km^2	Punjab	1992	177	16	21	2	364
		2003	160	9	10	1	214
	Haryana	1992	147	17	42	12	194
		2003	171	11	25	3	308
Per 100 ha of GCA	Punjab	1992	118	10	14	–	–
		2003	96	5	6	–	–
	Haryana	1992	111	13	31	–	–
		2003	124	8	18	–	–
Per 100 ha of NSA	Punjab	1992	215	19	26	–	–
		2003	188	10	12	–	–
	Haryana	1992	187	21	53	–	–
		2003	215	13	31	–	–
Per 1000 people	Punjab	1992	440	39	53	5	904
		2003	322	18	20	1	432
	Haryana	1992	395	45	112	31	521
		2003	350	22	51	6	629

Source: Derived from MoA (2004b).

Table 7. *Land size distribution in the Trans-Gangetic Plain states in 2000–01*

	State	Marginal (< 1 ha)	Small (1–2 ha)	Semi-medium (2–4 ha)	Medium (4–10 ha)	Large (>10 ha)	Total
% of landholdings	Haryana	46.1	19.2	18.2	13.2	3.3	100
	Punjab	12.3	17.4	32.9	30.2	7.2	100
	All India	63.0	18.9	11.7	5.4	1.0	100
Land size (ha/hh)	Haryana	0.45	1.43	2.81	5.99	16.48	2.32
	Punjab	0.63	1.40	2.67	5.75	15.14	4.03
	All India	0.40	1.41	2.72	5.80	17.18	1.32

Source: MoA (2006).

The Green Revolution induced agricultural growth in Punjab and Haryana, which was accompanied by steady reductions in poverty. The high crop productivity and the States' large dairy herd result in the rural people of Punjab and Haryana having the lowest levels of poverty, 6.4 and 8.3%, respectively, of any states in India. Compared to the national average, female literacy in Punjab (64%) is relatively favourable, whereas Haryana's (56%) is average

(Annex 1). Table 8 presents selected indicators in relation to the Millennium Development Goals (MDGs) for the surveyed districts and for all the districts in the two states. Most indicators present a striking similarity, whereby the surveyed districts approximate the overall average, suggesting relatively equitable progress at the district level. Table 9 presents some additional indicators at the district level. These highlight that 0–6 year olds represent a quarter of the population and gender bias in sex ratio, literacy and reported work participation.

Table 8. *Selected MDG related development indicators at district level*

	% of population below the poverty line	% of households going hungry	Infant mortality rate	% of children getting complete immunization	Literacy rate	Gross enrolment ratio (elementary level)
Patiala	7.4	1.0	61.0	72.0	70.0	59.5
Kurukshetra	5.3	2.9	71.0	85.2	70.0	78.7
Hisar	8.9	3.1	71.0	63.3	65.9	59.5
Average all Punjab/ Haryana districts[1]	8.3	0.8	64.3	70.6	69.0	72.1

1. Unweighted average across all districts.
Source: Derived from Debroy and Bhandari (2003).

Table 9. *Selected additional development indicators at district level*

	0–6 sex ratio (female per 1000 male)	% of 0–6 year olds in the population	Female: male literacy ratio	Pupil: teacher ratio	Female work participation	% of women receiving skilled attention during pregnancy
Patiala	770	22.9	82.7	60.4	15.8	83.6
Kurukshetra	770	25.6	77.7	48.6	17.7	74.3
Hisar	830	28.1	67.1	53.7	25.8	56.7
Average all Punjab/ Haryana districts[1]	804	26.0	77.2	52.6	20.2	67.9

1. Unweighted average across all districts.
Source: Derived from Debroy and Bhandari (2003).

The Rice–Wheat Consortium (RWC) has recently tried to synthesize the biophysical and socio-economic drivers and modifiers of agricultural development in the IGP. Table 10 presents the RWC's summary description for TGP, which highlights the influences and interactions of natural, physical and human capital, and to which can be added the important elements of social and financial capital. These factors are key to our better understanding of the dynamics of agriculture, rural development and the underlying livelihood strategies of this breadbasket of India. The summary serves as a useful complement to the livelihoods framework (Figure 2) when reviewing the responses from the TGP village surveys.

Table 10. *Characteristic biophysical and socio-economic features of the Trans-Gangetic Plain*

Biophysical		Socio-economic	
Climate	Semiarid with 400–800 mm annual rainfall, 85% received between June to September	Farmer characteristics	Middle level education and highly enterprising with capacity to take risks; Affluent farmers. Agricultural holdings consolidated but relatively medium sized. Enhanced growth of peri-urban agriculture and private sector agro-industries.
Physical features	Alluvial coarser to medium fine textured calcareous soils, gently sloping, saucer shaped topography; alkali soils also exist in stretches; water quality low in pockets. Marginal lands being reclaimed.	Infrastructure for inputs; technology and extension	Excellent support
Irrigation	Long distance inter-basin transfer of water, intensely irrigated systems, extensive ground water development, use of low quality ground waters for irrigation	Marketing of produce	More favourable to rice and wheat
Energy	Tractorization very popular, rice being mechanized	Research support	Premier institutional network exist
Bio-climate	Favourable to RWCS; Cereal based systems	Policy support	Adequate

Source: Unpublished background tables developed for RWC (2006).

4 Livelihood platforms

4.1 Livelihood assets

The starting point of the livelihood framework are the assets owned, controlled, claimed or in some other means accessed by the farm households. These are the basic building blocks upon which households are able to undertake production, engage in labour markets and participate in reciprocal exchanges with other households (Ellis 2000, 31). The asset base of the surveyed villages will be reviewed based on five asset categories: natural capital, physical capital, human capital, financial capital and social capital (Figure 3).

4.1.1 Natural capital

The main natural capital assets utilized by the people to generate means of survival in the surveyed villages comprise land, water and livestock. There is a high pressure on land: more than 90% of the village land area is reportedly cultivated—which compares to state level data (84% Punjab, 80% Haryana—Annex 1). There is a significant rainfall gradient across the surveyed villages—Patiala and Kurukshetra receiving some 600 mm annually whereas Hisar is located in the semi-arid tract with less than 400 mm. There is considerable use of the groundwater for irrigation purposes, an issue further elaborated below. Rainfall and temperature give rise to a defined seasonality—with a relatively cool winter with sporadic rains (*rabi* season) and a hot humid monsoon (*kharif* season). There is a short pre-monsoonal hot dry spell (summer season). The landscape in the surveyed clusters is primarily plain, of low altitude (200–250 masl, Table 11) and highly suitable for crop agriculture. Land quality constraints (e.g. salinity [salt rich], sodicity [sodium rich], water logging) were not specifically reported to seriously constrain land use in the surveyed villages. This contrasts with the recent review of salinity, sodicity and other water quality problems in the IGP (Minhas and Bajwa 2001, 277). They rated 41% of groundwater resources in Punjab and 63% of Haryana as marginal or unfit for drinking and irrigation as their use leads to salinity, sodicity and toxicity problems in soils and adversely affects land productivity. Only in Hisar was some land left fallow during *rabi* due to excessive seepage from irrigation canals—but the land could still be used for rice in *kharif*.

About three-quarter of households in surveyed villages have access to land, with an average landholding of some 4 ha per household (Table 11). These figures compare reasonably well with aggregate state level data (landless rural population 22% Punjab 19% Haryana; average farm size 1995–96—3.8 ha Punjab, 2.1 ha Haryana—Annex 1). Compared to other states in the IGP, the share of area cultivated is very high, the landless population is relatively low and farm size is relatively high (Annex 1). However, in the Kurukshetra cluster two out of the six surveyed villages were predominantly landless and implied an extremely high pressure on the limited land (e.g. one village had 60% and another 80% landless).

Table 11. *Natural capital indicators*

Cluster	Altitude (m)[a]	Access to land (% of hh)	Farm size (ha/farm hh)	Herd size (# of cow equivalents per hh)[b]
Patiala	244 b	83	2.8	5.3
Kurukshetra	244 b	62	4.6	4.6
Hisar	203 a	71	2.7	3.8
Mean (s.d., n, p.)	229 (27, 16, 0.00)	72 (19, 18, ns)	3.7 (2.3, 18, ns)	4.6 (2.6, 18, ns)

s.d.: standard deviation; n: number of observations; p.: Significance of group-effect. ns: non-significant (p > 0.10). Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison. a. Indicative value from GPS. b. Using following weights: 1.2 for buffalo, crossbred cows and draught animals; 1 for *desi* cows and equines; .1 for sheep, goats and pigs; and 1.4 for camels.

After land and water, livestock is the next main natural asset both in terms of value and prevalence. The average livestock herd comprises 4.6 cow equivalents per household (Table 11) with livestock ownership by households near universal.

Other natural capital assets are limited. There are few natural surface water bodies and inland fisheries are not important. Natural vegetation is also limited, except for some shrub land in the Hisar cluster. There is no significant tree cover, except for sporadic trees on the homestead or on field borders, with some poplar tree plantations in the Kurukshetra cluster. Wildlife is also correspondingly scarce.

4.1.2 Physical capital

The physical capital asset base is relatively highly developed, both through public and private investment. The surveyed villages typically had high coverage of utility services (electricity, piped water), a high penetration of telephones and availability of public transport (Table 12). Although coverage was widespread, quality of services was not uniform and sanitation often wanting. The density and quality of the rural road network is good, both in the surveyed villages and at the state level (road density of 104 km/km^2 Punjab; 59 km/km^2 Haryana—Annex 1). Travel times to the nearest urban centre and agricultural market thereby both average less than half an hour (Table 13).

Irrigation development is probably the most striking and widespread physical capital asset in this subregion. Ninety percent of the village area is reportedly irrigated (Table 14)—which compares to state level data (95% Punjab, 84% Haryana—Annex 1). Irrigation development comprises both surface water through extensive canal networks and groundwater development through electric and diesel tubewells. Despite the prevalence of irrigation, there is significant variation amongst the clusters in terms of irrigation development and sources. Most striking is the prevalence of canal irrigation in the Hisar cluster, which contrasts with the prevalence of primarily electric tubewells in the other clusters. This has implications for the cost and reliability of irrigation. Canal irrigation tends to be relatively cheap (a flat rate per crop season) but also relatively insecure, being dependent on the seasonal operation of canals and field location in the scheme (head or tail). Diesel tubewells are more expensive to run but relatively secure. Electric tubewells take an intermediate position: drawing on subsidized electricity rates (World Bank 2005a) but subject to an erratic rural electricity supply. The Hisar cluster's dependence on canal water is in part dictated by the quality of the groundwater (brackish).

Table 12. *General physical capital indicators*

Cluster	Electricity supply (% of household)	Public water supply (% of household)	No. of phones (#/100 hh)	Availability public transport (% of villages)
Patiala	98	77	50 b	58
Kurukshetra	99	83	34 ab	75
Hisar	98	98	16 a	100
Mean (s.d., n, p.)	99 (3, 18, ns)	86 (33, 18, ns)	33 (27, 18, 0.08)	78 (39, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 13. *Selected market access indicators*

Cluster	Good access road (% of villages)	Travel time to urban centre (minutes)	Travel time to agricultural market (minutes)
Patiala	100	20	16 a
Kurukshetra	100	21	20 a
Hisar	100	30	40 b
Mean (s.d., n, p.)	100 (0, 18, ns)	23 (11, 18, ns)	25 (16, 18, 0.01)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 14. *Irrigation indicators*

Cluster	% of area irrigated	Primary irrigation source (% of villages)			
		Electric TW	Diesel TW	Canal	Pumped from surface water
Patiala	92	100	0	0	0
Kurukshetra	95	67	33	0	0
Hisar	73	17	0	100	0
Mean (s.d., n, p.)	87 (24, 18, ns)	61	11	33	0

The high investment in large agricultural machinery in the Patiala and Kurukshetra clusters is another striking feature. There is more than one tractor for every three farm households, more than double the tractor density in the Hisar cluster. This reflects the overall high tractor density across Punjab and Haryana states, which is very high both compared to the remainder of the IGP and India as a whole (tractors/100 ha: 10.4 Punjab, 9.4 Haryana—Annex 1). There is also significant investment in combiners in the Patiala cluster, with some 4 combiners per 100 households. Investment in ZT drills is still primarily concentrated in the Kurukshetra cluster (Table 15).

Table 15. *Mechanization indicators*

Cluster	No. of tractors (per 100 farm hh)	No. of powertillers (per 100 farm hh)	No. of combines (per 100 farm hh)	No. of ZT drills (per 100 farm hh)
Patiala	39 b	0	3.8 b	1.0 a
Kurukshetra	38 b	0	0.3 a	7.5 b
Hisar	17 a	0	0.0 a	0.1 a
Mean (s.d., n, p.)	31 (19, 18, 0.07)	0 (0, 18, ns)	1.4 (2.1, 18, 0.00)	2.9 (4.8, 18, 0.07)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

4.1.3 Human capital

Human capital comprises the labour and skills available to the household. The average family size is 8. The derived population density at the village level amounts to 400 people per square km. This figure is comparable to the rural population density at the state level (320 Punjab, 340 Haryana—Annex 1), but is relatively low compared to the remainder of the IGP. About a third of the household heads in the surveyed villages had no formal education, although this was significantly lower in the Patiala cluster. Assuming no formal education to be synonymous with illiteracy, our overall average and Haryana figures are somewhat less favourable than the reported male literacy rates at the state level (76–79% Punjab and Haryana—Annex 1). The importance of education was widely acknowledged amongst the villagers, as illustrated by the investment of farm households in the education of the youth.

Table 16. *Human capital indicators*

Cluster	Village level population density (people/km^2)	Family size (#/hh)	Hh head with no formal education (% of hh)
Patiala	440	8.9	16 a
Kurukshetra	310	7.2	41 b
Hisar	480	7.7	39 b
Mean (s.d., n, p.)	410 (190, 18, ns)	7.9 (2.0, 18, ns)	32 (22, 18, 0.07)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison

4.1.4 Financial and social capital

Specific indicators for financial and social capital were not collected in the surveyed communities, but from the village discussions it became clear that they played an important and varied role that merits closer attention in future studies. These assets and the underlying processes like the social relations that shape them were perceived to be too problematic and sensitive to collect and quantify reasonably within the surveyed communities, particularly in view of our rapid scoping study with outsiders spending only half a day in each community.

Financial capital comprises the stocks of money to which the households have access. Convertible assets and cash savings from the various productive activities are important sources of financial capital in the surveyed villages. Livestock often plays an important role as a productive convertible asset. Other convertible assets include stocks of unsold produce. From the discussions it became clear that financial constraints were common place and many households relied on the local credit market to alleviate these leaving a number significantly indebted.

Social capital comprises the community and wider social claims on which individuals and households can draw by virtue of their belonging to social groups of varying degrees of inclusiveness in society at large (Ellis 2000, 36). On average, the surveyed communities comprised 2300 people and 320 households per village (Table 17), providing a rough indicator of social coherence. Social capital influenced some of the transactions within the community (e.g. mobilization of labour, credit, machinery, crop residues, milk). Social capital most likely also plays an important role in times of crises.

Table 17. *Village size*

Cluster	# of people	# of households
Patiala	2400	260
Kurukshetra	1800	290
Hisar	2800	400
Mean (s.d., n, p.)	2300 (1600, 18, ns)	320 (240, 18, ns)

4.2 Access modifiers

The translation of a set of assets into a livelihood strategy composed of a portfolio of income earning activities is mediated by a great number of contextual social, economic and policy considerations. The key categories of factors that influence access to assets and their use in the pursuit of viable livelihoods are access modifiers on the one hand and the trends and shock factors on the other (Figure 3). Access modifiers include social relations, institutions and organizations and comprise the social factors that are predominantly endogenous to the social norms and structure of which the rural households are part. The trends and shock factors consist predominantly of the exogenous factors of economic trends and policies and unforeseen shocks with major consequences on livelihood viability (Ellis 2000, 37–38). The access modifiers as pertaining to the study sites are reviewed here, whereas the subsequent section reviews the trends and shocks.

4.2.1 Social relations

The social positioning of individuals and households within society play a major role in the communities. Social divisions clearly existed in the communities surveyed and resulted in the social exclusion of particular individuals or groups within the communities (e.g. based on caste, class/wealth, origin, gender). For instance, although living within the same village perimeter, landless households typically lived in specific hamlets, often at the edge of the village. Migrant labour sometimes live outside the villages (e.g. in the tubewell house), typically have low social status and are often not considered as part of the resident households in the village. However, as in the case of social capital, and exacerbated by the sensitivities involved (e.g. in the case of caste) specific indicators of social relations within the surveyed communities were difficult to collect through the approach followed.

Gender inequity plays a key role. Across the two states, female literacy is substantially lower (64% Punjab, 56% Haryana) than male literacy (76% Punjab, 79% Haryana—Annex 1). Another clear indicator was the limited participation of women during the group meetings. Women labourers also tend to be paid less than males (see labour market discussion below). In the surveyed villages, there is also a significant gender based division of labour. Women were typically less involved in crop activities and more in livestock activities. Particularly in the Patiala and Kurukshetra clusters this seemed to be a status issue, the better-off households limiting the involvement of the female household members in field based activities. Only in the Hisar cluster was there significant women involvement in crop activities. Even where women are involved in crop field activities, there is division based on type of activities, e.g. women typically do no tractor-based activities but do contribute to various crop management activities such as weeding and harvesting. Women are typically involved in all livestock activities (including milking, watering, fodder/feeding, cleaning), which are more homestead and/or village based. Women's involvement in crop and livestock activities however does not necessarily imply they have a say over the income derived from these activities. Women's say over crop income was reported as increasing from the Patiala cluster to the Kurukshetra cluster to the Hisar cluster, thus in part reflecting their greater involvement.

Women typically have more say over livestock income. Still, the reported levels of women having some say over the derived income are typically only half the level of their reported involvement (Table 18).

Table 18. *Gender issues*

Cluster	Women involved in		Women have say in	
	Crop activities (% of villages)	Livestock activities (% of villages)	Crop income (% of villages)	Livestock income (% of villages)
Patiala	17	100	0	50
Kurukshetra	33	100	33	33
Hisar	100	100	50	67
	50	100	28	50

4.2.2 Institutions

Land and credit market

Most land is privately held, with only a fraction reportedly being communal (4%). The rental and sales market of private land are monetized, with a significant difference in rates between the Patiala and Kurukshetra clusters on the one hand and the Hisar cluster on the other, which is largely a reflection of the more secure irrigation access and the corresponding higher productivity levels and pressure on the land (Table 19). The ratio of rental to purchase price averages 2%. This indicator of the average annual return to investment in land thereby is lower than the prevailing rate of interest. This suggests that despite the high pressure on land, financial capital remains the most limiting production factor.

Compared to the other states in the IGP, credit markets are relatively developed in Punjab and Haryana. Institutional sources have been widely used for mechanization investments (e.g. 12% per year for vehicle/tractor; 9% per year for implements)—leading some to fear that this has contributed to an over-tractorization (Sharma 2004). Yet despite the availability of institutional sources, informal moneylenders still seem to meet the bulk of credit demand in the surveyed villages. Indeed, for many households institutional credit is often either not available (e.g. in view of the limited sums involved or the lack of collateral) or not desired (e.g. in view of the transaction costs involved). The reported informal interest rate averaged 1.75–2% per month (Table 19), which was significantly lower than the rates charged in the other surveyed states of the IGP. Other sources of credit include the provision of inputs on credit, credit from market traders, consumer credit from Cooperative societies and the recently initiated public Kisan Credit Card scheme (a public scheme to facilitate farmer credit access to working capital).

Table 19. *Selected credit and land market indicators*

Cluster	Interest rate moneylenders (%/year)	Irrigated land rental price ('000 INR/ha)	Irrigated land purchase price ('000 INR/ha)[a]	Rental: purchase price (%)
Patiala	21 a	37 b	1,500 b	3.0
Kurukshetra	24 b	28 b	1,500 b	1.5
Hisar	24 b	15 a	700 a	1.8
Mean (s.d., n, p.)	23 (2.2, 17, 0.01)	27 (12, 17, 0.04)	1,300 (600, 17, 0.03)	2.1 (0.8, 5, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.
a. Based on combination of reported values and estimated values. Estimated values replace missing values using reported rental price in village and 2.1% as average rental:purchase price ratio.

Labour market

There is an active rural labour market in each community. The average wage rate amounted to INR 87 per day (Table 20), which compares reasonably against the statutory minimum daily wage of INR 83 in Punjab and Haryana. The average wage rate is relatively high compared to other IGP states (Erenstein et al. 2007). Crop labour needs are highly seasonal and nearly all villages reported periods of labour scarcity. Wage rates typically nearly double during peak periods (Table 20), such as wheat and rice harvesting and rice transplanting.

Table 20. *Selected labour market indicators*

Cluster	Male wage rate (INR/day)	Female: male wage ratio	Peak: average wage ratio	Labour scarcity (% of villages)	Seasonal in-migration (% of villages)	Seasonal out-migration (% of villages)
Patiala	91	0.7 a	1.8	100	100 b	50
Kurukshetra	79	0.8 a	1.9	83	100 b	50
Hisar	92	0.9 b	2.0	100	50 a	33
Mean (s.d., n, p.)	87 (14,16, ns)	0.8 (0.2, 16, 0.01)	1.9 (0.5, 14, ns)	94 (24, 18, ns)	83 (38, 18, 0.02)	44 (51, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Female wage rates tend to be lower than male wage rates, although this could partly reflect differences in working hours and the type of tasks implemented. The extent of the wage difference also depends on the locality. In the Patiala and Kurukshetra clusters women's wage rates averaged 70–80% of men's, whereas in the Hisar cluster 90% (Table 20), reflecting the more active involvement of women in crop activities in Hisar. Women labourers tend to be local.

The surveyed communities are net-users of agricultural labour. All villages in the Patiala and Kurukshetra clusters reported seasonal in-migration, typically seasonal male migrants from Bihar and UP, particularly for rice transplanting and harvest. This seasonal migration originally started with the advent of rice as a new crop in Punjab and Haryana, in response to the seasonal labour demand and the limited enthusiasm of local labourers for working in standing water. A recent study (Singh 2006) estimates that migrant labour in Punjab now comprises 17% of the state's population. In the Hisar cluster only half the villages reported seasonal immigration, partly a reflection of the prevailing wheat–cotton cropping system. Compared to seasonal in-migration, seasonal out-migration of villagers to work elsewhere was half as common in each of the surveyed communities.

Agricultural input and output markets

Chemical fertilizer and herbicides are widely used and their availability does not seem to be an issue in general, although untimeliness of particularly fertilizer through public channels was mentioned in some communities. The purchase of improved seeds is widespread, but provides only a rough aggregate proxy as it will vary by crop species and type. For instance, seed purchase is not systematic for the prevalent wheat and rice crops as seed re-use is common. Overall improved seed is considered positively, thus enhancing productivity, accessible and good value. Non-price issues of external inputs seem more important than price issues, including timeliness of access and method of application. There are also active markets for machinery services, particularly for tractor services (all clusters) and for combiner services (the Patiala and Kurukshetra clusters).

Table 21. *External input use (% of hh reportedly using)*

Cluster	Purchase improved seeds	Chemical fertilizers	Herbicides
Patiala	61	92	100
Kurukshetra	85	100	100
Hisar	78	100	83
Mean (s.d., n, p.)	74 (28, 18, ns)	97 (12, 18, ns)	94 (19, 18, ns)

Punjab and Haryana are the prime beneficiaries of the Minimum Support Price (MSP) schemes for rice and wheat (World Bank 2005a, 19). The Food Corporation of India (FCI) thereby procures nearly 100% of total market arrivals of wheat in both states and approximately 90% (Punjab) and 50% (Haryana) of total market arrivals of rice. The lower share for rice in Haryana partly reflects the greater extend of Basmati cultivation, which does not fall under the scheme. As a result, farmer reported prices for wheat and paddy are constant across villages and reflect the MSP for 2004–05 (INR 6.4 per kg and INR 5.9 per kg Grade A respectively, Table 22). The assured market and steady increases in the MSP have removed market risk from these crops and have benefited the rice–wheat producers considerably. Other crops do not benefit from similar schemes and are thereby subject to market risk.

Table 22. *Selected commodity prices (INR/kg, farm gate)*

Cluster	Wheat	Paddy	Basmati paddy
Patiala	6.4	5.9	9.5
Kurukshetra	6.4	5.8	11.9
Hisar	6.4	5.9	9.0
Mean (s.d., n, p.)	6.4 (0.0, 17, ns)	5.9 (0.2, 14, ns)	10.8 (2.0, 9, ns)

For comparative purposes selected livestock prices were compiled during the group discussions (Table 23). The reported purchase/sale prices of the different cattle types suggest significant differences in relative livestock demand and preferences. Across the three clusters, buffalo fetched the highest price per head, followed by cross-bred cattle and *desi*/local cattle. Whereas prices were relatively similar in the Patiala and Kurukshetra clusters, the Hisar cluster reported relatively high prices for *desi* cattle and buffalo.

Table 23. *Selected animal and produce prices (INR, farm gate)*

Cluster	Local cow (INR/head)	Crossbred cow (INR/head)	Buffalo (INR/head)	Milk (INR/litre)
Patiala	1,200	11,300	15,000 a	10.7
Kurukshetra	2,700	11,500	16,500 a	10.0
Hisar	4,800	10,000	23,100 b	10.6
Mean (s.d., n, p.)	3,800 (1,900, 11, ns)	10,900 (2,400, 18, ns)	18,200 (5,300, 18, 0.01)	10.4 (1.8, 17, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

More surprisingly, milk prices were relatively constant at INR 10–11 per litre across the three surveyed clusters and villages despite varying closeness to urban centres. Most milk was reportedly traded through local milk salesmen/cooperatives without industrial processing and/or consumed/sold locally within village/household. No direct sales to pasteurizing plants were reported in the surveyed villages. In Punjab, approximately 50 pasteurizing plants exist, but these still only have a small market share.

There are also active markets for crop residues (particularly wheat residues or *bhusa*) and other livestock feed (e.g. concentrates, green fodder). These will be dealt with in more detail when discussing crop–livestock interactions (chapter 6).

4.2.3 Organizations

In terms of organizations, the study focused the discussions on agricultural services. The use of artificial insemination (AI), veterinary, livestock and crop extension services is reportedly widespread (Table 24). AI is primarily used for cross-bred (dairy) cattle and this service apparently satisfies a demand from livestock keepers—particularly in view of allowing quality improvement of the stock and the cost of keeping male stock for bull services and the correspondingly limited numbers of bulls in the village. Some organizational issues and poor access were reported for AI and veterinary services. Despite the reported use of extension services, lack of access to new knowledge sources was perceived to be an issue that limited the development of the systems. Village cooperative societies played a varying role in terms of farm input supply/acquisition and the provision of farm machinery services to members and non-members. These organizations sometimes also accept deposits and supply daily consumption items on credit.

Table 24. *Use of selected agricultural services (% of hh reportedly using)*

Cluster	Artificial insemination	Veterinary services	Livestock extension	Crop extension
Patiala	70	100 b	55	80
Kurukshetra	59	82 a	78	100
Hisar	67	100 b	52	82
Mean (s.d., n, p.)	65 (38, 18, ns)	94 (17, 17, 0.09)	63 (40, 15, ns)	86 (28, 11, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

4.3 Trends and shocks

Wheat is the traditional food crop in the surveyed communities. In the Patiala and Kurukshetra clusters rice came in as a new crop in the mid-1970s and now is the prevalent *kharif* crop. These clusters thereby typify the Green Revolution and the rapid transformation of the regional agricultural systems into the national granary. Active public intervention to stimulate agricultural growth were important at the time, including the development of irrigation, input supply systems (including technological improvement, dissemination and subsidies) and favourable output markets (including price policy and effective procurement of food grain). These have initially boosted wheat and rice yields and returns and thereby shifted the crop pattern in favour of these crops in the Patiala and Kurukshetra clusters and across Punjab and Haryana (Annex 2). In the Hisar cluster irrigation limitations have prevented any significant spread of rice.

One of the striking features of the surveyed communities is the perceived current *status quo*. After the rapid changes of the 1970s, the systems seem to have plateaued and stagnated over the last decade. The use of improved seed and agro-chemicals is widespread and well-established (fertilizer universal, herbicides widespread). The labour peaks and scarcities increased the agricultural labour costs. These, together with enhanced timelines, provided the driver for widespread mechanization and herbicide use. Particularly in the Patiala and Kurukshetra clusters tractor use is now near universal and combiner use widespread (Table 25). The widespread use of mechanization relies heavily on contracted services, as ownership of machinery is significantly less and farm size is small (Table 15). Beri et al. (2003, 31) found that 87% of farmers in Punjab and 43% in Haryana used mechanized planting for wheat instead of traditional broadcasting, whereas manual transplanting still was the universal practice for rice. One of the more recent changes is the advent of zero tillage wheat using a tractor drawn zero till seed drill. There was widespread knowledge of zero tillage in the surveyed communities, but its use was largely limited to the Kurukshetra cluster and to a lesser degree the Patiala cluster (Table 25). Cost savings seemed to be the main drive behind its adoption. Another recent household survey in the rice–wheat systems of Haryana has reported adoption levels of 34.5% for zero-tillage wheat (Erenstein et al. 2006), driven by a significant 'yield effect' and a 'cost saving effect'. The use of combiner still seems to be spreading, and social consequences thereof merit attention. The advent of the combiner has subsequently led to the increased use of the *bhusa* combine/reaper particularly in the Kurukshetra cluster—which harvests wheat straw left in the field by the combine harvester (Thakur and Papal 2005).

Table 25. *Mechanization and zero tillage (ZT) indicators*

Cluster	Use of tractor (% of farm hh)	Use of combiner (% of farm hh)	Knowledge of ZT (% of villages)	Use of ZT (% of farm hh)
Patiala	98 b	85 b	100 b	8 a
Kurukshetra	97 b	77 b	100 b	18 b
Hisar	72 a	2 a	33 a	0.3 a
Mean (s.d., n, p.)	89 (23, 18, 0.08)	57 (42, 16, 0.00)	78 (43, 18, 0.00)	9 (11, 18, 0.02)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

The dominance of wheat and rice in terms of crop production has not been challenged of late in the surveyed villages. In fact, the area under the two crops in the Patiala and Kurukshetra clusters still tended to be upward during the last decade in view of their relatively stable and high returns. Sugarcane was the crop that was most commonly reported to have been reduced in terms area, primarily due to payment problems by sugar mills. In general across the subregion, market factors (e.g. market access, market assurance) rather than technological change are driving the changes. An exception to this rule is the advent of mung bean in the Hisar cluster, made possible by new short duration varieties.

One of the striking features of the communities surveyed was the lack of shocks having widespread impact on the rural population. Shocks seemed primarily individual and social in scope (e.g. accidents, sudden illness, loss of access rights etc.), with immediate effects on the livelihood viability of the individuals and households concerned. The communities thereby seemed relatively stable and secure. Only in the Hisar cluster was some mention made of occasional livestock disease shocks linked to the transhumance of cattle from Rajasthan. The extent and importance of seasonal livestock migration between the plains and the hills seems to have dwindled over time (e.g. Singh and Grewal 1990).

5 Livelihoods strategies

The asset status of households, mediated by social factors and exogenous trends and shocks, results in adoption and adaptation over time of livelihood strategies. Livelihood strategies are dynamic and are composed of activities that generate the means of household survival (Ellis 2000, 40). The present chapter reviews the main livelihood activities in the surveyed communities: crop production, livestock and non-farm based activities.

5.1 Crop production

Crop production is the major activity for households with access to land (owned or hired, i.e. farm households). The prevalence of irrigation infrastructure typically allows for two crop seasons per year, each season with its distinct set of crops. In *kharif*/monsoon season, the village cropped area is allocated to rice (50%), pulses/oilseeds (13%), fodder crops (10%), other cereals (5%), sugarcane (3%), horticulture (4%) and other crops (10%—Table 26). These averages however mask significant variation over the three clusters. Rice is primarily concentrated in the Patiala and Kurukshetra clusters (70–75% cropped area), and virtually absent from in the Hisar cluster (5%) due to irrigation constraints. Our figures for the Patiala and Kurukshetra clusters compare reasonably with Beri et al. (2003, 17): in their survey they found that rice occupied 82 and 73% of cropped area in Punjab and Haryana, respectively. The Patiala and Kurukshetra clusters in turn differ in some respects, sugarcane being more widely grown in the Kurukshetra cluster. Being located in the 'Basmati-belt', the Kurukshetra cluster also has a significantly higher rice area share devoted to fine rice types (primarily scented Basmati rice). Basmati rice is of higher value than coarse rice (Table 22), but is lower yielding and subject to market risk. The relative absence of rice in the Hisar cluster implies a more varied cropping pattern, including pulses/oilseeds (e.g. cluster bean, mung bean, kidney bean), cotton and millet. A striking similarity amongst the clusters is the area devoted to fodder crops (primarily sorghum/jowar), a reflection of the importance of the livestock activity and lack of alternative fodder sources.

Table 26. *Crop share of* kharif *area (% of village cultivable area)*

Cluster	Rice	Other cereal	Sugarcane	Horticulture	Pulses/ oilseeds	Other crops	Fodder crops
Patiala	76 b	0 a	1 a	4	4 a	0 a	12
Kurukshetra	69 b	0 a	7 b	8	3 a	0 a	8
Hisar	5 a	16 b	0 a	1	33 b	31 b	9
Mean (s.d., p.) [n=18]	50 (37, 0.00)	5 (10, 0.00)	3 (6, 0.07)	4 (8, ns)	13 (19, 0.00)	10 (21, 0.08)	10 (9, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

In *rabi*/winter season, the village cropped area is allocated to wheat (66%), fodder crops (9%), pulses/oilseeds (8%) and horticulture (2%—Table 27). Whereas the Patiala and Kurukshetra clusters are relatively similar in terms of *rabi* crops and with three-quarter devoted to wheat, the Hisar cluster again is significantly different. In the Hisar cluster irrigation facilities limit the area devoted to wheat to half the cultivated area, with a significant share devoted to pulses/oilseeds (particularly mustard and rapeseed). Fodder crops (primarily Egyptian clover/*berseem*) again provide a striking similarity amongst the clusters. Our figures for the Patiala and Kurukshetra clusters again compare reasonably with Beri et al. (2003, 17): in their survey they found that wheat occupied 86 and 83% of cropped area in Punjab and Haryana, respectively.

Table 27. *Crop share of* rabi *area (% of village cultivable area)*

Cluster	Wheat	Other cereal	Sugarcane	Horticulture	Pulses/ oilseeds	Other crops	Fodder crops
Patiala	75 b	0	1 a	3	1 a	0	11
Kurukshetra	75 b	0	3 b	1	2 a	0	9
Hisar	48 a	0	0 a	1	20 b	0	7
Mean (s.d., p.) [n=18]	66 (25, 0.08)	0 (1, ns)	1 (3, 0.07)	2 (3, ns)	8 (12, 0.00)	0 (0, ns)	9 (9, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Rice–wheat is the main cropping system in the surveyed communities (61% of overall villages, Table 28), though limited to the Patiala and Kurukshetra clusters. Wheat-based systems (22% overall) prevailed in the semiarid Hisar cluster primarily due to irrigation constraints, and include cotton–wheat (11% overall), cotton–wheat/pulses/oilseeds (6%) and pulses/oilseeds–wheat (6%). Irrigation constraints imposed a pulses/oilseeds–fallow system to the other communities in the Hisar cluster (17% overall). A rice-based system prevailed in one community in Patiala (6% overall), and included significant fodder crops in both monsoon and winter (rice/fodder–fodder). The dominance of wheat in the cropping pattern (all clusters) and rice (the Patiala and Kurukshetra clusters) is thereby prominent. All systems however also have approximately 10% of the cultivated area devoted to fodder crops in both seasons.

Table 28. *Main cropping system (% of villages)*

Cluster	Rice based	Rice–wheat based	Wheat based	Other
Patiala	17	83	0	0
Kurukshetra	0	100	0	0
Hisar	0	0	67	33
Mean [n=18]	6	61	22	17

Another striking feature of crop production is its extent and intensity. The seasonal cropping intensity in the surveyed villages averages 96% in *kharif* and 86% in *rabi*, resulting in an annual cropping intensity of 182%. The corresponding figures for the Hisar cluster are somewhat lower, due to irrigation constraints that limit the *rabi* area. The intensity in the study villages compares well with the overall averages of 187% and 173% reported for Punjab and Haryana State, respectively (Annex 1).

Table 29. *Cropping intensity indicators (% of cultivable land)*

Cluster	Kharif	Rabi	Annual
Patiala	97	91	188
Kurukshetra	95	91	186
Hisar	95	76	171
Mean (s.d., n, p.)	96 (9, 18, ns)	86 (19, 18, ns)	182 (23, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

The reported yields for the two main crops are relatively favourable (3.8 t/ha for wheat and 6.3 t/ha for paddy), the highest amongst the IGP subregions surveyed (Erenstein et al. 2007). This reflects the combination of widespread irrigation facilities and input use and a relatively favourable agro-climate. The Patiala cluster reported significantly higher yields than the two other clusters, both for rice and wheat (Table 30). In the case of rice this likely reflects the less widespread cultivation of fine rice types, which typically have lower yields than coarse rice. In the case of wheat this likely reflects more timely planting. The reported wheat yields compare reasonably with the state wide averages reported of 4.2 and 4.0 t/ha for Punjab and Haryana, respectively, in 2003–04, which in turn are significantly higher than the national average of 2.7 t/ha (Annex 2). Rice yields average 3.7 and 2.7 t/ha state wide in Punjab and Haryana respectively in 2003–04, which again are significantly higher than the national average of 2.1 t/ha (Annex 2).

Rice is primarily produced for the market in all three clusters, with approximately all produce marketed except for seed retained (Table 30). While wheat is mainly produced for the market, a significant share is retained for own consumption (Table 30). The marketed share in the Hisar cluster is relatively low in view of the more limited wheat area. The orientation of rice and wheat production thereby clearly reflects the traditional preference for wheat consumption in the area. The marketed shares compare well against the average marketed surplus ratios for the triennium 1999–2002, with 96 and 91% for rice and 80 and 78% for wheat in Punjab and Haryana, respectively (Annex 1; MoA 2004a), which are both significantly higher than the nationwide average of 70% for rice and 67% for wheat.

Table 30. *Rice and wheat: Yields and marketed surplus*

Cluster	Wheat (t/ha)	Paddy (t/ha)	Marketed share wheat (%)	Marketed share paddy (%)
Patiala	4.3 b	7.0 b	79 b	96
Kurukshetra	3.3 a	5.3 a	78 b	92
Hisar	3.5 a	6.0 a	42 a	99
Mean (s.d., n, p.)	3.8 (0.7, 15, 0.05)	6.3 (1.0, 12, 0.00)	68 (24, 17, 0.00)	94 (7, 14, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

5.2 Livestock production

5.2.1 Types of livestock

Consistent with expectations, the surveys confirmed that in the TGP subregion wheat–rice–buffalo farming systems were the basis of rural livelihoods. In each of the three clusters nearly all large and small landholders and landless households kept buffalo (Table 31) with an average of 2.5 heads per village household (Table 32). *Desi*/local cows were kept by many fewer households (10% village households), while relatively more households had dairy crossbreds (18% village households). Draught animals (mainly male buffalo and to a lesser extent oxen) were kept by two-fifth of sample village households (Table 31) with an average of 0.4 heads per village household (Table 32). In contrast to bovines, other livestock were kept by very few households (Table 31), except some equines and camels in the Hisar cluster (see Annex 5:18). Any small-stock (sheep, goats and pigs) were invariably kept by landless families and mainly in drier areas (the Hisar cluster) where they depended upon grazing the limited common property resources that remain in these intensely cropped areas (see Annex 5:17).

Notable was that very few households had backyard poultry (Table 31). Nor in the surveyed villages were there commercial (broiler and layer) chickens, the development of which has been limited in Punjab (relative to Andhra Pradesh) by policy constraints (regulation, taxation). By contrast there have been no such barriers to dairy herd expansion.

Underlying these livestock ownership figures were some clear trends. In each location the number of *desi* cows was declining and being substituted by buffalo (Murrah) and dairy crossbred cows. The proportion of households with crossbreds varied reflecting production tradeoffs relative to buffalo in terms of milk quality and quantity and sturdiness.

Table 31. *Livestock ownership (% of hh)*

Cluster	Buffalo	Local cow	Crossbred cow	Draught	Caprine and ovine	Pigs	Poultry	Equine and camel
Patiala	100 b	1	7	18	0.7 a	0.3	1.3	0.5
Kurukshetra	100 b	20	34	56	0.3 a	0.3	0.3	0.2
Hisar	93 a	8	13	45	1.8 b	0.1	0.0	11
Mean (s.d., p.) [n=18]	97 (6, 0.07)	10 (18, ns)	18 (27, ns)	40 (43, ns)	0.9 (1, ns)	0.2 (0.5, ns)	0.6 (1.3, ns)	4 (11, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 32. *Livestock numbers (heads per hh)*

Cluster	Buffalo	Local cow	Crossbred cow	Draught	Caprine and ovine	Pigs	Poultry	Equine and camel
Patiala	3.3	0.0	0.3	0.2	0.1	0.0	0.2	0.0
Kurukshetra	2.3	0.4	0.4	0.3	0	0.0	0.0	0.0
Hisar	1.8	0.2	0.1	0.6	1.2	0.0	0.0	0.1
Mean (s.d., p.) [n=18]	2.5 (1.5, ns)	0.2 (0.5, ns)	0.2 (0.3, ns)	0.4 (0.6, ns)	0.4 (1.4, ns)	0.0 (0.0, ns)	0.1 (0.3, ns)	0.0 (0.1, ns)

Whereas earlier years had seen declining numbers of draught bovines (Table 6), over the last decade numbers have been surprisingly stable apparently because they still fulfil important transport functions, although currently they contribute little to tillage operations. The limited market opportunities for male cattle (in terms of meat production) appear to enhance the preference for buffalo.

It emerged from the surveys that the increases in buffalo ownership reported in the Hisar cluster reflect their lower production risks relative to cropping and the good market opportunities for milk. On the other hand, in the Patiala cluster where no increase in buffalo keeping was reported, it was associated with a saturated market for milk in an area of low production risk for the dominant crops, wheat and rice. Reports of declining buffalo ownership in the Kurukshetra cluster were related to management and labour issues.

The aggregate livestock herd averaged 4.6 cow equivalents per household (Table 33), the highest amongst the IGP subregions surveyed (Erenstein et al. 2007). Invariably bovines were stallfed in or near the household compound with chopped wheat straw as the basal diet (see Annex 5 for pictures). The preference for buffalo over cattle (on average 2.5 buffalo to 0.4 cattle per household, i.e. 6:1, Table 32) reflected owners' decision-making based on: (i) their observations of buffalo's production being less risky and more stable relative to crossbreds; (ii) the assured market in which the milk price was based on composition therefore favouring buffalo's high fat milk; and, (iii) the possibility of selling male calves and older culls (in contrast with cattle).

Table 33. *Livestock and milk sales*

Cluster	Herd size (# of cow equivalents per hh)	Regular livestock sales (% of villages)	Non-local livestock sales (% of villages)	Marketed share milk (% of output)
Patiala	5.3	33	50	71
Kurukshetra	4.6	17	33	49
Hisar	3.8	33	0	56
Mean (s.d., n, p.)	4.6 (2.6, 18, ns)	28 (46, 18, ns)	28 (46, 18, ns)	59 (28, 18, ns)

5.2.2 Marketing of livestock

As was shown by the results in Table 23, livestock keepers' preferences were matched by the much higher prices they paid for buffalo relative to dairy crossbreds and *desi* cattle. In most sample villages these sales and purchases were not regular occurrences (Table 33). In the Patiala cluster and to an extent in the Kurukshetra cluster but not in the Hisar cluster, some sales were outside the locality. Given the market value of buffalo (Table 23), these occasional sales will represent an important source of 'lumpy' cash which, on an annual basis, may exceed in value the income from milk sales, particularly as in the sample villages in the Kurukshetra and Hisar clusters, extracted milk yields were generally low and only about half of the milk was marketed (Table 33). Consequently the buffalo herd appears to serve less as a commercial dairy enterprise and more to fulfil the integrated functions of providing milk for household needs with surplus sold; dung for fuel and manure (Table 47); and to 'grow' capital for savings, financing and insurance purposes. This scenario is consistent with the low productivity of the buffalo herd reported in each of the three locations during the surveys. The scenario underlines the importance of the buffalo and its multiple functions which complement and are closely integrated with the rice–wheat cropping system in the risk-avoidance livelihood strategies of these rural households. In this regard, dairy is more of a tradition than a commercial venture in the agrarian economy of the TGP (Sidhu and Singh 2004).

The important role of livestock extends to the landless: the surveys confirmed that 50–100% of landless households kept livestock, with buffalo and cattle dominating in the Patiala and Kurukshetra clusters, while in the Hisar cluster some landless households had bovines, but others small ruminants, as expected in this more marginal agro-ecology. The livestock served the landless as an important source of cash income from sales of milk, fuel/manure and animals, and to meet home consumption needs, particularly of milk. A key factor favouring livestock was that it absorbed family labour, which had a relatively low opportunity cost. Another way through which the landless realized the livelihood benefits was through raising (share-cropping) young stock on a 50–50 basis, which was an effective way of accessing scarce feed resources (mainly straws) through this contractual relationship with land-owning households.

5.3 Non-farm based activities

After crop and livestock production, rural households in the surveyed communities are variously engaged in different types of off-farm activities. Such activities typically include farm labour on other farms, self employment and employment/service elsewhere. About half of the surveyed villages mentioned members of some households seasonally migrating out of the village (Table 20), mainly to work as farm labour in other villages and to a lesser extent as non-farm labour (e.g. masonry). Particularly the engagement in farm labour can be seen as indicator of relative poverty for the concerned household and is often associated with the landless.

5.4 Relative importance of livelihood activities

In the surveyed communities, the main livelihood activities were crop farming (65%), farm labour (14%), livestock rearing (13%), self employed (3%) and employed outside district (5%) (Table 34). There was some variation over the clusters, with crop farming being above average in the Patiala cluster, farm labour featuring most prominently in the Kurukshetra cluster and livestock rearing in the semi-arid Hisar cluster. The divergences over the clusters in part reflect the differential asset base available to the households (Table 35). Across surveyed communities, small farmers comprised the lion's share of rural households (57%), followed by landless poor (29%), large farmers (12%) and landless rich (2%). The communities in the Patiala cluster seemed to be relatively less skewed in terms of land access categories, with 75% categorized as small farmer, 14% landless and 9% large farmers. The communities in the Kurukshetra and Hisar clusters reported relatively more landless and more large farmers.

Our findings compare reasonably with a recent study (Khattra and Kataria 2005, 32) which reported the main occupational activities for rural households across Punjab to be crop farming (51%), farm labour (17%), service (11%), dairying (5%) and others (e.g. self-employment and business, 16%). In terms of subsidiary activities in the same study, dairying featured prominently (68%), followed by crop farming (22%) and others (5%).

Table 34. *Main livelihood activity (% of hh)*

Cluster	Crop farming	Livestock rearing	Employed on other farms	Self employed	Employed outside district
Patiala	77	10 a	4 a	4	5
Kurukshetra	56	5 a	31 b	2	7
Hisar	63	24 b	8 a	2	3
Mean (s.d., p.) [n=18]	65 (19, ns)	13 (13, 0.03)	14 (17, 0.01)	3 (3, ns)	5 (6, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 35. *Categorization of village households (% of hh)*

Cluster	Landless rich	Landless poor	Small farmers (<4 ha)	Large farmers (>4 ha)
Patiala	3	14	75 b	9
Kurukshetra	0	38	51 a	11
Hisar	4	35	46 a	15
Mean (s.d., p.) [n=18]	2 (4, ns)	29 (25, ns)	57 (25, 0.09)	12 (15, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Access to land provides a key indicator for differentiating amongst household livelihood strategies. For landed households crop production appeared as the main livelihood source, with livestock typically complementary and to a large extent dependent on the crop enterprise. Landless households depend primarily on their labour asset, with livestock providing an important contribution.

The increasing labour cost and drive for mechanization clearly have different implications for the livelihood strategies of landed and landless household, being a major cost of production for one and a major income source for the other. Most resident farm labourers worked locally and faced competition from seasonal migrants during the times of rice harvesting and rice transplanting.

Farm households typically contract casual labour for their crop operations (81%, Table 36). To a much lesser extent, use is made of permanent labourers, both for crop operations (25% farm households) and livestock activities (24% households). Casual labour is only sporadically used for livestock activities. These averages again mask significant differences across clusters. In terms of contracting casual and permanent labour for crop operations, the Patiala and Kurukshetra clusters show similar rates but such contracting is significantly lower in the Hisar cluster—largely a reflection of the less intensive cropping systems in this semi-arid area. On the other hand, contracting of casual and permanent labour for livestock operations is primarily concentrated in the Patiala cluster. Compared to the other IGP subregions, all labour use indicators are high (Erenstein et al. 2007).

Table 36. *Labour use by enterprise*

Cluster	Crop		Livestock	
	Use of casual labour (% of farm hh)	Use of permanent labour (% of farm hh)	Use of casual labour (% of hh)	Use of permanent labour (% of hh)
Patiala	90	32	24 b	51 b
Kurukshetra	89	39	3 a	13 a
Hisar	64	4	0 a	8 a
Mean (s.d.,) [n=18]	81 (29, ns)	25 (32, ns)	9 (20, 0.07)	24 (33, 0.04)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

6 Crop–livestock interactions

The previous two chapters presented the livelihood platforms and livelihood strategies pursued by the surveyed communities. Within this context, the present chapter specifically looks into the crop–livestock interactions. We start by reviewing the flows of the crop activities into the livestock activities. Particular emphasis is put on understanding crop residue management and livestock feeding practices. We subsequently address the reverse flows from livestock into crop activities—particularly in terms of manure and traction services. The chapter ends with an assessment of crop–livestock interactions.

6.1 Crop residue management

Crop residues (straw) are an important by-product of crop production and all the surveyed communities reported their use as animal feed. However, significant differences exist between the wheat and rice crops. The use of wheat residues (*bhusa*) as animal feed is near universal amongst the rural households. This stands in stark contrast with the use of rice residues, which are only used to some extent in the Kurukshetra cluster and are sporadically used elsewhere (Table 37). Two key factors explain the observed differences. Most striking perhaps is the importance of tradition: wheat is the traditional food crop in the subregion and this has made wheat residue the traditional dry fodder. Rice is a relatively recent arrival and farmers do generally not consider coarse grain rice residues as suitable animal feed (amongst others due to perceived silica content and fear of reduced milk yield, e.g. Sidhu et al. 1998, 164). This is in stark contrast with the traditional rice growing areas further east, where rice residues of similar varieties are intensively used as livestock feed (Varma et al. 2007). Within the TGP, only crop residues from fine grain rice varieties (particularly Basmati) are more widely appreciated and used as animal feed, explaining the more significant rice residue use in the Kurukshetra cluster. By-products from other crops can also provide additional sources of feed, particularly sugarcane tops and the crop residues from other cereals (e.g. millet and sorghum in the semi-arid Hisar cluster).

Table 37. *Crop residue collection for* ex situ *livestock feed (% of hh)*

Cluster	Wheat	Rice	Other crops
Patiala	100	2 b	0 a
Kurukshetra	98	63 a	35 ab
Hisar	87	2 b	60 b
Mean (s.d., n, p.)	95 (19, 18, ns)	28 (40, 14, 0.01)	30 (47, 17, 0.09)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Livestock pressure on crop residues is relatively similar per cultivated ha across the communities surveyed. However, in view of the above crop differences, more disaggregated measures of pressure seem more appropriate (e.g. per cereal ha and per wheat ha).
The Patiala and Kurukshetra clusters highlight relatively similar pressures for the various indicators. The corresponding disaggregated pressures in the Hisar cluster tend to be higher, in view of the prevailing wheat–cotton system (Table 38). Compared to other IGP states, the livestock pressure on crop and cereal residues is relatively low in the TGP, reflecting its larger farm size (Erenstein et al. 2007).

Table 38. *Indicators of livestock pressure on crop residues (cow equivalents per hectare at village level)*

Cluster	On crop residue (cow eq./ha)	On cereal residue (cow eq./ha)	On wheat residue (cow eq./ha)	On rice residue (cow eq./ha)
Patiala	1.0	1.7	3.7	3.2 a
Kurukshetra	1.0	1.3	2.5	2.7 a
Hisar	1.2	3.0	5.5	33 b
Mean (s.d., p.) [n=18]	1.1 (0.7, ns)	2.0 (1.7, ns)	3.9 (3.5, ns)	7.2 (15, 0.02)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Crop residue use as livestock feed primarily relies on harvesting the residues for *ex situ* use (stall feeding). *In situ* stubble grazing is absent from the rice–wheat zone, but some stubble grazing has been reported in the semi-arid Hisar cluster (Table 39). About three-quarter of the villages also reported other than livestock feed uses for crop residues (Table 39). About a third of the villages reported the use of rice residues for industrial processing (cardboard factories, paper mills), particularly in the Kurukshetra cluster. Other reported rice residue uses included fuel and construction material (e.g. thatching and ropes, particularly for making *bhusa* stacks). Overall though the quantities involved in non-feed uses were relatively small.

Table 39. *Crop residue management practices (% of villages)*

Cluster	*Ex situ* feed use	*In situ* grazing	Non-feed use	*In situ* burning
Patiala	100	0	67	100 b
Kurukshetra	100	0	100	100 b
Hisar	100	33	50	33 a
Mean (s.d., n, p.)	100 (0, 18, ns)	11 (32, 18, ns)	72 (46, 18, ns)	87 (35, 15, 0.00)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

The practice of *in situ* burning of crop residues is widespread in the wheat–rice zone, and much less so in the wheat–cotton zone of the Hisar cluster (Table 39). The practice of *in situ* burning as a land preparation measure is reported for both rice and wheat crops. However, the quantities of crop residue actually burned are significantly higher in the case of rice. Rice residues having limited value as livestock feed or for non-feed use, are generally left in the field after the harvest and subsequently burned. By contrast wheat residues are intensively collected with only the leftovers burned in the field (see Annex 5:5). A recent study reported similar findings (Table 40, Beri et al. 2003). The practice of burning is a reflection of farmers' perceived need to have 'clean' fields prior to initiating their mechanized land preparation. Indeed, in an earlier study in Punjab, surveyed farmers indicated that incorporating residues into the soil involved additional labour, irrigation and tillage (Sidhu et al. 1998, 165). Burning is primarily done to vacate the field in little time (reported by 71% farmers in Punjab, 96% Haryana—Beri et al. 2003) whereas the cost of collecting the residue was perceived to be high (55% Punjab, 1% Haryana—Beri et al. 2003).

Table 40. *Residue use by volume (survey data, % of residue produced on 501 farms*

	Punjab		Haryana	
	Rice	Wheat	Rice	Wheat
Burned *in situ*	82	17	63	24
Fodder	4	59	19	68
Incorporated *in situ*	11	0	14	4
Sold	2	24	2	3
Other use	0.5	0.3	2	1

Source: Beri et al. (2003, 20–24).

The choice of harvesting mode (manual or combine) has direct implications and tradeoffs for crop residue management. Manual harvesting of cereal crops is labour intensive but allows for maximum recovery of crop by-products by allowing crops to be cut at near ground level and subsequent off-site threshing (see Annex 5:16). The recovery of by-products by combine harvesting is more problematic as the crop is cut well above ground level and the cut residues are spread unevenly over the harvested fields (see Annex 5:4). Combiners are used to harvest both rice and wheat in the rice–wheat areas, but the extent of their use tends to be more for rice (rice vs. wheat area share: Punjab: 87–92% vs. 53–59%; Haryana: 62% vs. 51%—Beri et al. 2003; Sidhu et al. 1998). The tradeoffs for combining rice in terms of residue foregone indeed tend to be more limited. In fact, a study reported that almost half the surveyed farmers in Punjab cut the rice stubble with a tractor-drawn shredder after combining to hasten drying and realize a more effective burning (Sidhu et al. 1998). Another important factor is the timeliness of wheat establishment; combining generally has favourable implications for reducing the turn-round time between rice and wheat.

To address the potential loss of wheat residues when combining, a *bhusa*/chaff combine was developed by local manufacturers in Punjab in the mid-1980s. The tractor-pulled machine collects the straw, cuts the stubbles, processes the straw into *bhusa* and collects it in a enclosed trailer attached behind (Thakur and Papal 2005). The *bhusa* combiner implies additional costs and recovers at least half of the residue (Beri et al. 2003; Thakur and Papal 2005). The *bhusa* combiner/reaper seems increasingly popular in the Patiala and Kurukshetra clusters (100 and 67% of surveyed villages reporting use) as well as elsewhere in the rice–wheat belt of Punjab and Haryana (Sidhu and Singh 2004) in response to an opportunity to be able to use the combine harvester while retaining most of the valuable wheat residues.

The widespread mechanization of harvest and residue management practices is particularly striking compared to the other IGP states (Erenstein et al. 2007). The popularity of combine harvesters in the rice–wheat zone of the TGP reflects the potential cost savings (high labour cost for manual harvesting and threshing), reduced labour management problems (seasonal labour shortages) and enhanced timeliness. Other factors that affect the advent of combines include timely access to and cost of combine services, field size and prevalent cropping system. The widespread use of combines in the Patiala and Kurukshetra clusters indeed contrasts with their relative absence in the Hisar cluster. There the demand for combine services is less due to the prevailing wheat–cotton systems and more stringent residue scarcity. Manual harvesting also prevails for long grain rice varieties (Basmati) for a number of reasons, including reduced breakage, more prone to lodging (reducing effectiveness of mechanical harvesting), more limited field size and more intensive residue use.

There is no additional processing of wheat straw prior to its use as livestock feed. When harvested manually, wheat bundles are typically fed into a mechanical thresher which separates grain from finely chopped wheat residue (*bhusa*). Wheat residues are also finely chopped when collected with *bhusa* combiner after combine harvesting, but more likely to include impurities and therefore of lower quality. This leads some farmers to keep threshed *bhusa* for own use and sell off combined *bhusa* (Sidhu, personal communications). *Bhusa* is subsequently stored and used year round up to the next wheat harvest (Table 41). *Bhusa* is mainly stored in the open in *bhusa* stacks. These non-permanent self-supporting conical structures (*kup*; *sarkanda*) are constructed annually at harvest time by intricately enveloping a compact heap of wheat *bhusa* with layers of rice straw and rice rope (see Annex 5). The rice straw shell shields the *bhusa* from the elements and reduces spoilage to some 10–15%. *Bhusa* stacks are owned by individual households and are preferably located close to the compound or on the village perimeter. *Bhusa* is also stored inside houses, a practice which is increasingly common as one moves from the Patiala cluster to the Kurukshetra cluster to the Hisar cluster. The decision to store in the open or inside seems to reflect such tradeoffs as the cost of constructing a stack and storage losses relative to the availability of space and *bhusa* at the household level. The prevalence of inside storage in the Hisar cluster is likely associated with a more stringent overall residue scarcity.

Table 41. *Duration of crop residues storage (months)*

Cluster	Wheat	Rice
Patiala	12	1
Kurukshetra	12	6
Hisar	12	–
Mean (s.d., n, p.)	12 (0, 18, ns)	5 (4, 8, 0.07)

For the instances where rice residue is collected and used, residue processing and storage differ from the prevalent wheat practices. These instances typically rely on manual harvesting and subsequent threshing leaves the rice residue relatively intact. Rice residues are therefore typically chaffed mechanically prior to feeding. Rice residue use as livestock feed is seasonal and storage in stacks/heaps is therefore typically limited to a month in the Patiala cluster and half a year in the Kurukshetra cluster (Table 41).

Several types of crop residue transaction exist between households. Nearly all surveyed villages reported sales of crop residues (Table 42). In three out of five villages crop residues were also used as in-kind payment and in half the villages crop residues were sometimes given away (Table 42). However, these aggregate transactions again mask significant differences between the wheat and rice crops. Residue sales and in-kind payments primarily relate to wheat, whereas residue gifts are largely restricted to rice.

Table 42. *Crop residue transaction practices (% of villages)*

Cluster	Sales	In kind payment	Given away
Patiala	100	67	33
Kurukshetra	83	67	67
Hisar	100	50	50
Mean (s.d., n, p.)	94 (24, 18, ns)	61 (50, 18, ns)	50 (51, 18, ns)

About 2 out of 5 households are engaged in the wheat residue market: with 16% being net sellers and 24% being net buyers (Table 43). In the Patiala and Kurukshetra clusters net selling households tend to outnumber net buyers. This is in stark contrast with the Hisar cluster, where net sellers are uncommon and net buyers relatively common thus—reiterating the relative wheat residue scarcity in the area.

On average, wheat residues were sold at INR 1.4 per kg but varied from a seasonal low of INR 1.2 after the wheat harvest to a seasonal high of INR 1.9 during the winter months (Table 44). The average price was relatively similar across clusters, but the seasonality tended to be more pronounced in the Kurukshetra and Hisar clusters. Wheat residues thereby provide a significant contribution to the income derived from crop production, although the wheat straw value seems relatively low compared to their importance for livestock production.

Table 43. *Categorization of households as deficit or surplus in crop residue (% of hh)*

	Surplus (net seller)		Deficit (net buyer)	
Cluster	Wheat	Rice	Wheat	Rice
Patiala	14	0	9	0
Kurukshetra	28	20	20	1
Hisar	6	1	44	0
Mean (s.d., n, p.)	16 (21, 18, ns)	9 (26, 14, ns)	24 (32, 18, ns)	0.3 (1, 18, ns)

Table 44. *Crop residue prices (INR/kg)*

	Wheat			Rice		
Cluster	Average	Peak	Trough	Average	Peak	Trough
Patiala	1.4	1.6	1.2	–	–	–
Kurukshetra	1.3	1.8	1.0	0.2	0.3	0.2
Hisar	1.4	2.2	1.3	–	–	–
Mean (s.d., n, p.)	1.4 (0.3, 18, ns)	1.9 (0.6, 18, ns)	1.2 (0.4, 18, ns)	0.2 (0.1, 3, ns)	0.3 (0.2, 2, ns)	0.2 (0.1, 2, ns)

Less than 1 in 10 household are engaged in the rice residue market, with participation largely confined to the Kurukshetra cluster (Table 43) where a fifth of long grain rice producing households reportedly sell rice residues. Only in the Kurukshetra cluster did the rice residue have any market value, albeit at a fraction of the wheat residue price (INR 0.2 per kg—Table 44).

The participation rates in residue markets however fail to capture those households that cannot participate. Indeed, many residue-deficient smallholders and landless often lack the purchasing power; hence the importance of the non-market transactions. Both residue in-kind payments and residue gifts are primarily from landed household to (landless) labourers and represent an important source of supplementary income, livestock feed and/or fuel for the landless. In addition, residue-deficient poor households are more likely to use rice residue for feed purposes and to collect residues left-over in the field.

On aggregate though, the bulk of the wheat residues is used on the farm itself with only the surplus residues transacted between households. In case of rice, the bulk of the residues is not used at all, but when used, it is primarily by other than the producing household.

Residue quality factors did not play a major role in determining residue price. Only sporadically were other than seasonal factors mentioned, for instance mode of harvest (thresher preferred over *bhusa* combine), cleanliness and variety.

Crop residue considerations indeed did not play a major role in varietal choice. Farmers' varietal selection criteria for both rice and wheat mainly reflected productivity considerations. Only in case of similar grain productivity was residue production occasionally considered as additional criteria. The consideration of residue was more obvious in the semiarid Hisar cluster and reflected primarily residue quantity, reiterating its relative residue scarcity.

6.2 Livestock feed inputs and availability

As discussed in the previous chapter, livestock production in the TGP is dominated by buffalo, which are stallfed throughout the year on a basal diet mainly of wheat *bhusa* (chopped straw) (Tables 37, 39, 41 and 45). For landowning households the *bhusa* is mainly home-produced, but purchases and *bhusa* received in lieu of wages or as gifts are also important sources of basal feed especially for marginalized and landless households (Tables 42 and 43). In the TGP where common property resources are all but absent (except in the Hisar cluster) and cultivation intensity is high, grazing was only reported in the Hisar cluster (Table 45). In the same way, the use of collected grasses (e.g. from the banks of irrigation channels or from field boundaries and roadsides) was limited to about a quarter of the households (Table 45). Compared to the other IGP states, the reliance on grazing and collected forage for feed was limited (Erenstein et al. 2007).

Table 45. *Use of feed sources (% of hh)*

Cluster	Other crop by-product*	Compound feed	Grazing	Collected grasses/forage	Green fodder
Patiala	87	25	0 a	38	70
Kurukshetra	97	33	0 a	15	100
Hisar	98	34	26 b	32	63
Mean (s.d., n, p.)	94 (19, 18, ns)	31 (35, 18, ns)	9 (17, 18, 0.00)	27 (33, 16, ns)	75 (40, 16, ns)

* Other than crop residues.

On the other hand most households in each of the three clusters used green fodder (Table 45). This complement to the wheat *bhusa* basal diet was produced from the approximately

10% of village cultivable area planted in each season to forage crops (Tables 26 and 27): mainly jowar/sorghum in the *kharif*/monsoon and berseem/Egyptian clover in the *rabi*/winter. Although most forages were grown for feeding the households' own bovines, there was some trading with prices for jowar ranging from INR 15–20,000/ha of fodder crop or INR 0.2–0.5/kg fresh weight. Other occasional forage crops were oats (mainly for fodder) and barley (mainly for grain). Most households had a chaff cutter which was used for chopping the green fodders and for the crop residues not chopped during harvesting. The village groups said that the area devoted to forage production was not increasing, an indication of the apparent lack of any significant trend towards specialization in dairy production.

A further complement to the wheat *bhusa* basal diet was a range of locally available crop by-products of which the nutrient-dense types were used primarily for lactating milch animals, although apparently fed at low levels. These feeds included oilseed cakes (mustard, rape, cotton seeds), the quality of which was said to be variable. The by-products were reported to cost INR 7–8 /kg, i.e. less than the prevailing milk price (Table 23). As the production response may be significantly more than 1 litre milk per 1 kg nutrient-dense feed, this suggests their use would show a good profit, raising the question therefore why these 'straights' (non-compounded feeds) are not used more intensively. Contributing factors may include the small quantities of home-produced by-products, the reported variability of the 'straights' and of the small quantities of compounded feed that was purchased (at a cost of INR 6–8 /kg) for lactating animals, and cash flow constraints. While rice bran was relatively widely available, it was not reported as being used for feeding buffalo or cattle, but rather incorporated into the industrial production of feeds for broilers and layers.

When reviewing these various sources of feed supply, the villages reported that for crop residues the Kurukshetra cluster had a surplus, the Patiala cluster was self-sufficient and the Hisar cluster had a deficit, while in each location crop by-products were said to be insufficient but that the green fodder supply was generally sufficient despite some deficit between *rabi* and *kharif* after the last cut of berseem. These assessments have, of course, to be related to current bovine production levels, which for milk yield were low and the relatively limited sales volume (averaging 59% of milk output, Table 33). This suggests that many bovine keeping households did not have as a primary objective the regular sale of milk, but rather satisfying immediate household needs. In the same way, there were limited reports of mineral mixture purchases, despite known links between poor reproductive performance and mineral deficiencies. Overall though the reported feed management practices still compare favourably to other IGP states (Erenstein et al. 2007). Nonetheless, one can conclude that while bovines represented an integral part of the livelihood strategies of most landed households, their role was not perceived as primary income earners, but more as converters of readily available crop residues (essentially wheat *bhusa* in the TGP) into: (i) milk primarily for household consumption with surplus being sold; (ii) dung for use as manure and/or fuel or for sale (Table 47); (iii) traction power mainly for transport; and, (iv) herd growth as a means of capital saving.

It is also important to point out that bovines also fulfilled these same roles for some landless households, with feed sources coming mainly from the collection of free resources: bunds, weeds in fields, rice residue, and from purchases of wheat *bhusa* and green fodder or through partial in-kind payment and the grazing, e.g. on stubbles and common property resources, especially for small ruminants.

6.3 Livestock input to crop production

Farm yard manure (FYM) and traction services are the two main potential flows from livestock into crop activities. Both of these traditional crop–livestock interactions now have imperfect substitutes in the form of chemical fertilizer and tractors.

Although chemical fertilizer use is near universal amongst farm households in the surveyed villages, FYM use is still widespread (Table 46). This aggregate use rate however says little about the regularity and intensity of manure application. Indeed, another study (Sidhu et al. 1998, 166) found that although FYM use was near universal amongst surveyed farmers in Punjab, no field received FYM every year (but typically once in every three to four years) and application invariably focused on the rainy season and fodder crops. The livestock density in the surveyed villages averaged 1.1 cow equivalent per cultivated ha (Table 38) which limits the total potential quantity of manure available. Most large ruminants are stallfed or kept tethered close to the homestead allowing the recovery of most of the dung produced. Dung is typically collected in open heaps on or near the homestead within the village perimeter. Only 58% of the annually collected dung was reportedly used as FYM (Table 45).

Forty percent of the dung is used to produce dung cakes as year round household fuel source. Dung cakes are produced manually mainly during the dry season so as to dry properly in the open. They are stored in the open in elaborate stacks which sometimes are sealed with dung plaster to protect against the elements (see Annex 5). Dung cakes are typically produced by women and used for both own household use and sale, the latter being an additional source of income for small farmers and landless households. The use of dung cakes at household level is likely to vary depending on the availability of alternative fuel sources, but at community level was relatively similar across the three clusters. Use of dung for biogas plants was uncommon. Our findings thereby differ somewhat from a recent study in Punjab and Haryana (Beri et al. 2003), which estimates 72% of manure to be used as FYM, 21% as dung cakes and 7% for biogas plants.

Although approximately 90% of farm households use tractors (own or rented), draught animals are still reportedly used by 31% of farm households for crop operations in the surveyed villages (Table 46). There has therefore been a significant substitution of machinery for traditional animal traction services for crop operations. Most of this substitution occurred in the 1980s. The substitution has been less far reaching in the semi-arid Hisar cluster (Table 46). More surprising perhaps is that still 31% of households use animal draught services for crop operations (including hauling), but this compares to the 40% of households reportedly keeping draught animals (Table 31). As indicated above, draught animals have also seen the substitution of traditional oxen by male buffalo.

Table 46. *Comparative indicators of external and livestock input use for crop production (% of farm hh reportedly using)*

Cluster	Tractors use	Draught animals use	Chemical fertilizers use	FYM use
Patiala	98 b	30	92	69
Kurukshetra	97 b	17	100	92
Hisar	72 a	43	100	91
Mean (s.d., n, p.)	89 (23, 18, 0.08)	31 (35, 11, ns)	97 (12, 18, ns)	84 (32, 18, ns)

Data followed by different letters differ significantly—Duncan multiple range test (significance level: 0.10), within column comparison.

Table 47. *Dung use (% of dung allocated to use)*

Cluster	As fuel	As FYM	Other
Patiala	40	59	2
Kurukshetra	36	61	3
Hisar	46	55	0
Mean (s.d., p.) [n=18]	40 (15, ns)	58 (13, ns)	2 (5, ns)

6.4 Assessing crop–livestock interactions

The aforementioned interactions have highlighted the dependence of livestock on feed derived from crop production, but the livestock services to crop production (traction, FYM) seem more limited, reflecting the widespread substitution through chemical fertilizer and tractors. Over the decades, the intensification and commercialization of the crop systems have thereby weakened the crop–livestock interactions overall, contributing to long-term environmental impacts such as the low soil organic matter contents.

The crop–livestock interactions typically focus on physical products and services, the tangible direct interactions between crop and livestock production. These however ignore the less tangible indirect system interactions. Most prominent amongst these are the risk implications of having a more diverse livelihood portfolio. The co-variance of income derived from crop production and livestock production is likely to be low. The two enterprises also have different resource use patterns (particularly labour and cash flow) which imply complementarities and potential resource savings at the household level by allowing more efficient resource use.

Financial interactions between the livestock and crop enterprise are indeed important in the surveyed communities. In nearly all villages it was reported that financial proceeds from livestock production are used to meet crop production expenses. The reverse was less common, but income from crop production was increasingly used for livestock production as one moved from the Patiala cluster to the Hisar cluster. No explicit mention was made of the role of capital accumulation or safety net issues. Capital accumulation for landed households seems mainly through land, especially in view of increasing land demand for secondary and tertiary sectors.

The group meetings discussed the advantages and disadvantages of crop–livestock interactions. These tended to highlight the importance of the crop and livestock enterprises in terms of contributing to household income and household consumption, the latter particularly as in kind contribution with the advantage of not requiring cash outlays. At the village level, advantages included the availability of feed sources to the landless and enhanced social coherence (e.g. exchange of produce like *lassi* between households).

In terms of disadvantages mention was made of stray male cattle being a nuisance in certain communities. Because of their religious status, cattle slaughter is prohibited except in the states of Kerala and Nagaland. Another interesting view in one community was the perception that the livestock enterprise 'trapped' the young generation by its year-round labour demands, preventing their mobility to pursue other livelihood venues.

Most surprising perhaps was that the contributions of crop and livestock were generally related to the individual crop and livestock enterprise, and not so much attributed to interactions. Perhaps the two enterprises are so obviously interdependent that this is not expressed overtly. Indeed few households are specialized in either crop or livestock production and integrated farm systems are the rule. The livestock (buffalo, cattle) component is thereby highly integrated with the crop (rice–wheat) system, albeit with distinct management for the two enterprises. In fact, instead of interdependency, it appears more of a one-way resource dependency of livestock on crop residues with limited flow back in terms of dung or traction. At household level more interdependency is apparent in view of complementary labour needs and internal non-monetary services. Noteworthy is also that the level of integration has changed over time, as wheat–cattle systems were relatively interdependent in the pre-Green Revolution era.

Similarly, the currently predominantly integrated farm systems are neither static nor uniform. Small scale farm systems are highly integrated and likely to remain so in the medium term. Large land holdings however seem to move towards crop specialization having the means to invest in mechanization and thereby circumvent labour bottlenecks. Further specialization into commercial dairy is likely for those that have a potentially big enough milk enterprise and secured market access. Such specialization is more likely in the peri-urban interface. Such specialized dairy would also imply an increasing spatial separation between livestock production and feed production and further reliance on and development of crop residue and fodder markets.

7 Discussion and recommendations

7.1 Livelihood security and environmental sustainability

Perhaps the most striking feature of the current rice–wheat–buffalo livelihood systems in the TGP is their security for those with an adequate asset base. Particularly the rice–wheat system provides an attractive and stable income to the farm household with minimal risk. The secure and profitable system thrives having both limited market risk (assured market and MSP) and production risk (secure irrigation). The inherent security and profitability also imply there is limited scope for crop diversification within the current context. This contrasts with the cotton–wheat systems in the Hisar cluster which are more risk prone and where more diversification was apparent.

Livestock production has provided a livelihood diversification opportunity for rice–wheat producers. This component added value to the crop production enterprise by using crop by-products. It thereby added to the level and stability of household income and reduced seasonality and overall risk. However, compared to the other subregions, the livestock's non-market functions probably play a less important role in livelihood strategies in the TGP, particularly in view of the relative low risk of crop production plus relatively good access to financial services.

The divergent management of the crop and livestock component is another striking feature. Crop production is largely intensified, with high external input use, high productivity and high market integration. In contrast, livestock intensification seems lagging with the 'harvesting' of milk and sales of surplus milk. This strongly suggests that the incentives for livestock intensification have so far been less pronounced. On the one hand, the surveyed communities in the subregion thereby highlight the importance of market forces and irrigation for intensification and diversification. On the other, they highlight the prominent role of livelihood security and risk aversion even in productive and commercial agricultural systems.

The livelihood security for those with an adequate asset base is in stark contrast with those households that lack such resources. Some asset-poor households have benefited through permanent employment options on large farms. However, the asset-poor typically have a poor bargaining position (e.g. Rawal 2006). Primarily reliant on their unskilled labour, their livelihood security was further undermined by the advent and widespread use of labour saving technologies (mechanization and herbicides). Herbicides in fact had a double impact on the landless, on the one hand substituting labour and thereby keeping a check on wage rates and on the other reducing the availability of a potential feed source. Herbicide and other agro-chemical residues may also potentially contaminate feed sources (weeds, crop residues) with uncertain animal health effects. The labour peaks associated with widespread rice–wheat cultivation on relatively large farms has also resulted in a seasonal inflow of labour from other states, thereby depressing the wage of local labour and reportedly creating social problems (Singh 2006).

7.1.1 Environmental sustainability

A major threat to the current livelihood strategies are their environmental implications. The surveyed communities highlight three major environmental impacts. First, the widespread use of tubewells particularly in the rice–wheat systems has led to an overexploitation of groundwater. Groundwater use exceeds natural recharge leading to declining water tables in several communities and beyond (e.g. Bhullar and Sidhu 2006). Second, the continuous rice–wheat cultivation with prevalent crop management practices has also led to the deterioration of soil and land quality (e.g. Bhullar and Sidhu 2006). Organic matter management is particularly problematic, with the largely one-way extractive flows from the field leading to depletion of soil organic matter stocks. Although the potential of pests and diseases build up exists, these are reportedly not a significant problem. Third, the burning of crop (rice) residues during land preparation also contributes to significant air quality pollution (smog) in both rural and urban areas in the region. Except for the declining groundwater tables, these environmental impacts are not necessarily perceived as such by the surveyed communities.

The dominance of agricultural activities in the subregion implies that the subregion is already characterized by its limited rangeland, forests and biodiversity. More important perhaps are the need to maintain agricultural productivity in these highly productive areas so as to reduce agricultural pressure on fragile natural resources elsewhere. The advent of the virulent new stem rust for wheat (UG99, Raloff 2005) and global warming (Ortiz et al. 2006) could thereby have major implications for the TGP and beyond.

7.2 Outlook and constraints

Looking into the future, landed households themselves typically put more emphasis on wanting to expand crop production activities relative to livestock, particularly in the Patiala and Kurukshetra clusters. Potential expansion of crop production typically revolved around expanding the area under the prevalent crops, particularly rice, wheat and cotton. Some communities mentioned an interest to diversify crop production (e.g. vegetables, sunflower, and flowers) or to substitute oilseed/pulses for wheat. Overall though, the landed households seemed to have relinquished any major drive for change and to settle for the *status quo*, further reflecting the security of the current crop system and the limited incentives to change. For the livestock component even less intended change was perceptible, with landed households typically opting for more of the same in terms of milk and animals, with only some desire for stock quality improvement.

Various hindrances to such intended change were reported by the surveyed communities. In the case of crops, marketing problems hindered eventual crop diversification. Water constraints ranked high in the Hisar cluster and land and labour constraints were specifically reported in the Patiala cluster. Access to and cost of credit and increasing costs of production were also variously mentioned as hindrances for crop expansion. In the case of livestock, hindrances revolved around milk marketing constraints, the lack of and/or quality of livestock services (AI, veterinary) and household resource constraints.

The limited scope for developing crop and livestock production has led many landed households to invest in human capital development through the education of the young. However, these investments have not always paid off in view of limited employment opportunities and sometimes lackluster education. The raised expectations of the younger generation have led to frustrations and social problems in the communities surveyed.

Hindrances to future development also clearly vary by household. Some landed households have over-invested in mechanization, some have become seriously indebted. For other households land fragmentation has made agriculture barely viable as an enterprise. The asset base available to the households will in the end largely dictate their outlook. For smallholders, labour intensive high value crops seem the most promising option, provided they secure access to water, finance and markets. Other landed households will thrive on diversification or specialization, including value addition through vertical integration. But for all landed households the outlook will, to a large extent, be determined by the performance of the non-agricultural sector, both in terms of providing additional off-farm livelihood sources and strengthening the foundations of farm livelihood sources (e.g. by absorbing some of the non-viable producers and creating demand for new products and quality).

The prospects for the landless are particularly meager. Unskilled labour is their basic asset, but the value of that asset will continue to be eroded in view of incessant supply and labour saving technologies limiting demand. Indeed, finding sufficient employment was one of their pressing problems. Landless would benefit from better basic education to strengthen their human capital asset and bargaining position. Their limited access to other assets typically constrains their ability to diversify their livelihoods. The landless frequently cited the high cost of capital, their limited access to land (in terms of housing, livestock keeping and cultivation) and social constraints as major problems. Livestock diseases and feed availability constraints were two other problems.

Perhaps the biggest hindrance to change is the complacency with the current *status quo* by landed households and the public sector. Everyone seems to be waiting for another major breakthrough, but unwilling to put their cosseted livelihoods at risk. Yet certain trends continue: the rural population continues to grow, farm size continues to decline each generation due to fragmentation and water tables continue to subside. The natural resource base thereby seems stretched to the limit, but with no new major technological breakthrough in sight to propel these systems from their current plateau. The TGP thereby seems to have reached an important crossroads, whereby something has got to give (e.g. Gill and Singh 2006; Jodhka 2006; Sidhu and Bhullar 2004).

7.3 Agenda for action

The present study is a scoping study. Our intention was therefore to provide a basic understanding and to flag issues in the TGP, not to necessarily provide any definitive answers or recommendations. The study raises a number of issues and we explore here some of the policy implications, particularly for research and development.

The first area for intervention is the need for a more enabling environment for economic and human development in general. Two underlying objectives stand out. First, to enhance the human capital base and skills through basic education. Second, to spur the economic growth of the secondary and tertiary sectors to absorb surplus labour from the primary sector and the rural landless (e.g. Sidhu 2002; Sidhu and Singh 2004).

A second priority intervention is the need for a more enabling environment for agricultural development. The development of the rice–wheat systems in the TGP has been such that it has created a cosseted *status quo* that is gradually being undermined by natural resource degradation and population growth. The agricultural sector needs to be reinvigorated and put on a growth track again. This requires some delicate interventions, basically dismantling the rice–wheat bias without jeopardizing national food security. This implies levelling the playing field for all players by dismantling subsidies (e.g. electricity [e.g. Bhullar and Sidhu 2006; Narendranath et al. 2005], fertilizer, water), relaxing MSP, enhancing private sector participation and enhancing access to resources including knowledge (both technical and market).

A third area for intervention relates to equity. The rural society in the TGP is marked by social contrasts (gender, caste, class) and these have often been further consolidated by the past agricultural developments. In the case of gender, there is a need to redress the male bias and address women's issues separately. There is a strong gender division of labour, yet access to resources and knowledge is male biased. For instance, primarily male extension agents imply immediate knowledge blockages to females. Interregional equity considerations could imply shifting some of the cereal procurement further downstream.

There are inter-linkages between these three broad intervention areas. For instance, inequity is likely to have slowed down economic growth (World Bank 2005b). The saying 'literate women, literate household' thereby merits to be pursued more vigorously.

A final intervention area relates more to the traditional domain of agricultural R&D. Indeed, the study highlights the need for households to pursue more vigorously diversification and specialization strategies. Diversification strategies should revolve around a shift away from continuous rice–wheat cropping to more diverse systems that rotate highly productive rice–wheat crops with other crops. Specialization strategies should pursue higher value commodities and vertical integration so as to add value. In this respect investment and strengthening of the horticultural and dairy sectors merit follow up. The key challenge thereby is to enable viable and attractive livelihood options while reducing the negative environmental externalities.

These strategies would benefit from further applied research to generate more appropriate crop and livestock management options. This includes further technology development/adaptation to make the crop and livestock enterprises more efficient and less environmentally degrading. However, equally important, it implies better understanding and addressing the implications and tradeoffs of these options at the household and community level. A livelihood systems perspective will be useful in this respect. Biomass management is one area that warrants more systematic study. First, in terms of understanding biophysical flows and stocks and the socio-economic market and non-market transactions. Second, in terms of developing technological options that allow farmers to manage biomass efficiently without compromising the environment. The *bhusa* combiner is an interesting example in this respect. It shows how technology can address specific needs and thereby create the necessary incentive for its use and further spread. It also shows the need for and potential of private sector involvement. Most technological changes are likely to be incremental and require endurance, open-mindsets and entrepreneurial skills. In the end the biggest challenge will be to overcome the complacency of the landed, and to change the prevailing sense of business as usual.

Cross-cutting action research needs for the IGP

The present study and its companion studies also highlight a set of specific research needs that cut across the subregions. These specific needs relate to the land use systems of the IGP and their crop, livestock and crop–livestock interaction components and include action-research to:

- Understand and address local variation in land use systems and the resulting constraints and opportunities for diversification and intensification;
- Address key issues including community-action for improved management of land, water and livestock resources and ways to increase market access for inputs (including knowledge) and outputs;
- Improve the productivity of the staple crops, including through identifying resource-conserving technologies (RCTs), while factoring in any trade-off effects on the feeding of crop residues to livestock; and, related to that:

  i. Investigate whether variation in rice, wheat and maize varieties for fodder quality (nutritional value) is an avenue for increasing the available quantity and quality of crop residues for feeding goats, cattle and buffalo; and,

  ii. Investigate organic matter (OM) management and particularly crop biomass management issues impacting on the prevalent crop–livestock livelihood strategies of landed and landless households, taking account of the multiple functions of the crop residues and of the various livestock species within a household and community.

Central to achieving the overall goals of improving livelihoods and more sustainably using natural resources in the IGP will be strengthening the client orientation and productivity of the agricultural R&D community. Research on crop–livestock interaction can serve as a good entry point for that process.

References

Beri V, Sidhu BS, Gupta AP, Tiwari RC, Pareek RP, Rupela OP, Khera R and Singh J. 2003. *Organic resources of a part of Indo-Gangetic Plains and their utilization.* NATP. Dept of soils, PAU, Ludhiana, India.

Bhullar AS and Sidhu RS. 2006. Integrated land and water use: A case study of Punjab. *Economic and Political Weekly* 41(52):5353–5357.

Business World. 2005. *The marketing white book, 2005.* Business World, New Delhi, India.

Census India. 2005. *Census info India 2001, Version 2.0.* Office of the Registrar General, New Delhi, India.

Debroy B and Bhandari L. 2003. *District-level deprivation in the new millennium.* Konark Publishers, New Delhi, India.

Devendra C, Thomas D, Jabbar MA and Zerbini E. 2000. *Improvement of livestock production in crop–animal systems in agro-ecological zones of south Asia.* ILRI (International Livestock Research Institute), Nairobi, Kenya.

Ellis F. 2000. *Rural livelihoods and diversity in developing countries.* Oxford University Press, Oxford, UK.

Erenstein O, Malik RK and Singh S. 2006. Adoption and impacts of zero tillage in the irrigated Rice–Wheat systems of Haryana, India. Forthcoming RWC Paper. CIMMYT India and RWC, New Delhi, India.

Erenstein O, Thorpe W, Singh J and Varma A. 2007. *Crop–livestock interactions and livelihoods in the Indo-Gangetic Plains, India: A regional synthesis.* Crop–livestock interactions scoping study—Synthesis. CIMMYT–ILRI–RWC, New Delhi, India.

ESO (Economic and Statistical Organization). 2004. *Statistical abstract of Punjab.* Publication No. 905. Economic and Statistical Organization, Government of Punjab, Chandigarh, Punjab, India.

Evenson RE and Gollin D. 2003. Assessing the impact of the Green Revolution, 1960 to 2000. *Science* 300:758–762.

Frankel FR. 1971. *India's Green Revolution: Economic gains and political costs.* Princeton University Press, Princeton, USA.

Fujisaka S, Harrington L and Hobbs PR. 1994. Rice–wheat in south Asia: Systems and long-term priorities established through diagnostic research. *Agricultural Systems* 46:169–187.

Gill A and Singh L. 2006. Farmers' suicides and response of public policy: Evidence, diagnosis and alternatives from Punjab. *Economic and Political Weekly* 41(26):2762–2768.

Harrington LW, Fujisaka S, Hobbs PR, Sharma HC, Singh RP, Chaudhary MK and Dhiman SD. 1993. *Wheat and rice in Karnal and Kurukshetra Districts, Haryana, India: Farmer's practices, problems and an agenda for action.* Haryana Agricultural University (HAU), Indian Council of Agricultural Research (ICAR), CIMMYT, IRRI, Mexico, DF.

Hazell PBR and Ramasamy C. (eds), 1991. *The Green Revolution reconsidered: The impact of high-yielding rice varieties in south India.* Johns Hopkins University Press, Baltimore, USA.

IASRI (Indian Agricultural Statistics Research Institute). 2005. *Agricultural research data book 2005.* IASRI/ICAR (Indian Council of Agricultural Research), New Delhi, India.

Jodhka SS. 2006. Beyond 'crises' rethinking contemporary Punjab agriculture. *Economic and Political Weekly* 41(16):1530–1537.

Khattra PS and Kataria P. 2005. *Livestock–crop production system analysis for sustainable production.* Research project report, National Agricultural Technology Project (ICAR). Co-operating centre, Department of Economics, Punjab Agricultural University, Ludhiana, India.

Kumar P, Jha D, Kumar A, Chaudhary MK, Grover RK, Singh RK, Singh RKP, Mitra A, Joshi PK, Singh A, Badal PS, Mittal S and Ali J. 2002. *Economic analysis of total factor productivity of crop sector in Indo-Gangetic Plain of India by district and region*. Agricultural Economics Research Report 2. ICAR (Indian Agricultural Research Institute), New Delhi, India.

Kumar P, Joshi PK, Johansen C and Asokan M. 1999. Sustainability of rice–wheat based cropping systems in India: Socio-economic and policy issues. In: Pingali P (ed), *Sustaining rice–wheat production systems: Socio-economic and policy Issues*. Rice–Wheat Consortium Paper Series 5. RWC, New Delhi, India. pp. 61–77.

Lipton M and Longhurst R. 1989. *New seeds and poor people*. Unwin Hyman, London, UK.

Minhas PS and Bajwa MS. 2001. Use and management of poor quality waters for the rice–wheat based production system. *Journal of Crop Production* 4(1):273–306.

Minhas PS and Samra JS. 2003. *Quality assessment of water resources in the Indo-Gangetic Basin part of India*. Technical bulletin No. 1/2003. Central Soil Salinity Research Institute (CSSRI, ICAR), Karnal, India.

MoA (Ministry of Agriculture). 2004a. *Agricultural statistics at a glance*. Agricultural Statistics Division, New Delhi, India.

MoA (Ministry of Agriculture). 2004b. *Seventeenth livestock census 2003*. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, New Delhi, India. (Available from http://dahd.nic.in/census.htm). Available online at (Accessed on 27/10/2007).

MoA (Ministry of Agriculture). 2005. *Agricultural statistics at a glance 2005*. Agricultural Statistics Division, Ministry of Agriculture, New Delhi, India.

MoA (Ministry of Agriculture). 2006. Agricultural statistics at a glance 2006. Agricultural Statistics Division, Ministry of Agriculture, New Delhi, India. (Available from http://dacnet.nic.in/eands/agStat06-07.htm) (Accessed on 27/10/2007).

Narang RS and Virmani SM. 2001. *Rice–wheat cropping systems of the Indo-Gangetic Plain of India*. Rice–Wheat Consortium Paper Series 11. RWC, New Delhi, India.

Narendranath G, Shankari U and Reddy KR. 2005. To free or not to free power: Understanding the context of free power to agriculture. *Economic and Political Weekly* 40(53):5561–5570.

Ortiz R, Sayre KD, Govaerts B, Gupta R, Subbarao GV, Bana T, Hodson D, Dixon JM, Ortiz-Monasterio JI and Reynolds M. 2006. Climate change: Can wheat beat the heat? Unpublished paper. CIMMYT, Mexico, D.F.

Paris TR. 2002. Crop–animal systems in Asia: Socio-economic benefits and impacts on rural livelihoods. *Agricultural Systems* 71(1–2):147–168.

Parthasarathy Rao P, Birthal PS, Dharmendra K, Wickramaratne SHG and Shrestha HR. 2004. *Increasing livestock productivity in mixed crop–livestock systems in south Asia*. Project report. National Centre for Agricultural Economics and Policy Research and ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), Patancheru, India.

Parthasarathy Rao P and Hall AJ. 2003. Importance of crop residues in crop–livestock systems in India and farmers' perceptions of fodder quality in coarse cereals. *Field Crops Research* 84(1–2)–189–198.

Pingali PL and Shah M. 1999. Rice–wheat cropping systems in the Indo-Gangetic Plains: Policy re-directions for sustainable resource use. In: Pingali P (ed), *Sustaining rice–wheat production systems: Socio-economic and policy issues*. Rice–Wheat Consortium Paper Series 5. RWC, New Delhi, India. pp. 1–12.

Pinstrup-Andersen P and Hazell PBR. 1985. The impact of the Green Revolution and prospects for the future. *Food Reviews International* 1(1):1–25.

Raloff J. 2005. Wheat warning—New rust could spread like wildfire. *Science News Online* 168(13).

Rawal V. 2006. The labour process in rural Haryana (India): A field-report from two villages. *Journal of Agrarian Change* 6(4):538–583.

Rosegrant MW and Hazell P. 2001. *Transforming the rural Asian economy: The unfinished revolution.* Oxford University Press for the Asian Development Bank.

RWC (Rice–Wheat Consortium). 2005. *Research highlights 2004.* Rice–Wheat Consortium for the Indo Gangetic Plains, New Delhi, India.

RWC (Rice–Wheat Consortium). 2006. *A research strategy for improved livelihoods and sustainable rice–wheat cropping in the Indo-Gangetic Plains: Vision for 2006–2010 and beyond*. Rice–Wheat Consortium for the Indo Gangetic Plains, New Delhi, India.

Seth A, Fischer K, Anderson J and Jha D. 2003. *The Rice–Wheat Consortium: An institutional innovation in international agricultural research on the rice–wheat cropping systems of the Indo-Gangetic Plains (IGP)*. The Review Panel Report. RWC, New Delhi, India.

Sharma SK, Subba Rao AVM, Murari K and Sharma GC. 2004. *Atlas of rice–wheat cropping system in Indo-Gangetic Plains of India.* Bulletin No. 2004-I. PDCSR (ICAR), Modipuram, India.

Sharma VP. 2004. Livestock economy of India: Current status, emerging issues and long term perspectives. *Indian Journal of Agricultural Economics* 59(3):513–553.

Sidhu BS, Rupela OP, Beri V and Joshi PK. 1998. Sustainability implications of burning rice- and wheat-straw in Punjab. *Economic and Political Weekly* 33:163–168.

Sidhu HS. 2002. Crisis in agrarian economy in Punjab: Some urgent steps. *Economic and Political Weekly* 37.

Sidhu RS and Bhullar AS. 2004. Changing structure of the farm economy in Punjab: Impact of livestock on income and employment. *Indian Journal of Agricultural Economics* 59(3):578–587.

Sidhu RS and Singh S. 2004. Punjab: Agricultural wages and employment. *Economic and Political Weekly* 39:4132–4135.

Singh J and Grewal SS. 1990. *Socio-economic profile of migrant Gujjars in Punjab.* Department of Economics and Sociology, PAU, Ludhiana.

Singh J and Sidhu RS. 2005. Factors in declining crop diversification: Case study of Punjab. *Economic and Political Weekly* 39(52):5607–5610.

Singh J, Erenstein O, Thorpe W and Varma A. 2007. Crop–livestock interactions and livelihoods in the Gangetic plains of Uttar Pradesh, India. Crop–livestock interactions scoping study—Report 2. Research Report 11. ILRI (International Livestock Research Institute), Nairobi, Kenya. 88 pp.

Singh R. 2006. *Migrant labour in India: A case study of Punjab.* Classical Publishing Company, New Delhi, India.

Singh Y, Singh B and Timsina J. 2005. Crop residue management for nutrient cycling and improving soil productivity in rice-based cropping systems in tropics. *Advanced Agronomy* 85:269–407.

Thakur TC and Papal SS. 2005. Retrieval of rice–wheat straw after combining—A viable solution for accelerating zero-till technology and promoting further utilization of straw. In: Malik RK, Gupta RK, Singh CM, Yadav A, Brar SS, Thakur TC, Singh SS, Singh AK, Singh R and Sinha RK (eds), *Accelerating the adoption of resource conservation technologies in rice–wheat system of the Indo-Gangetic Plains, Proceedings of the project workshop June 1–2, 2005.* Directorate of Extension Education, CCS HAU, Hisar, Haryana, India. pp. 165–174.

Thomas D, Zerbini E, Parthasarathy Rao P and Vaidyanathan A. 2002. Increasing animal productivity on small mixed farms in south Asia: A systems perspective. *Agricultural Systems* 71(1–2):41–57.

Thorpe W, Erenstein O, Singh J and Varma A. 2007. *Crop–livestock interactions and livelihoods in the Gangetic Plains of Bihar, India.* Crop–livestock interactions scoping study—Report 3. Research Report 12. ILRI (International Livestock Research Institute), Nairobi, Kenya. 88 pp.

Varma A, Erenstein O, Thorpe W and Singh J. 2007. *Crop–livestock interactions and livelihoods in the Gangetic Plains of West Bengal, India.* Crop–livestock interactions scoping study—Report 4. Research Report 13. ILRI (International Livestock Research Institute), Nairobi, Kenya. 94 pp.

World Bank. 2005a. *India—Re-energizing the agricultural sector to sustain growth and reduce poverty.* Oxford University Press, New Delhi, India.

World Bank. 2005b. *World development report 2006: Equity and development.* Oxford University Press, Oxford, UK.

Annex 1. Socio-economic and development indicators in IGP states

Indicators		Year/source	Punjab	Haryana	Uttar Pradesh	Bihar	W. Bengal	All India
Population (10^6)		2001 (1)	24.4	21.1	166.2	83.0	80.2	1029
Increase (%)		1991–2001(1)	20.1	28.4	25.9	28.6	17.8	21.6
Population density (per km^2)		2001 (3)	484	478	690	881	903	325
Rural population (%)		2001 (3)	66.1	71.1	79.2	89.5	72.0	72.2
Farming population (%)		2001 (3)	32	46	48	31	25	
Landless population (%)		2001 (2)	22	19	29	51	33	
Literacy	Male (%)	2001 (4)	76	79	70	60	78	76
	Female (%)	2001 (4)	64	56	43	34	60	54
Rural population below poverty line (%)		1999–2000 (1:9–10)	6.4	8.3	31.2	44.3	31.9	27.1
Share of agri. in GSDP at 1993–94 prices (%)		2001–02 (1)	39	31	33	35	23	24
Per cap income at current prices		2002–03 (2)	26,000	26,600	10,300	6,000	18,800	18,900
% of hh in income classes (INR/month)	< INR 3000		52.4	64.2	80.7	85.1	77.8	
	INR 3001–6000		38.7	26.5	14.9	10.6	16.4	
	INR 6001–10000	2002–03 (2)	6.5	6.8	3.4	3.3	4.4	
	INR 10001–20000		2.2	2.5	0.9	1.0	1.4	
	> INR 20000		0.1	neg.	neg.	neg.	0.1	
Geographical area (10^3 ha)		2000–01 (3)	5036	4421	24093	9416	8875	328724
Cultivated area (10^3 ha)		2000–01 (3)	4250	3526	17612	7437	5417	141087
Area irrigated (%)		2000–01 (3)	95	83.9	72.8	48.7	43.5	39.1
% of area irrigated by source	Canal		24	50	24	31	11	30
	TW	2000–01 (3)	76	50	69	55	53	40
	Others		0	0	7	14	36	30
Cropping intensity %		2000–01 (3)	187	173	154	147	168	137
Average farm size (ha)		2000–01 (5)	4.03	2.32	0.83	0.58	0.82	1.32
# of tractors (10^3)		2001–02 (3)	442	331	677	107	35	3084

Indicators		Year/source	Punjab	Haryana	Uttar Pradesh	Bihar	W. Bengal	All India
# of pumpsets energized (10^3)		2002 (4)	811	427	815	276	112	13044
Expenditure by SAU's (INR 10^6)		2004–05 (4)	1410	1025	738	708	594	
Foodgrains	Area (10^6 ha)	2002–03 (1)	6.13	3.98	17.90	6.88	6.54	111.50
	%		5.5	3.6	16.1	6.2	5.9	100
	Production (10^6 t)		23.49	12.34	36.30	10.27	15.52	174.19
	%		13.5	7.1	20.8	5.9	8.9	100
Marketed	Rice	1999–2002(1)	96	91	74	68	55	70
Share (%)	Wheat	1999–2002(1)	80	78	58	67	–	67
Fruits	Area (10^3 ha)	2002–03 (4)	40.5	31.9	280.3	294.8	152.2	3787.9
	Production (10^3 t)		578	237	4314	3038	1786	45203
Vegetables	Area (10^6 ha)	2002–03 (4)	0.14	0.16	0.85	0.61	1.21	6.1
	Production (10^3 t)		2.3	2.1	15.8	8.3	17.4	84.8
Milk production (10^6 t)		2002–03 (1)	8.7	5.1	15.3	2.6	3.6	87.3
Egg production (10^9)		2002–03 (1)	3.5	1.2	0.8	0.7	2.8	40.2
Fish production (10^3 t)		2002–03 (1)	66	35	250	166	1120	6200
Dry fodder (10^6 t)		2002–03 (4)	29.4	18.9	80.8	15.6	21.6	377.7
Green fodder (10^6 t)		2002–03 (4)	25.5	19.0	35.8	1.3	1.9	503.1
Wet dung production (10^6 t.)		1987 (4)	33.2	34.5	24.2	22.4	21.7	615.5
Electricity consumption for agriculture (%)		2001–02 (1)	27	42	20	23	7	25
Road length (Km/100 km^2)		2000 (3)	104	59	53	19	56	45
Fertilizer use (kg/ha)		2003–04 (4)	184	167	127	81	122	90

Sources: (1) MoA (2004a); (2) Business World (2005); (3) ESO (2004); (4) IASRI (2005); (5) MoA (2006).

Annex 2. Area, yield and production of major crops in IGP states

Crop	State	1974–75			2003–04		
		Area (× 10^3 ha)	Production (× 10^3 t)	Yield (kg/ha)	Area (× 10^3 ha)	Production (× 10^3 t)	Yield (kg/ha)
Wheat	Punjab	2213	5300	2395	3444	14489	4207
	Haryana	1117	1954	1749	2303	9134	3966
	U.P.	6152	7176	1164	9150	25567	2794
	Bihar	1478	2000	1353	2119	3778	1783
	W. Bengal	422	837	1984	426	986	2315
	All-India	18010	24104	1338	26581	72108	2713
Rice	Punjab	569	1179	2072	2614	9656	3694
	Haryana	276	393	1426	1016	2793	2749
	U.P.	4530	3523	778	5952	13012	2187
	Bihar	5228	4540	868	3557	5393	1516
	W. Bengal	5420	6543	1207	5857	14662	2504
	All-India	37889	39579	1045	42496	88284	2077
Maize	Punjab	522	898	1720	154	459	2981
	Haryana	124	125	1010	15	38	2573
	U.P.	1394	827	593	947	1319	1392
	Bihar	881	572	650	607	1440	2374
	W. Bengal	46	52	1137	41	97	2359
	All-India	5863	5559	948	7322	14929	2039
Sugarcane	Punjab	123	6150	50,000	123	7870	64,000
	Haryana	161	5910	37,000	161	9340	58,000
	U.P.	1492	61479	41,000	2030	112754	56,000
	Bihar	141	5568	40,000	103	4222	41,000
	W. Bengal	29	1682	58,000	17	1268	Na
	All-India	2894	144289	50,000	3995	236176	59,000
Total Pulses	Punjab	328	245	746	48	48	824
	Haryana	781	374	479	196	149	740
	U.P.	3154	2185	694	2708	2339	886
	Bihar	1554	867	558	684	562	824
	W. Bengal	682	376	550	252	30	840
	All-India	22024	10020	455	23440	14940	637
Total Oilseeds	Punjab	368	290	790	87	102	1167
	Haryana	214	149	694	640	990	1547
	U.P.	3784	1927	509	1140	928	814
	Bihar	296	132	446	149	125	842
	W. Bengal	204	75	369	684	651	952
	All-India	17313	9152	529	23700	25290	1067
Cotton	Punjab	547		373	452		414
	Haryana	246		311	526		372
	U.P.	35		118			150
	Bihar	–		–	–		–
	W. Bengal	–		–	–		–
	All-India				7630		370

Source: MoA (2005b).

Annex 3. Survey team members

Name	Institution	Participation in cluster (team)		
		Patiala	Kurukshetra	Hisar
Dr Joginder Singh	PAU (Ludhiana)	A	A	A
Dr Bill Thorpe	ILRI–India (Delhi)	A	A	A
Pankaj Singh	RWC (Kurukshetra)	A	A	
Dr OP Lattiwal	KVK (Kurukshetra)		A	
Dr Ashwani Kumar	HAU (Hisar)			A
Dr Arun Varma	Retired (Ex ADG ICAR)	B	B	B
Elumalai Kannan	Research assistant ILRI-India	B	C	C
Dr NV Patil	CIBR (Nabah)	B		
Dr Ghan Shyam Singh	CIBR (Nabah)	B		
Dr SP Goel	KVK (Kurukshetra)		B	
Dr Kuldeep Singh	RWC (Kurukshetra)		B	
Dr RS Dhukia	HAU (Hisar)			B
Dr P Bhatnagar	HAU (Hisar)			B
Dr Olaf Erenstein	CIMMYT-India (Delhi)	C	C	C
Manjinder Singh	Research associate	C	B	B
Dr JS Chandi	KVK (Patiala)	C		
Dr Samar Singh	RWC (Karnal)		C	
Dr BS Punia	Buffalo Institute (Hisar)	C	C	
Dr Batla	KVK (Kurukshetra)		C	
Dr RK Malik	HAU (Hisar)			C
Dr RS Ratan	HAU (Hisar)			C

Crop-livestock interactions scoping study
Farmers group discussion

State: …………District: ……………………. Village: ……………………………..
Date: ………… Team members: ……………………………..…………………
…………..……………………………..…………..……………………………..

GPS code: …………… X- Coord: …….…………. Y-Coord………………….
(Decide on a code you will use on the GPS unit and on the checklist. Make sure it's a unique identifier. Take reading in village – probably place of meeting)

0 Village characteristics (from key informant)

Number of people in village: ……	**Number of households: ……**
	Number of farm hh: ……
	Number of landless hh: ……

Prevailing cropping system: ……………………………………

Overall assessment of the road infrastructures in the area:

Availability of public transport:	1. high, 2. low, 3. non existent
Type of public transport:	1. bus, 2. jeep/van, 3. train, 4 ….
Travel time by public transport:	
• to nearest urban centre (70% ag; more than 500)	…
• to nearest agricultural market centre	…
Distance to all weather road	… km
Quality of all weather road:	1. Good, 2. Bad

Access to basic facilities:

% of hh with **electricity** : ….	
% of hh **piped public water**: …	
Number of phones in village: …	

Education level of the household heads

Education level	% households in the location
No formal education	
Primary level	
Secondary level	
Higher level	

Introduction

Start by setting the scene – create common understanding for whole group.
Focus: Crop residue mgt – linkage between crop and livestock mgt. Changes and implications. Problems and solutions. Questions typically assess indicators of change - try to understand why. Write down any related information on additional space/sheets.

When estimating % shares of population, ask "out of 10 farmers in this location, how many…". You don't have to get a consensus. If this is the case, indicate range of answers.
The exercise does not have to be "linear"- for example, if the participants give answer for subsequent questions at the same time, note the answer down and don't ask again! Write down any additional related discussion. Try to involve all participants in discussion.

Number of **farmer participants**: ……	# of **women** among participants: ……

1 Land resource

Total village land area (ha): ………

	Private irrigated *(specify main source …………………)*[a]	Private rainfed	Communal	
Divide village area by land type				*(check total = 100% or village area)*
Prevalent number of crops per year				
Rental price (Rs per year per ha)				
Purchase price (Rs per ha)				

[a] *e.g. 1. Canal; 2. Electric tubewell; 3. Diesel tubewell; 4. Other……*

2 Main types of crops grown

First assess the types and aggregate area of crops and fodder that are grown in the area (first column).

Season	Type *(use large categories, eg pulses, vegetables)*	Indicative aggregate area (ha)	% of farmers growing crop
Kharif	Rice		
	Basmati rice		
	Sugarcane		
	Vegetables		
	Forage (specify …………….)		
	Others………		
	Others………		
	Others………		
	Fallow		
	Communal land		
		(check seasonal total = 100% or village area)	
Rabi	Wheat		
	Vegetables		
	Pulses		
	Forage (specify …………….)		
	Others………		
	Others………		
	Others………		
	Fallow		
	Communal land		
		(check seasonal total = 100% or village area)	

List any significant **changes in crops** over last decade:

	Crops area decreased	Crops dropped out	Crops area increased
Crop(s)			
Why			

Do small and large landholdings grow different types of crops?: 1. Yes; 0. No

Crops mainly grown by small holders (<4 ha)	Crops mainly grown by large holders (?4 ha)

3 Livestock population

Type	% of households keeping livestock	Total number of animals in village *(to nearest 10)*	Trend over last decade *(1-Up; 2-Down; 3-Same)*	Why *(reason for up or down trend)*	Who owns *(0-Landless, 1-Small, 2- Large, 3-All)*	Main feeding system *(1-Only grazing, 2-Stall feeding, 3-Both)*
Buffalo milch						
Dairy cattle (indigenous)						
Dairy cattle (cross bred)						
Draft animals (main purpose 1. transport; 2. crop production) Type ……………						
Sheep						
Goat						
Pigs						
Poultry						
Others…						
Others…						

Of all livestock dung produced in the village, how much is…

Use of dung	% of total
Used as fuel	
Used as manure	
Other …	
Not used/wasted	

4 Livelihood types

Main livelihood activity

Assess the main sources of livelihood in the area. Start by asking the type of activity (crop, livestock etc…). Only after, try to assess the importance of each activity (%). To do this, ask "out of 10 farmers in the area, how many are mainly crop farmers " If you cannot get a consensus, indicate range of answer.

Activity	% households in the location who derive a main part of their living from the activity
Crop farming	
Livestock rearing	
Employment on other farms	
Self employment (e.g. business)	
Employment outside the district	
Other, specify	

Breakdown of main livelihood activity by landholding
Subdivide the households by their landholding. Assess corresponding main sources of livelihood using previous categories.

Landholding	% households in the location	Predominant income source
Landless but "rich"		
Landless and "poor"		
Small (< 4 ha)		
Large (?4 ha)		

Note: Landless do not cultivate land. Check with first page for total number of landless and farmers.

5 Non-feed inputs and services for livestock activities

	% households using	Any significant change in use over last decade	Why *(reason for change, e.g. availability)*
AI services			
Bull services			
Veterinary services			
Extension messages			
Other inputs, specify: ……..			
Other services, specify: ……			

6 Inputs and services for crop activities

	% farmers using	Changes in use over last decade	Why (reason for change)
Purchased improved seed			
Chemical fertilizer			
Manure			
Herbicides			
Tractors			
Combine harvester			
Draft animals (specify main use: 1. tillage; 2. weeding; 3. marketing)			
Extension messages			
Other inputs, specify:……			
Other services, specify: ……			

Number of **tractors** in village: ……	Number of **combiners** in village: ……

7 Marketing of farm products

7.1 Sales of main crops and livestock products

Produce	% of average production sold or exchanged	Main market outlet	Price [1]
Wheat			
Rice			
Basmati rice			
Other crops…..			
Other crops…..			
Other crops…..			
Other crops……			

Milk			
Dung as manure			
Dung as fuel			

[1] *Indicate if price is seasonal and provide corresponding range.*

7.2 Sales of animals

Where are surplus animals mainly sold?	1. Local; 2. Outside community, ….
How regular is the sale of surplus animals as source of income?	1. Regular; 2. Irregular *(sporadic sales, as needed, etc.)*

Types of animals	Price [1]
Local cattle	
Crossbred cattle	
Buffalo	

[1] *Use Heifer price (36 months animal) for buffalo and cattle. Indicate if price is seasonal and provide corresponding range.*

8 Crop residue use

In this section we look at crop residues only – i.e. the dry fodder/straw as byproduct from crop production. Next section includes green fodder and other byproducts.

Are crop residues **collected** to be used as livestock feed *ex situ*? 1. Yes; 0. No

	Wheat	Rice	Other … ………
% of farms using			
Main livestock types for which used			
How are residues collected from field?			
Changes in use *(if any)*			

Are crop residues **processed** (e.g. chopped) before use as feed? 1. Yes; 0. No

	Wheat	Rice	Other … ………
How are residues processed?			
Problems with processing *(if any)*			
Number of choppers in village			

Are crop residues **stored** for later use? 1. Yes; 0. No

	Wheat	Rice	Other … ………
Duration			
How are residues stored?			
Problems with storage *(e.g. spoilage, fire, rodents, etc…)*			

Are crop residues used for **other uses** than livestock feed? 1. Yes; 0. No

	Wheat	Rice	Other … ………
List types of uses *(e.g. fuel, construction, other…)*			

Are crop residue stubbles **grazed** *in situ*? 1. Yes; 0. No

	Wheat	Rice	Other … ………
% of farmers using			
When & where			
Type of animals			
If not own animals, grazing fees			

Are crop residues **sold**? 1. Yes; 0. No

	Wheat	Rice	Other … ………
% of farms with residue surplus (selling more than buying)			
% of farms with residue deficit (buying more than selling)			
What is main outlet for those selling	1. Local; 2. Outside ……....	1. Local; 2. Outside ……....	1. Local; 2. Outside ……....
What is main source for those buying	1. Local; 2. Outside ……....	1. Local; 2. Outside ……....	1. Local; 2. Outside ……....
Describe crop residue marketing chain if sold outside *(e.g. form, intermediaries, time and regularity transactions; storage location)*			

Crop residue **prices**

	Wheat	Rice	Other ……
Average grain yield			
Average residue price			
Are residue prices seasonal? • At peak • At trough	0. No; 1. Yes Month: … Price: … Month: … Price: …	0. No; 1. Yes Month: … Price: … Month: … Price: …	0. No; 1. Yes Month: … Price: … Month: … Price: …
What other factors affect prices? (non-seasonal - e.g. variety, quality, etc)			

Are crop residues used as **payment in kind**? 1. Yes; 0. No

For which crops	1. Wheat, 2. Rice, 3 …
Specify (for what; to whom; why; when)	

Are crop residues also **given away** for free? 1. Yes; 0. No

For which crops	1. Wheat, 2. Rice, 3 …
Specify (to whom; why; when)	

Are crop residues **burned in the field**? 1. Yes; 0. No

	Wheat	Rice	Other ……
% of farms burning			
Why			
Trend in use (if any)			

Criteria determining which **crop variety** to cultivate

	Wheat	Rice	Other ……
What is the main criterion determining which variety to grow?			
Is crop residue use an important criterion?	0. No; 1. Yes	0. No; 1. Yes	0. No; 1. Yes
If yes, explain (e.g. quantity, quality, etc)			

Of all above crop residue uses, **which use** of crop residues is the **largest** by volume? Second and third largest? *(tick column)*

	Wheat			Rice		
	1	2	3	1	2	3
Used as stall feed						
Used as stubble feed						
Used for non-feed						
Burned in field						
Left in field						
Other …						

Of all above crop residue uses, **which users** of crop residues are the **largest** by volume? Second and third largest? *(tick column)*

	Wheat			Rice		
	1	2	3	1	2	3
Used on own farms						
Sold/exchanged within village						
Sold outside village						
Other …						
Not used						

Notes:

9 Other feed inputs for livestock activities

Feed source	Main source (1.own, 2-purchased)	% of house-holds using	Main livestock types for which used	Specify season (when)	Price (Rs/Kg)	Changes in use over last decade	Why (reason for change)
Crop byproducts ………………… ………………… ………………… …………………							
Compound feed (dairy meal)							
Grazing							
Collected grasses/forage							
Produced green forage ……							
Other, specify:							

Other practices using normal crops for green fodder (e.g. wheat, barley, etc)

Practice	% of farmers practicing it
Grazing of green crop (before grain) *in situ*	
Selling of green crop (as forage)	

10 Overall fodder/feed availability

How would you categorize the village in terms of **self-sufficiency** on an annual basis for the following **feed sources** *(tick one column)*

	Deficient (importing)	Self-sufficient	Surplus (exporting)
Crop residues			
Other crop byproducts			
Grazing			
Collected grasses/forage			
Produced green forage			
Other, specify: ________			

Fodder/feed availability

Which are the critical months when fodder/feed is not available?	
Suggestions to improve upon problem of fodder/feed availability	

11 Other system issues

Use of hired labour

Activities	% of farmers hiring casual labour	% of farmers hiring permanent labour
Crop-related activities		
Livestock-related activities (specify activities….)		
For other agricultural activities, specify: ……..		

Casual wage rate

Male: Rs …… per day	Female: Rs …… per day

Is there occasionally **shortage** of casual labour? 1. Yes; 0. No

Peak period	
Casual wage rate during peak	Rs …… per day
Does casual labor from elsewhere migrate to the village during those times?	0. No; 1. Yes, from …

Does casual labor from the village also seasonally migrate to other places?	0. No; 1. Yes, to …

Role of women

	Crop related activities	Livestock- related activities
Are women in the village involved in?	0. No; 1. Yes	0. No; 1. Yes
Which are their main tasks?		
Have women more say over income from crop or livestock? *(tick)*		

Crop-livestock interactions

	In same farm household	In same village
What are the main **advantages** of having simultaneously crop and livestock…		
What are the main **disadvantages** of having simultaneously crop and livestock…		

(e.g. soil/land health, water use, pest control, water use, labor use, income, etc…)

Financial crop-livestock interactions

How significant is the use of income from crops for buying livestock or livestock inputs?	0. Not significant; 1. Significant.
How significant is the use of income from livestock for buying crop inputs?	0. Not significant; 1. Significant.

Local interest rate with village money lenders

Seasonal loan ………	Investment loan ………

Have you heard of zero-tillage? 1. Yes; 0. No

What % of farmers use zero-till drill?	
How many zero till drills are there in community?	
What is your perception of zero-tillage technology?	

Future outlook

	Crop production	Livestock production
Do farmers want to expand crop or livestock production?	0. No; 1.Yes	0. No; 1.Yes
How/which activities?		
What are the hindrances? (e.g. credit, market, land resources, water…)		
Any other constraints?		

What is the main problem affecting the village?

Comments:

Close group discussion and thank participants. Take a tour of village and surrounding fields to observe first hand. Please note any observations, discussions and general perception of crop-livestock issues if not covered before.

Crop-livestock interactions scoping study
Landless group discussion

After completing group discussion with farmers, request to meet a small group (5-10) of landless households from the village. Try hard to include some women. Discuss with them below and related issues.

Number of **participants**: ……	# of **women** among participants: ……

What share of landless households have livestock?:

Main types of animals:

How do they procure the livestock feed? (types, seasons, prices):

Describe importance of livestock to them (e.g. relative to other sources):

What problems do you face?

Annex 5. Selected photographic impressions from study area

Patiala cluster

1. Buffalo, chaff cutter, wheat *bhusa*

2. Dung cake stack

3. Wheat *bhusa* stack

4. Wheat combine harvesting in progress

5. In-site wheat residue burning

6. Wheat *bhusa* storage

Kurukshetra cluster

7. Livestock pen

8. Village scene – road as livestock pen

9. Village scene – after the survey

10. Youngster, buffalo, *bhusa*, manure, shed

11. Building wheat *bhusa* stack

12. Wheat bhusa stack


13. Village scene during survey


14. Village scene with buffalo


15. Dung cake stacks


16. Wheat manual harvest in progress


17. Small ruminants grazing along irrigation canal


18. Transport of wheat bhusa after threshing