EFFECT OF FARM MECHANIZATION ON AGRICULTURAL GROWTH AND COMPARATIVE ECONOMICS OF LABOUR AND MACHINERY IN INDIA

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PREFACE

The present study is undertaken for the Ministry of Agriculture, Government of India. The study is motivated mainly by the recent efforts of the Government of India to promote agricultural growth in the eastern region in general and mechanization in particular. The study attempts to analyze the pattern of mechanization, its effect (if any) on agricultural growth and comparative economics of labour and machinery in the eastern Indian states of Bihar and West Bengal. The study has undertaken an analysis of secondary data, supplemented by in-depth primary data surveys in these states, to understand farmers' perspective and the situation at the ground level. The Institute of Economic Growth (IEG) has carried out the analysis based on the secondary data and coordinated the primary data surveys carried out by the various Agricultural Economic Research Centres (AERC). This report presents an integrated analysis based on the primary data surveys conducted by the AERC s and the analysis based on the secondary data from published sources. The studies by the following AERC s have been used in this report (the states covered are in the parentheses) – Bhagalpur (Bihar) and Viswa Bharati (West Bengal). Study from Waltair AERC (Orissa) - was not received and therefore could not be included.

We wish to thank Dr B. S. Bhandari and other officials of the Directorate of Economics & Statistics for their cooperation and support. We thank the study teams in the AERC s of Bhagalpur and Santiniketan for their inputs through their primary data-based reports. We wish to thank the Institute for Economic and Social Change, Bangalore for their invaluable comments and suggestions on the draft report. We would like to place on record our appreciation of our colleagues in the Agricultural Economics Research Unit at IEG for their support. In particular, we are highly indebted to Dr Ankush Agrawal for devoting his valuable time and energies to coordinate the study at a crucial stage. We are also thankful to Shri Surit Das for meticulously going through the draft and providing important suggestions, which went a long way in improving the write-up.

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EXECUTIVE SUMMARY

1) Abstract

The level of mechanization in the study states of the eastern region is very low. All the three states in the study region are below the national average of farm power availability. Orissa and Bihar are way below the national average while West Bengal is closer. The total share of the three eastern study states in tractor sales is quite low between 1997-98 and 2012-13—less than 10% of the total national sales.

The crop duration index (CDI) is less than 50% in the study period in both the study states. This indicates that more than 50% of the land remains uncultivated. The scope to increase land utilization by the use of increased mechanization needs to be explored.

The percentage of farmers using machinery ranges from 21% to 100% for different types of machinery, whereas the percentage of farmers owing such machinery ranges from 7% to 50%. This underlines the importance of the hire market for agricultural machinery in Bihar. The cost of machinery is disproportionately high in West Bengal probably because of the lack of custom hiring facilities. Farmers also indicated that hire facilities are either not available or are quite expensive when available.

Machines are mainly used for only three operations—ploughing, irrigation and marketing. Also, there is a discrepancy between the preference for tools and machines for many operations—particularly for ploughing, irrigation, harvesting, threshing and marketing—and their actual use. Efforts should be made to provide the appropriate and preferred tools and machinery to the farmers.

The growth trends in the costs of machinery and labour indicate some scope for substitution of labour with machinery in Bihar for pulses. In West Bengal, the share of machine labour in total input costs is quite low. The paddy and potato farmers in this state are operating at mere subsistence level; the gross revenue covers only the operational costs.

Econometric analysis shows that machines play only a minor role in increasing gross cropped area (GCA) or yield. The results show that the major determinants are irrigation, seed and fertilizer. Irrigation (GIA) and fertilizer use (NPK) are significant in explaining GCA. Mechanization shows no effect (or negative effect). The variable significantly affecting yield is irrigated area.

2) Introduction

The present study intends to assess the effect of this increased focus on mechanization on agricultural growth in the eastern region. Its specific objectives are to assess the

1. pattern of mechanization at the crop and operation level;
2. comparative economics of labour and machinery in the region; and
3. impact of recent mechanization on agricultural growth, if any.

The study has undertaken an analysis of secondary data at the national and state level, supplemented by in-depth primary data surveys all over the country to understand the situation at the ground level and farmers' perspective.

3) Methodology:

Secondary and primary data sources are used in the study. The major data sources for the study are the primary data surveys in the study states. These are supplemented with the data from Cost of Cultivation Studies, which will give operation-wise labour use details, for secondary data analysis. Secondary data are collected from published sources such as *Cost of Cultivation of Principal Crops in India, Agricultural Statistics at a Glance*, etc. Tabular analysis, supplemented with econometric analysis, is the broad methodology followed.

4) Results

Results based on Secondary Data

1. The level of mechanization in the study states is very low. All the three states in the study region are below the national average of farm power availability. Orissa and Bihar are way below the national average. The total share of the three eastern study states in tractor sales was less than 10% of the total national sales between 1997-98 and 2012-13. This is quite low, and shows the poor state of tractorization in these states.

2. As per the cost of cultivation statistics (CoC), the share of machinery costs in total input costs is much higher in Bihar than in West Bengal. The growth trends in the costs of machinery and labour indicate some scope for substitution of labour with machinery in Bihar for pulses. In West Bengal, the share of machine labour in total input costs is quite low. The paddy and potato farmers in this state are operating at mere subsistence level, with gross revenue covering only the operational costs.

3. Econometric analysis shows that machines play only a minor role in increasing area or yield. The results show that the major determinants are irrigation, seed and fertilizer. Irrigation (GIA) and fertilizer use (NPK) are significant in explaining GCA. Mechanization shows no effect (or negative effect). The variable significantly affecting yield is irrigated area.

Results based on Household Surveys (primary data)

1. CDI is less than 50% in all three study years in both the study states, indicating that more than 50% of the land remains uncultivated. The scope to increase land utilization by the use of increased mechanization, along with other input and output policies, may be urgently explored. Results indicate that there exists scope for increasing the use of machinery in Bihar.

2. The percentage of farmers using machinery in Bihar ranges from 21% to 100% for different types of machinery, whereas the percentage of farmers owing such machinery ranges from 7% to 50%, underlining the importance of hire market for agricultural machinery in Bihar. This is also indicated by farmers in both states, indicating that the major problems are the lack of hiring facilities and the expensiveness of such facilities, when available.

3. Machines are used for mainly three operations—ploughing, irrigation and marketing. The percentage of farmers using machines is higher for these operations, but the proportion of expenditure is lower for ploughing. Therefore, greater use of tractors and power tillers may be encouraged in ploughing. Also, there is a discrepancy between the preference for tools and machines for many operations—particularly ploughing, irrigation, harvesting, threshing and marketing— and their actual use. Efforts should be made to provide the appropriate and preferred tools and machinery to the farmers.

Policy Implications

1) Given the very low level of mechanization in the two states and the low CDI, mechanization needs to be promoted through appropriate policies supplemented with suitable input and output policies.

2) Custom hiring centres need to be established, as many farmers said that the lack of such facility was a major problem.

3) Provision of other inputs, particularly irrigation, seed and fertilizers, needs to be improved, as our econometric results show that these inputs affect the area and yield levels more than the machinery use.

Chapter 1
Introduction

Agriculture provides livelihood to a majority of the Indian population. While the contribution of agriculture to GDP has come down rapidly over the past decades, the proportion of the population dependent on the sector makes it crucial in development policymaking. From the beginning of the period of planned development in 1951, a large part of government efforts has been devoted to agriculture. In the 1950s and 1960s, India relied heavily on food aid to feed its growing population. In the mid-1960s, however, after a disruption in food aid supplies, India embarked on a policy of self-sufficiency in the principal foodstuffs. An ambitious programme was launched to increase the production and productivity of agriculture. Large funds were allocated for the development of general infrastructure, including irrigation, rural electrification, rural transport and market yards. Agricultural production was stimulated through extension and advisory services, plant protection measures, animal health services and research in publicly funded institutions. A minimum support price scheme was introduced for the main agricultural crops, and its coverage progressively expanded. Supply of basic inputs, electricity, water and fertilizers at subsidized prices was also an important part of domestic support. However, although in the initial stages of the green revolution in India, farm mechanization played a major, complementary role to input usage, it has not progressed as desired (Rao 1975). Mechanization in the form of tractors, seed drills or tubewells (pumpsets) enable a farmer to save time and hence grow an extra crop, or to devote more area to existing crops. Assured water supply through tubewells should help the farmer exercise better control over the quantum and the timing of irrigation, thereby helping him realize higher yields.

Although presently India is the top producer of four-wheeled tractors with growing exports to markets like USA (Rajdou, 2009), Indian agriculture is far less mechanized than that of other South Asian countries viz., Bangladesh and Sri Lanka. While India has about 22% of area under mechanized tillage, Bangladesh and Sri Lanka have about 80% of their agricultural area mechanized (Biggs *et al*., 2011). Even within India, the extent of mechanization is extremely varied, and disparities between regions

are large. Punjab and Haryana have the highest levels of mechanization while eastern states like West Bengal, Bihar and Orissa have the lowest.

Against this backdrop, the central government and various state governments have taken several measures. Two central sector schemes—'Promotion and Strengthening of Agricultural Mechanization through Training' and 'Testing and Demonstration and Post harvest Technology and Management'—were launched during the 11th Five Year Plan. At the same time, mechanization is also promoted through other programmes viz., Macro Management of Agriculture (MMA), Rashtriya Krishi Vikas Yojana (RKVY), National Horticulture Mission (NHM) and National Food Security Mission (NFSM), etc.

1.2 Objectives

The present study intends to assess the effect of this increased focus on mechanization on agricultural growth in the eastern region. Its specific objectives are to assess the (1) pattern of mechanization at the crop and operation level, (2) comparative economics of labour and machinery in the region and (3) impact of recent mechanization on agricultural growth, if any.

1.3 Conceptual Framework and Brief Review of Literature

Mechanization in the developed economies is greatly facilitated by technical progress and industrial development, leading to substitution of labour with capital due to reduction in cost of machines and fuel. Also, because of the rapid economic growth in these economies, demand for labour in non-agricultural sectors increases more rapidly, which leads to shortfall in labour supply to agriculture. This, in turn, leads to rise in agricultural productivity, thereby increasing per capita incomes in agriculture. The increase in agricultural incomes results in lesser preference to manual labour and increases preference for mechanization (Heady 1960, Rayner and Keith 1968).

The context in which farm mechanization started in India in the mid-1960s is different from that of developed countries. The population was growing at a significant rate, which

resulted in an increasing supply of labour for the agricultural sector. The growth in per capita incomes was also negligible during this period. This was contrary to the pattern observed in developed countries, and could not be easily explained by neo-classical theory—mechanization is a response to changes in relative factor prices or factor prices relative to output. Rao (1975) explained that Ricardo's framework is more appropriate here.

> *With every increase of capital and population, food price will generally rise, on account of its being more difficult to produce. The consequence of a rise of food price will be a rise of wages, and every rise of wages will have a tendency to determine the saved capital in a greater proportion than before to the employment of machinery (Ricardo, 1966, pp 395).*

Rapid increases in population increase supply of labour but at the same time increase demand for food and other agricultural commodities. Such increase in food prices result in corresponding rises in agricultural wages (cash and kind) leading to mechanization, particularly in the absence of public investment in other inputs such as irrigation.

> *Thus, whereas in a developed economy the incentives for farm mechanization emanate from rapid industrialization and growth of per capita income resulting in the shortage of labour for the farm sector, in a developing economy like India, the incentive for mechanization is provided by the rise in prices of agricultural commodities as a result of rapid growth of population and the failure of public investment in inputs like irrigation to match the growing demand for agricultural commodities. … In view of this one should expect the relationship between the rate of mechanization on the one hand, and wage rates, leisure preference and the demand for animal products etc., on the other to be in the same direction as in a developed economy …* (Rao 1975, pp 35-36).

The extent of impact of mechanization on economic growth in general and agricultural growth in particular has also been studied by several scholars. Steckel and White (2012)

demonstrate, through use of a detailed counterfactual analysis, that mechanization in the production of farm products increased the United States' GDP by more than 8.0 percent, using 1954 as a base year. This result suggests that studying individual innovations can significantly increase our understanding of the nature of economic growth. The study refutes the notion of Fogel (1964) that no single innovation is significant enough to influence economic growth, and that technological change consists of countless small innovations (No Hero theory). Olmstead and Rhode (2001) also reach similar conclusion after studying the benefits from adoption of farm tractors. They conclude that economic historians have largely underestimated the impact of mechanization on growth coming through the channels of reduction in input costs and land augmentation.

Mechanization and related issues such as farm size and productivity were at the centre of India's agricultural debates during the 1960s and 1970s. However, with the shift in focus to technological inputs into agriculture, such as high-yielding varieties and chemical fertilizers, the focus shifted away from farm mechanization. Some important studies on farm mechanization appeared in the 1960s and 1970s. These studies explored the broad themes of (1) effect of mechanization on employment, (2) effect of mechanization on output and (3) cost benefit analysis of mechanization.

Singh (1968) was one of the earliest studies exploring the effect of tractors on labour use. Using data from four districts of Punjab (Bhatinda, Hissar, Ludhiana and Sangrur), the study finds that non–tractor-owning households used 38 per cent more labourers than tractor-owning households. However, the limitation of the study is that tractor-owning households and non–tractor-owning households are not homogeneous in other respects. Sarkar and Prahladachar (1966) address this issue by looking only at tractor households and examining the change in permanent labour use because of tractorization. Again, this study looks only at the permanent labour and not the total labour use. Rudra et al. (1969, 1969a, 1970) and Rudra (1971) find that tractors create demand for permanent labour and replace casual labour. This study finds ratios of one permanent worker and between 100 and 200 days of casual labour for non-mechanized farms; zero permanent worker and between 100 and 200 days of casual labour for farms with pumps and tubewells but no tractors; two permanent workers and between 100 and 200 days of casual labour for

tractorized farms. Rao (1972a), using Economics of Farm Management for the district of Ferozpur for 1968-69, finds tractors to be not labour-displacing. The study indicates complementarity between tractorization, irrigation and use of HYV seeds. But Sharma (1972), in a careful study finds somewhat different results for Haryana. He finds that while tractorized farms use higher amount of *total labour*, labour use *per acre* is 7 per cent higher among bullock farms. This is because labour requirement for ploughing is drastically cut by tractorization although there is greater labour use for irrigation, weeding and harvesting in tractorized farms. In a recent study, Foster and Rosenzweig (2011) use new panel data from India to examine the relationship between farm size and productivity. This examination is based on a model that incorporates agency costs favouring family workers and scale-dependent returns to mechanization arising from the fact that a larger contiguous land area is better-suited for high-capacity machinery, and falling credit costs with owned land. Their estimates, based on appropriately-computed labour shadow prices, indicate that while small farms have lower labour costs per farm, large farms use substantially less labour per acre, are more mechanized and more efficient.

There is a similar lack of consensus about the impact of tractors on output. Rudra (1973) finds that pumps and tubewells appear to contribute to higher value of output per acre but the marginal contribution of tractors is insignificant and even negative in some cases. In contrast, Rao (1972a), Sapre (1969) and Sharma (1972) find a significant positive impact. Rao (1973) carried out a detailed study of tractorization in the Ferozpur district of Punjab. He evaluated tractorization on both dimensions – private profitability and social benefit-cost analysis. He finds that for small farms of 10 acres, tractors seem to yield rather low private returns but for large farms, the private profitability is quite high. He observed that the incentives for tractorization arise from the higher demand for bullock and human labour with higher scale of operations, which in turn, leads to a rise in bullock and labour costs. His main finding is that, given the pattern of landholding at the time, tractorization on large farms is beneficial from a private as well social point of view. It is important to note that the benefits of tractorization arise from yield improvement and cost reduction (of bullock and human labour) resulting from tractors. Rao's (1973) conclusions about tractorization are based on his earlier work on positive effects on both

these counts. However, Vashishtha (1972) uses data from the same district (Ferozpur) for the same period (1968-69) but finds no evidence that mechanization leads to higher employment and output per acre. This study finds that seed, fertilizer and irrigation emerge as the main yield-increasing factors.

1.4 Database and Research Methodology

Secondary and primary data sources are used in the study. The major data sources for the study are the primary data surveys in the study states. These are supplemented with the data from Cost of Cultivation Studies, which will give operation-wise labour use details, for secondary data analysis.

For primary survey, multi-stage sampling has been adopted. At the first stage, two districts in each state have been selected. One covered under the mechanization promotion programmes or alternately highly mechanized in the state and the second district not covered by any of the programmes (or with low density of mechanization). At the second stage, one village from each of the two districts has been randomly chosen. At the third stage, a complete listing of all the households using machinery for farm operations is made. Out of this complete listing, 50 households are selected randomly from each village, thus totalling 100 households in each state. The number of households from each size-group in the sample is in proportion to the total number of households of that size-group in the population.

In West Bengal, the districts of Hooghly (highest density of tractors) and Purulia (lowest density of tractors) have been selected for the study. District Bhagalpur has been selected in Bihar and further two villages / cluster of villages were chosen in two different blocks of the district.

Secondary data are collected from published sources such as Cost of Cultivation Studies, *Agricultural Statistics at a Glance*, etc. Tabular analysis, supplemented with econometric analysis is the broad methodology followed.

1.5 Organization of the Report

The present study is organized into seven chapters.

The first chapter introduces the study with its backdrop and specifies the particular objectives of the study. It also describes the database used, methodology followed for the study and previous work on mechanization in India.

The second chapter describes the status of mechanization in India and the study states, including various mechanization programmes implemented in these states.

The third chapter discusses the results of the econometric analysis based on the secondary data collected from *Cost of Cultivation* Studies.

The results of the primary survey are discussed in four subsequent chapters, viz. from the fourth to sixth chapters.

In particular, the fourth chapter describes the demographic profile and cropping pattern of the study region based on primary data collected through field survey.

The fifth chapter examines the pattern and costs of mechanization in various farm operations.

The sixth chapter attempts to examine and analyse farmers' perception regarding use of machinery and government assistance programmes to promote mechanization.

Lastly, the seventh chapter summarizes the key findings, draws concluding observations based on the findings and attempts to outline the policy implications accordingly.

Chapter 2

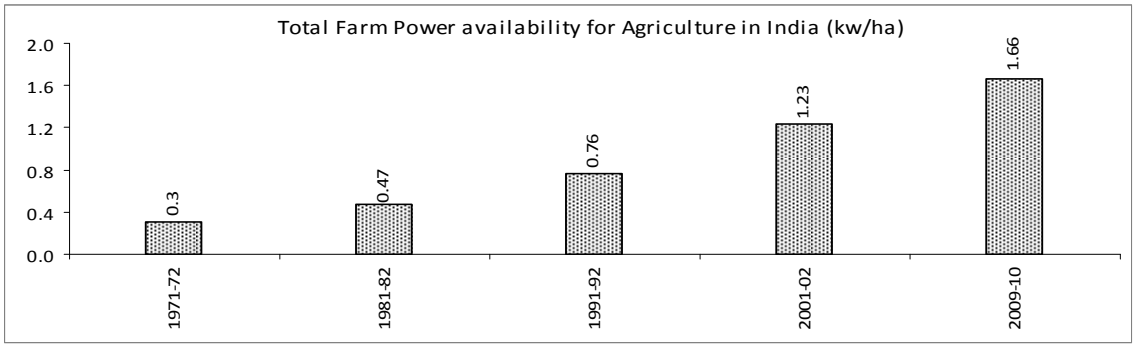
Mechanization Trends in India

This chapter presents the mechanization trends in India in general and eastern region and the study states in particular. Various government programs and initiatives undertaken to promote mechanization in the study states are also discussed.

2.1 Farm Power Availability - All India

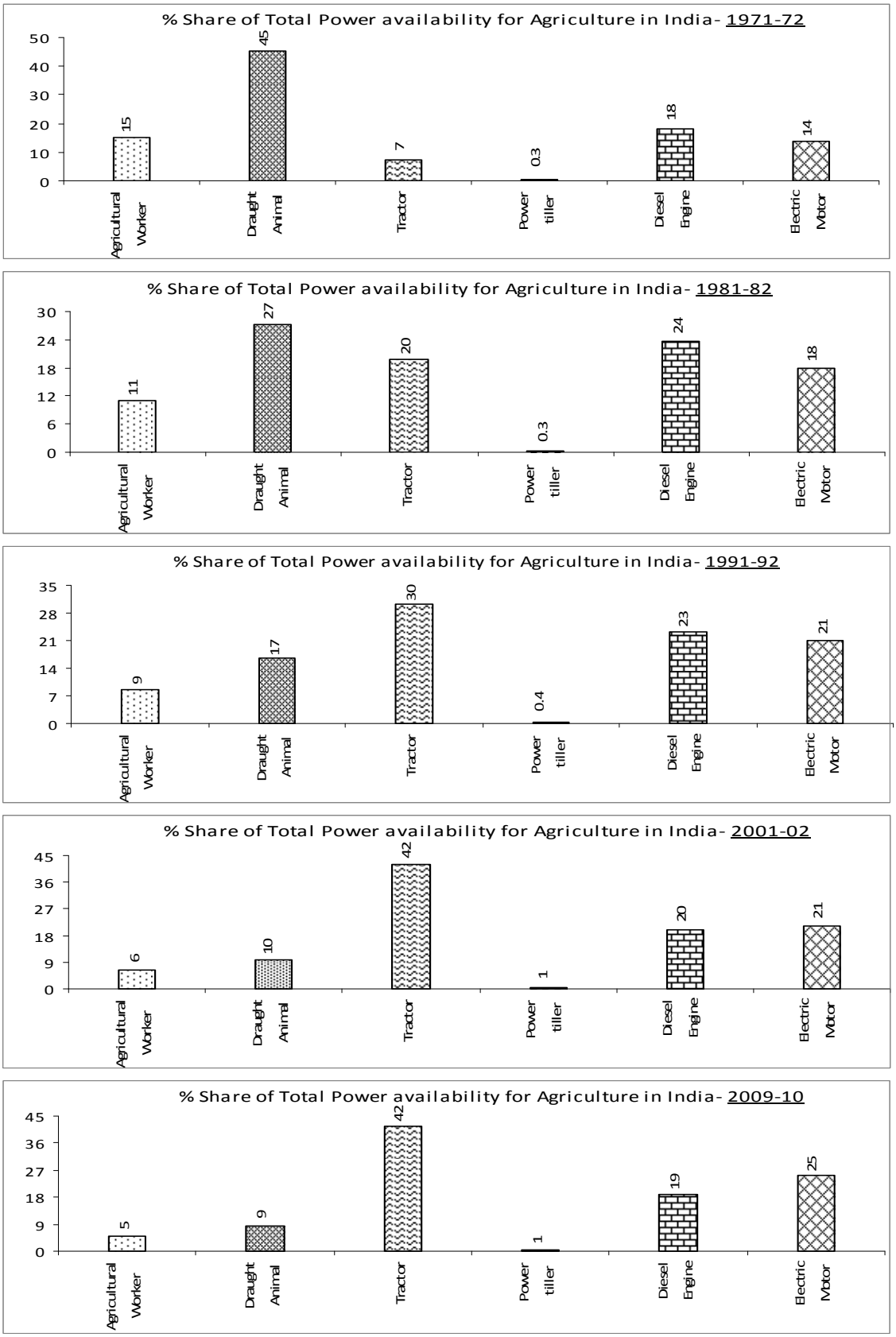
Total farm power availability in the country increased from 0.30 kw/ha in 1971-72 to 1.66 kw/ha in 2009-10 (Figure 2.1). The share of draught power came down by 36 percentage points, from 45% to 9%, during this period (Figure 2.2). The share of agricultural workers also came down from 15% to 5% (a decline of 10%). On the other hand, the share of tractors increased from 7% to 42% (+35%). Although there is a huge increase in share of tractors in farm power availability during the past three decadal periods, i.e. 13% in 1981-82 compared to 1971-72, it followed similar growth during 1991-92 (10%) and 2001-02 (12%) with respect to previous decade. However, the stagnation (0% increase in share) during the period 2001-02 to 2009-10 is a concern. Diesel engines remain almost constant, growing from 18% to 19%, and electric motors showed a decent growth, from 14% to 25%.

Figure 2.1: Farm power availability in India in last few decades



Source: Agricultural Research Data Book 2013, IASRI

Figure 2.2: Sources-wise farm power availability in India in last few decades

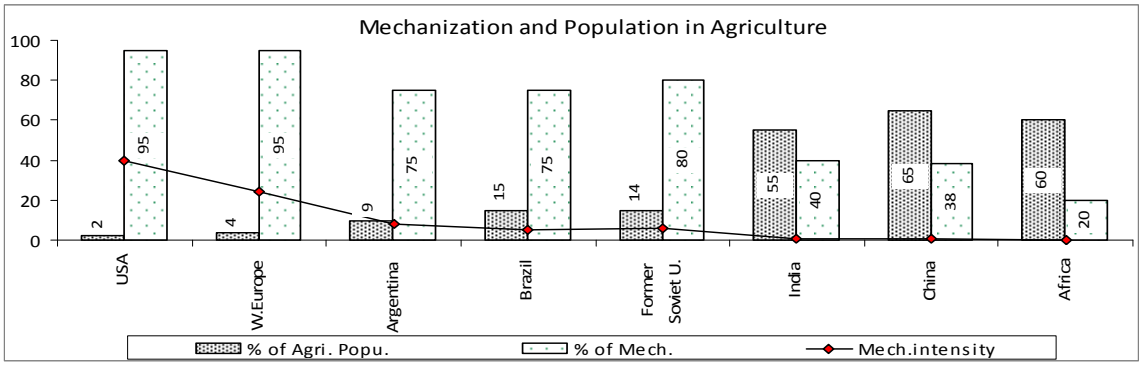


Source: Agricultural Research Data Book 2013, IASRI

2.2 Agricultural Population and Mechanization

The percentage of mechanization in India is 40% while the percentage of population engaged in agriculture is 55%, leading to a mechanization intensity of 0.73 (Figure 2.3). As compared to this low level of mechanization intensity, developed countries such as US and Western European countries have an intensity of 40 and 24 respectively. Even countries like Brazil and Argentina have corresponding figures of 5 and 8 respectively. This gives an indication of the low level of mechanization in India.

Figure 2.3: Mechanization and population in agriculture



Source: FAOSTAT and MoA (2013)

2.3 Farm Power Availability in Eastern States

All the three states in the eastern study region are below the national average of farm power availability (Table 2.1). Orissa and Bihar are way below the national average, while West Bengal is closer.

Table 2.1: State-wise Farm Power Availability

State-wise Farm Power Availability		
State	1997-98	2001
Andhra Pradesh	1.4	1.6
Assam	0.7	0.8
Bihar	0.7	0.8
Gujarat	0.5	0.8
Haryana	1.9	2.3
Himachal Pradesh	0.6	0.7
Jammu and Kashmir	0.5	0.6
Karnataka	0.8	0.9
Kerala	0.7	0.8
Madhya Pradesh	0.7	0.8
Maharashtra	0.6	0.7
Orissa	0.5	0.6
Punjab	3.0	3.5
Rajasthan	0.6	0.7
Tamil Nadu	0.8	0.9
Uttar Pradesh	1.5	1.8
West Bengal	1.1	1.3
India	1.2	1.4

Srivastava N.S.L (2006), "Farm Power Sources, their Availability and Future" in *Status of Farm Mechanization in India*, DAC, MoA, GoI

2.3.1 Tractor Sales

The production and sale of tractors was quite high in the 1960s and the 1970s, but slowed down in the 1980s and 1990s (Table 2.2), and picked up again in the 2000s. State-level data on tractor sales is available with us only from 1997-98 until 2012-13 (Table 2.3). The total share of the three eastern study states during this period is less than 10% of the total national sales, showing the poor state of tractorization in these states. For calculating the growth rates in sales, we divided this period into two sub-periods—sub-period I from 1997-98 to 2004-05 and sub-period II from 2005-06 to 2012-13. Sub-period I denotes the period of widespread agricultural stagnation in the country and sub-period II is when agricultural growth started to show a turnaround. The compound annual growth rate (CAGR) of tractor sales at the all-India level was -4% in period I while Orissa and Bihar recorded positive growth rates of 2% and 32% respectively. West Bengal recorded a decline (of -2%) similar to the national trend. In the second sub-period, however, all the three states recorded impressive positive growth rates in accordance with the national trend.

Table 2.2: Compound Annual Growth Rate of production and sale of tractors and power tiller

Compound Annual Growth Rates of Production and Sale of Tractors and Power tillers in India				
Year	Tractors		Power tillers	
	Production	Sale	Production	Sale
1961-62 to 1970-71	44	30		
1971-72 to 1980-81	16	11		
1981-82 to 1990-91	7	8	19	21
1991-92 to 2000-01	8	9	10	10
2001-02 to 2010-11	13	13	3	17

Source: Agricultural Research Data Book 2013, IASRI

Table 2.3: State-wise annual sale of tractors –Compound Annual Growth Rates and Average % Share

State-wise Annual Sale of Tractors –Compound Annual Growth Rates and Average % Share						
States	CAGR			Average % Share		
	1997-98 to 2004-05	2005-06 to 2012-13	1997-98 to 2012-13	1997-98 to 2004-05	2005-06 to 2012-13	1997-98 to 2012-13
AP	2	4	11	6	9	7
ASM	-3	34	19	0.2	1	0.4
BHR	2	19	6	6	5	5
GJ	-9	12	8	6	7	7
HRY	-11	8	3	7	5	6
HP	2	8	8	0.2	0.3	0.3
JK	16	17	10	0.5	0.4	0.4
KRN	4	4	10	4	5	5
KRL	-21	-7	2	0.2	0.2	0.2
MP	-1	19	3	13	8	10
MHR	-13	16	11	5	8	6
ORS	32	8	13	3	2	2
PB	-14	12	0.1	9	5	7
RJ	-5	11	7	8	9	9
TN	-3	2	8	4	5	4
UP	-6	12	2	22	14	18
WB	-2	19	13	1	2	2
Other	27	23	27	5	15	10
INDIA	-4	12	7	100	100	100

Source: Agricultural Research Data Book 2013, IASRI

2.4. Mechanization in the Study States and Government Initiatives

2.4.1 Bihar

As far as efforts of the Government to promote and strengthen mechanization in agricultural sector are concerned, since the year 2009-10 of the 11th Five Year Plan (i.e., 2007-08 to 2011-12) the following six schemes/programmes were undertaken:

1. Macro-mode Management of Agriculture (MMA)
2. Integrated Scheme on Oilseeds, Pulses, Oil palm and Maize (ISOPOM)
3. Jute Technology Mini Mission – II
4. National Food Security Mission (NFSM)
5. Rashtriya Krishi Vikas Yojana (RKVY)
6. State Plan on Power Tiller Promotion Scheme (SPPTPS)

Under the above schemes, agricultural machines, tools and equipments are made available to farmers on subsidized prices. Bihar is known for its good cultivable land, adequate soft water resources, human resources, and climatic diversity. Although Bihar achieved satisfactory performance in agricultural production and productivity, the potential has not been fully realized. Agricultural mechanization has a significant role to play in enhancing the productivity of agricultural sector in Bihar.

Present Status of Mechanization in Bihar: Agricultural mechanization in the state in 2009-10 was 1 kilowatt/hectare, which is much lower than Punjab (3.75 KW/ha - the highest in India) and even lower than the national average of 1.5 KW/ha. The Agricultural Mechanization Programme/Scheme 2009-10 was launched in all the districts of Bihar. Under the six schemes mentioned in the previous sub-section farmers are provided with implements, machines and/tools such as the following:

Tractor, power tiller, zero till seed-cum-fertilizer-drill, raised-bed planter, sugarcane-cutter planter, potato planter, potato digger, tractor driven reaper, seed cleaner-cum-grader, mobile foot harvester, power weeder, power thresher, winnower, conoweeder irrigation pipe, sprinkler, pump set (diesel/electric driven), rotavator, combine harvester, wheel-ho, multi-row seed drill, sprayer duster, and other power driven/human driven agricultural implements, machines, etc.

Farm Mechanization in Bihar during 11th Five Year Plan: During the 2007-08 to 2011-12, the level of achievements (physical) in regard to farm mechanization in Bihar were quite satisfactory, rather much higher in comparison to performance in financial achievement terms (Table 2.4). Except in the year 2011-12 (97.31%), physical achievements against

targets in the four financial years were more than 100 and 200 percentages. Physical achievements during the years 2007-08, 2008-09, 2009-10 and 2010-11 were 154.03%, 121.91%, 296.88% and 242.54% respectively. As regards the financial achievement of farm mechanization programmes/schemes in the state of Bihar, Table 2.4 shows that in no financial year could it touch 100% mark and financial achievements remained less than the financial targets for all the years.

Here it is to be noted that range of subsidy on agricultural machineries/implements is very wide (i.e., from Rs. 3,000/- on 'conoweeder and nepshake sprayer' to Rs. 30,000/- meant for rotavator). It seems that the distribution of lower subsidy implements were higher, means more than the targets, whereas machines/farm implements with higher amounts of subsidies might have been availed/distributed in less than the targeted number. It could have possibly led to the situation of financial achievements of farm mechanization programme falling well below 100% of the targets, while the physical achievements were well above 100% of the targets.

Table 2.4: Progress of Agricultural Mechanization Programmes/Schemes in Bihar during 11th Five Year Plan

(Amount in Rs. Lakh)

Financial Year	Physical			Financial		
	Target	Achievement	%	Target	Achievement	%
2007-08	31784	48956	154	2852	2043	72
2008-09	86911	105956	122	16290	9798	60
2009-10	103589	307533	297	15390	12815	83
2010-11	120684	292708	243	15857	12713	80
2011-12	287157	279429	97	24138	21065	87

Source: Government of Bihar, Dept. of Agriculture, year 2012-13.

2.4.2. West Bengal

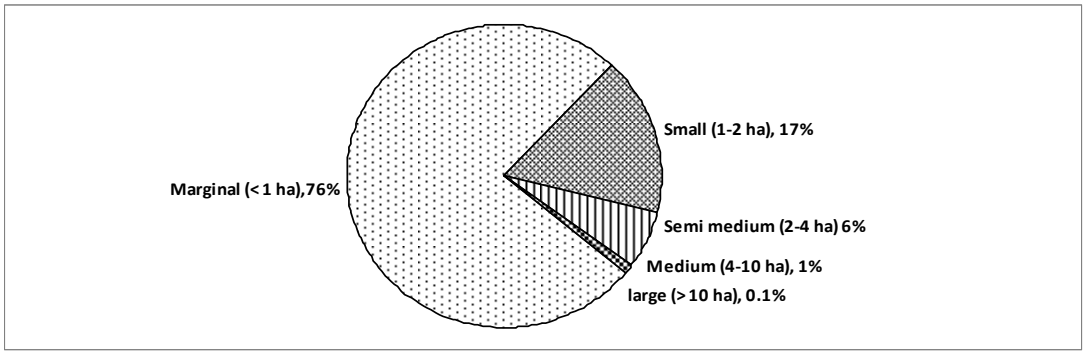
The state is the leading producer of paddy and second largest producer of potato. As paddy is primarily a wetland crop, not many machines had been used earlier. Lack of mechanization is one of the causes of delays in paddy cultivation, due to inadequate land preparation and irrigation. Better use of power tillers and introduction of improved machinery could improve the efficiency of energy use and thereby improve the energy productivity of paddy production system. Reasons for poor mechanization status in the state are low income, less land holding, lack of proper infrastructure and inadequate

facilities of repair and maintenance for different types of machinery/implements. The scope for mechanization exists in cultivation of almost all the major crops grown in the state viz. paddy, wheat, mustard, groundnut, potato, jute etc (State Agricultural Plan 212, NABARD 2012). There is also the scope of mechanization of horticultural crops mainly for crop protection and harvesting operations. The existing level of available farm power is about 1.25 kW/ ha which is inadequate to enhance the cropping intensity and output of the farm sector. This level needs to be raised to 3.0 KW/ha by 2020.

The main source of irrigation is open/tube wells. Farm power available in the state is 1.25 kW/ha. By and large, farmers have adopted mechanized ploughing and, for this purpose, relied mostly on the custom hiring of tractors. Though 33% of farmers have bullocks and ploughs, they mainly use bullocks for transportation of the crops. Desi plough, Bose plough, leveller, long handle spade, row marker and khurpi are the major implements used for performing various agricultural operations. Only 10% farmers have their own tractors and power tillers; 40% of the farmers have diesel pumpsets and 24% farmers have their own electric pumpsets for irrigating their land *(http://farmech.gov.in/FarmerGuide/WB/1w.htm)*. Sprayers and threshers are most extensively used and owned. Therefore, there is vast scope of mechanization in every nook and corner in the field of agriculture. There has been an increase in the purchase and use of power tillers in West Bengal in the last few years for paddy cultivation.

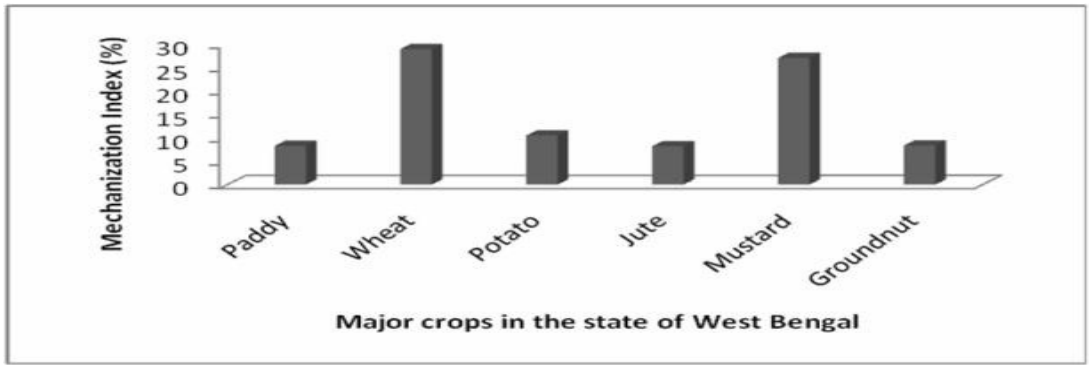
A number of suitable improved tools, implements and machinery were identified, developed and tested by IIT Kharagpur to bridge the existing mechanization gap for major cropping patterns of West Bengal. The popular and effective machinery for paddy and potato cultivation in the state has been in use among the farmers. Frontline demonstration and custom hiring services of IIT Kharagpur showed that farmers were more interested in self-propelled paddy transplanter, cono weeder, vertical conveyer reaper and flow through paddy thresher in paddy crop and semiautomatic and automatic potato planter and potato digger in potato.

Figure 2.4 Status of land holdings in West Bengal



Source: Report on Farm Mechanization (AERC, West Bengal)

Figure 2.5 Mechanization indices of major crops in West Bengal



Source: AERC West Bengal (2013)

With late start and having mostly small and marginal holdings, farm mechanization is gradually getting momentum in West Bengal and mostly for smaller machinery. The uses of different implements in West Bengal are as under (Table 2.5):

Table 2.5: Use of Different Farm Implements in West Bengal: 2006-07 to 2011-12

Implements	2006-07	2007-08	2008-09	2009-10*	2010-11*	2011-12*
Manually operated/ Bullock-drawn	14941	29852	35071	49310	61520	85830
Power drawn	2409	5716	27332	38330	54325	73075
Tractor and Power Tiller	3540	3860	5625	6175	7150	9400
Total	20890	39428	68028	93815	122995	168305

*Source: State Agricultural Plan for West Bengal 2009; * projected*

At present, mechanization in agriculture in the state is mostly confined to the use of power tiller, small implements, plant protection equipments and power threshers. With

the growing seasonal demand and high cost of labour, the need for mechanization is being felt increasingly. Keeping in view the small holding nature where individual ownership of farm equipment is not a feasible and viable proposition, the concept of 'Farm Machinery Hub' is being promoted in the state. This enables small farmers to rent the equipment they need. Farmers' cooperatives and big farmers are also being encouraged to use medium-range machinery like self-propelled rice transplanter, reaper, etc. Modern equipments include laser land leveller, rotavator, sub-soiler, zero till drill, happy-seeder, raised-bed former, ridgeseeder, inclined plate planter, automatic potato planter, straw baler, multi-crop thresher, sprinkler and drip irrigation system, automated milking machine and pasteurization machines, cattle feed machines and feed plant, portable fish carp hatchery, egg incubators, other livestock and poultry equipments etc.

2.4.3 Government Programmes on Farm Mechanization in West Bengal

In view of promoting farm mechanization, the state government has also taken several initiatives under major central sector schemes as well as state schemes. The achievement in promoting farm mechanization under major central sector schemes in West Bengal during 2012-13 may be stated as under (Table 2.6):

Table 2.6: Target and Achievement in Farm Mechanization under Major Central Sector Schemes in West Bengal: 2012-13

Scheme	Target for 2012-13 (Rs. in Crore)	Up to date Achievement of 2012-13 (Rs. in Crore)	Nos. of Farm Machinery Distributed so far	Rate of Subsidy (Rs.)
RKVY	19.071	14.70	Tractor-132 Power tiller-1517 Power reaper-97 Zerotillege-2 Pumpset-6625	Tractor- :45,000/- Power Tiller- :45,000/- Power Reaper- :40,000/- Zero Tillage Machine - :15,000/- Pump set- :10,000/-
BGREI	53.15	37.59	Tractor-249 Power tiller-2820 Power reaper-190 Zerotillege-06 Pumpset-21715	
NFSM	Rs. 8.573	Rs.3.33884	Tractor-11 No. Power Tiller -179 Pump set – 2382 Power Reaper - 23	

Source: National Conference on Agriculture for Rabi Campaign – 2013; Department of Agriculture; Govt. of West Bengal

Apart from the central sector schemes, the Government of West Bengal has initiated several schemes in view of promoting farm mechanization in the state. In particular, the Government of West Bengal has introduced three schemes for promoting mechanization in West Bengal. The first scheme titled One-Time Assistance (OTA) to Electrified Agricultural Pump (EAP) provides one-time assistance of Rs. 8,000 to farmers for electrification of shallow tubewells. The second scheme titled Financial Support Scheme for Farm Mechanization (FSSM) provides direct subsidy to the farmers for purchasing heavy farm equipments like tractors, power tillers, etc. The third scheme, 'Small Farm Implements', provides farmers OTA to purchase implements such as thresher, weeder, sprayer, drum seeder and irrigation pipes. The statements of target and achievement of these schemes as given as under (Table 2.7):

Table 2.7: Achievement of Farm Mechanization in West Bengal during 2012-13

Sl. No.	Name of the Scheme	Component	Fund Sanctioned (Rs. in Crore)	Achievement	
				Physical (Nos.)	Financial (Rs. in Crore)
1.	FSSM	1) Tractor up to 40 HP	101.73	332	64.958 -
		2)Power Tiller above 8 HP		4542	
		3)Pumpset-(Diesel/Electric)		41850	
		4) Power Reaper		293	
		5) Zero Till Seed Drill		2	
2.	One-Time Assistance for Electrification of Agricultural Pumpsets (OTA-EAP)	Electrification of Agricultural Pumpsets	24.90 for 31125 no. units	3430	2.744
3.	OTA to Small and Marginal farmers for purchase of Small Farm Implements.	1) Kanpsack sprayers, 2) Manually operated Paddy Thresher 3) Cono weeder 4) Drum Seeder, 5) PVC delivery pipe for carrying irrig. water. (6) Spade (I set of four spades of different sizes)	15.00	On progress	-

Source: National Conference on Agriculture for Kharif Campaign – 2013; Department of Agriculture; Government of West Bengal

The target for 2013-14 under the FSSM was initially set at Rs. 84.77725 Crores, while the budget for farm mechanization for 2013-14 under Sub-Mission on Agricultural Mechanization (SMAM) in West Bengal is as follows (Table 2.8):

Table 2.8: Budget for Farm Mechanization for 2013-14 under Sub-Mission on Agricultural Mechanization (SMAM) in West Bengal

Sl No	Scheme/Component	Target for 2013-14 (Rs. in Lakh)
1	Establishment of Farm Machinery Bank for Custom Hiring	6676.00
2	Promotion & Strengthening of Agricultural Mechanization through Training, Testing and Demonstration.	
	a) Demonstration Component	693.60
	b) Outsourcing of Training	82.875
3	Subsidy for selected agricultural machinery and equipment	7870.00
4	Input subsidy to small & marginal farmers for adopting suitable farm mechanization	3000.00
5	Enhancing farm productivity at village level by introducing appropriate Farm Mechanization in selected villages	600.00
6	Post harvest technology and management	69.65
TOTAL		18922.475

Source: National Conference on Agriculture for Rabi Campaign – 2013; Department of Agriculture; Govt. of West Bengal

Reports indicate that the state government allocated Rs. 12.23 crores for the Small Farms Implements scheme for the financial year 2013-14, of which only Rs. 6.28 crores were spent. In the case of the OTA EAP scheme, about Rs 19 crores of the Rs. 21 crores allocated for 2013-14 was not spent. In the case of the FSSM scheme, of the Rs. 53.34 crore allocated, only Rs.16.8 crores was spent at the end of the financial year. Hence, the achievement under different state-initiated mechanization schemes remains quite poor in the state.

2.5 Machinery Costs

Bihar

In Bihar, the share of machinery costs in total input costs is much higher than in West Bengal (Table 2.9). This share is higher than 10% for most crops except potato (3%). The share of machinery costs in value of production is also higher at more than 5% for all the crops except potato, for which it is 2% (Table 2.11). The share of machine labour relative to hired human labour is also higher, almost 50% for lentil, wheat and gram. As for the growth trends in these costs the growth rate of cost of machinery is lower than that of human labour for some crops, particularly pulses (Table 2.12). This is mainly because of faster growth in the wage rates of hired labour. These growth trends in the costs of

machinery and labour indicate some scope for substitution of labour with machinery in the state for pulses.

Table 2.9: Bihar: Share of machinery costs in operational costs (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Operational cost	Cost of human labour as % of operational costs	Cost of bullock labour as % of operational costs	Cost of machine labour as % of operational costs
Gram	2168	141	1279	6625	33	2	19
Lentil	2187	476	1047	5381	41	9	19
Maize	4397	336	1456	11703	38	3	12
Paddy	5935	705	1233	10610	56	7	12
Potato	8800	1141	1027	32605	27	3	3
Wheat	3123	597	2460	11338	28	5	22

Source: Estimated from cost of cultivation/production data, Directorate of Economics and Statistics, GoI (Table 295 to Table 2.23)

Table 2.10: Bihar: Share of machinery costs in total costs (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Total cost	Cost of human labour as % of total costs	Cost of bullock labour as % of total costs	Cost of machine labour as % of total costs
Gram	2168	141	1279	12106	18	1	11
Lentil	2187	476	1047	11018	20	4	10
Maize	4397	336	1456	17199	26	2	8
Paddy	5935	705	1233	15626	38	5	8
Potato	8800	1141	1027	41571	21	3	2
Wheat	3123	597	2460	16887	18	4	15

Table 2.11: Bihar: Share of machinery costs in value of production (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Value of Production	Cost of human labour as % of value of production	Cost of bullock labour as % of value of production	Cost of machine labour as % value of production
Gram	2168	141	1279	20946	10	1	6
Lentil	2187	476	1047	19484	11	2	5
Maize	4397	336	1456	25456	17	1	6
Paddy	5935	705	1233	16423	36	4	8
Potato	8800	1141	1027	61433	14	2	2
Wheat	3123	597	2460	20700	15	3	12

Table 2.12: Bihar: Growth Rate of Costs (2002-03 to 2009-10)

Crop	Cost of Human Labour			Cost of Bullock Labour			Cost of Machine Labour
	Qty	Price	Total cost	Qty	Price	Total cost	Total cost
Gram	5	4	9	-36	16	-26	2
Lentil	-1	7	6	-7	9	2	-4
Maize	-4	9	4	-23	7	-18	7
Paddy	-2	8	6	-10	7	-4	12
Potato	-6	10	4	-26	-2	-28	20
Wheat	-2	9	6	-9	7	-3	7

Table 2.13: Bihar: Growth Rate of Production vis-à-vis Costs (2002-03 to 2009-10)

Crop	Production			Cost of Machinery
	Yield	Price (value of production /yield)	Value of Production	Total cost
Gram	4	7	11	2
Lentil	-4	13	8	-4
Maize	2	12	14	7
Paddy	-0.3	10	10	12
Potato	4	7	11	20
Wheat	1	9	11	7

West Bengal

In West Bengal, the share of machine labour in total input costs is quite low, ranging from 3% in jute to a maximum of 5% in paddy (Table 2.14). The share of human labour is quite high, about 50% and above, in three out of the five major crops studied, that is, paddy, jute and rapeseed and mustard. It is notable that the total cost is higher than the value of production in case of two major crops, paddy and potato, but the operational costs are lower (Table 2.15 and Table 2.16). This indicates that paddy and potato farmers are operating at subsistence level with the gross revenue covering only the operational costs.

As regards the growth trends in these costs, the growth rate of bullock labour cost is generally negative for most crops (Table 2.17). The growth rate of the machine labour is quite high but in absolute terms it is less than 10% of the cost of human labour and less than 5% of the value of production (Tables 2.16 and 2.17). The high growth rate is possibly because of this low base effect.

Table 2.14: West Bengal: Share of machinery costs in operational costs (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Operational cost	Cost of human labour as % of operational costs	Cost of bullock labour as % of operational costs	Cost of machine labour as % of operational costs
Jute	14399	1901	519	20517	70	9	3
Paddy	11406	2339	894	19679	58	12	5
Potato	13686	1717	2018	52098	26	3	4
rpmst	6320	1855	489	12980	49	14	4
Wheat	7938	2523	693	18964	42	13	4

Table 2.15: West Bengal: Share of machinery costs in total costs (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Total cost	Cost of human labour as % of total costs	Cost of bullock labour as % of total costs	Cost of machine labour as % of total costs
Jute	14399	1901	519	29535	49	6	2
Paddy	11406	2339	894	27952	41	8	3
Potato	13686	1717	2018	69403	20	2	3
rpmst	6320	1855	489	19095	33	10	3
Wheat	7938	2523	693	26030	30	10	3

Table 2.16: West Bengal: Share of machinery costs in value of prod. (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Value of Production	Cost of human labour as % of value of production	Cost of bullock labour as % of value of production	Cost of machine labour as % value of production
Jute	14399	1901	519	31406	46	6	2
Paddy	11406	2339	894	26665	43	9	3
Potato	13686	1717	2018	63542	22	3	3
rpmst	6320	1855	489	20211	31	9	2
Wheat	7938	2523	693	22715	35	11	3

Table 2.17: West Bengal: Growth Rate of Cost (2002-03 to 2009-10)

Crop	Cost of Human Labour			Cost of Bullock Labour			Cost of Machine Labour
	Qty	Price	Total cost	Qty	Price	Total cost	Total cost
Jute	-2	7	5	-4	6	2	28
Paddy	-0.05	8	8	-5	-3	-8	9
Potato	-2	8	6	-7	2	-5	13
rpmst	0.2	9	9	-1	3	2	13
Wheat	4	14	19	-13	5	-8	39

Table 2.18: West Bengal: Growth Rate of Production vis-à-vis Costs (2002-03 to 2009-10)

Crop	Production			Cost of Machinery
	Yield	Price (value of production /yield)	Value of Production	Total cost
Jute	1	12	13	28
Paddy	1	9	11	9
Potato	-1	6	5	13
rpmst	-1	6	5	13
Wheat	4	8	11	39

Overall (Bihar and West Bengal combined)

The cost of machinery in total input costs is quite low in the study states. It ranges from 2% in jute to 11% in gram (Table 2.20). As a proportion of the value of production (VoP) also, the cost is quite low; it ranges from 2% for jute to 7% for wheat (Table 2.21). The absolute value of machinery costs is quite high for wheat, potato and paddy. In the case of paddy and wheat, total input costs are very close to the VoP (Tables 2.20 and 2.21). In fact, in the case of paddy, the costs are higher than the VoP; this shows that paddy farmers in these states, particularly West Bengal, operate under subsistence conditions. The growth rate of the cost of machinery is much higher than that of the wage rate in the study region.

Table 2.19: Overall: Share of machinery costs in operational costs (2002-02 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Operational cost	Cost of human labour as % of operational costs	Cost of bullock labour as % of operational costs	Cost of machine labour as % of operational costs
Gram	2168	141	1279	6625	33	2	19
Jute	14399	1901	519	20517	70	9	3
Lentil	2187	476	1047	5381	41	9	19
Maize	4397	336	1456	11703	38	3	12
Paddy	17341	3044	2127	30289	57	10	7
Potato	22486	2858	3045	84703	27	3	4
rpmst	6320	1855	489	12980	49	14	4
Wheat	11061	3120	3152	30302	37	10	10

Table 2.20: Overall: Share of machinery costs in total costs (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	Total cost	Cost of human labour as % of total costs	Cost of bullock labour as % of total costs	Cost of machine labour as % of total costs
Gram	2168	141	1279	12106	18	1	11
Jute	14399	1901	519	29535	49	6	2
Lentil	2187	476	1047	11018	20	4	10
Maize	4397	336	1456	17199	26	2	8
Paddy	17341	3044	2127	43578	40	7	5
Potato	22486	2858	3045	110974	20	3	3
rpmst	6320	1855	489	19095	33	10	3
Wheat	11061	3120	3152	42917	26	7	7

Table 2.21: Overall: Share of machinery costs in VoP (2002-03 to 2009-10)

Crop	Cost of Human Labour	Cost of Bullock Labour	Cost of machine labour	VoP	Cost of human labour as % of VoP	Cost of bullock labour as % of VoP	Cost of machine labour as % VoP
Gram	2168	141	1279	20946	10	1	6
Jute	14399	1901	519	31406	46	6	2
Lentil	2187	476	1047	19484	11	2	5
Maize	4397	336	1456	25456	17	1	6
Paddy	17341	3044	2127	43088	40	7	5
Potato	22486	2858	3045	124975	18	2	2
rpmst	6320	1855	489	20211	31	9	2
Wheat	11061	3120	3152	43414	25	7	7

Table 2.22: Overall: Growth Rate of Cost (2002-03 to 2009-10)

Crop	Cost of Human Labour			Cost of Bullock Labour			Cost of Machine Labour
	Qty	Price	Total cost	Qty	Price	Total cost	Total cost
Gram	5	4	9	-36	16	-26	2
Jute	-2	7	5	-4	6	2	28
Lentil	-1	7	6	-7	9	2	-4
Maize	-4	9	4	-23	7	-18	7
Paddy	-1	8	7	-6	1	-7	11
Potato	-4	9	5	-11	-0.02	-10	16
rpmst	0.2	9	9	-1	3	2	13
Wheat	3	14	17	-11	8	-6	12

Table 2.23: Overall: Growth Rate of Production vis-à-vis Costs (2002-03 to 2009-10)

Crop	Production			Cost of Machinery
	Yield	Price (VoP /yield)	VoP	Total cost
Gram	4	7	11	2
Jute	1	12	13	28
Lentil	-4	13	8	-4
Maize	2	12	14	7
Paddy	1	10	10	11
Potato	1	7	8	16
rpmst	-1	6	5	13
Wheat	5	7	12	12

Chapter 3
Econometric Analysis of Agricultural Growth and Mechanization

This chapter presents the results of the econometric analysis, exploring the relationship between mechanization and agricultural growth using secondary data. The two channels through which mechanization can impact agricultural growth are through the increase in cropping intensity (or GCA) or/and through improvements in yield. At the All-India level, we estimated two behavioural equations—one each to capture the effect of mechanization on GCA and foodgrain yield (output per ha) respectively. In both the equations, we have controlled for all other important effects such as irrigation, fertilizer consumption, technology, etc.

3.1 All-India Results

The results show that in the GCA equation, mechanization shows no effect (or negative effect) (Table 3.1). The variables that appear to have significant effect on GCA are irrigation (GIA) and fertilizer use (NPK). In the foodgrain yield equation again, mechanization does not have any significant effect on the dependent variable. This is in contrast to some of the recent studies such as Singh (2001), MoA (2013). The Singh et al. study does not control for the effects of any other major inputs such as irrigation, fertilizer, seeds etc. This is a classic omitted variable problem that can lead to highly biased results. In such cases, the included variable tends to pick up all the effect due to other variables as well. As the MoA (2013) study is basically a reproduction of the Singh (2001) results, both studies suffer from serious methodological shortcomings. We have attempted to address these limitations by including other relevant explanatory variables. When the effects of these other inputs such as irrigation, fertilizer, seeds, etc. are accounted for in our study, mechanization turns insignificant. The input that significantly affects yield turns out to be the percentage of irrigated area. Our results therefore show that when a proper account is made of other important variables, results can be vastly different.

At the national level, the following econometric model has been estimated.

$$GCA_t = f\,(GCA_{t-1},\ GIA_t,\ Fert_t,\ Farm\ Power_t, e_t)$$

$$FGYld_t = f\,(FGYld_{t-1},\ GIA/GCA_t,\ Fert/ha_t,\ Farm\ Power/GCA_t,\ e_t)$$

Notations:

GCA_t =GCA at time t
$FGYld_t$ =Foodgrain yield at time t
GIA_t,= Gross irrigated area in time period t.
$Fert_t$ = Fertilzer consumption in time period t
TRPWR/ MECPWR $_t$ = Tractor/mechanical power available in time t
DRAUGHT POWER $_t$ = Draft power available in time t
e_t = Error term

We have used irrigation and fertilizer consumption in addition to a measure of mechanization to isolate the effect of machinery on area and yield (Table 3.1). We have used two measures of mechanization from Sigh et al. (2010) – TRPWR and MECPWR. The first measure gives the per hectare farm power available from tractors alone whereas the second measure gives the farm power available per hectare from all mechanical sources, including diesel engines and electric motors, which are mainly used for irrigation. The results in Table 3.1 indicate that the TRPWR and MECPWR have a statistically insignificant effect, and that the use of machinery has a negligible effect on production—once the effect of other relevant variables, such as irrigation and fertilizers, is accounted for.

Table 3.1: Econometric Results (All India)

Dependent Variable	Explanatory Variables				R^2	D.W
	GIA	FERT	DRAUGHT POWER	TRPWR/ MECPWR		
GCA	0.29***	0.03**		-0.04	0.97	2.56
FGYLD (with TRPWR)	0.63*		-0.91**	-0.02	0.99	1.72
FGYLD (with MECPWR)	0.48		-0.97**	0.01	0.99	1.52

Source: Authors' computations

3.2 Results in the Study Region

This study uses data on the cost of cultivation from 1997 to 2009, and analyses the effect of expenditure on various inputs on VoP. The expenditure approach has been adopted since two of the important inputs, irrigation and machinery, are only given in value terms in CoC data. There are no measures of the quantity of these inputs available. The effect of machinery cost on VoP has been estimated after controlling for draught power, seeds, irrigation and fertilizer.

The following econometric model has been estimated for states of Orissa, Bihar and West Bengal.

$$VOMP_t = f\,(SEED_t, FERT_t, IRRGN_t, ALV_t, HLV_t, MLV_t\, e_t)$$

VOMP = value of main product (Rs/ha)
SEED = Expenditure on seed (Rs/ha)
FERT = Expenditure on fertilizer (Rs/ha)
IRRGN = Expenditure on irrigation (Rs/ha)
ALV = Expenditure on Animal labour (Rs/ha)
HLV = Expenditure on Human labour (Rs/ha)
MLV = Expenditure on machinery (Rs/ha)
e_t = Error term

The results indicate that in Bihar, the expenditure on machinery shows a significant effect only for potato (Table 3.2). For paddy, gram and maize it is insignificant. The expenditure on seed for gram, fertilizer for maize and potato and irrigation for paddy (negative) and potato shows significant effect on the dependent variable. The expenditure on human and animal labour generally shows a significant negative effect, perhaps indicating scale economies.

In Orissa, both the major crops, paddy and moong, show a significant positive effect for seed (Table 3.2). Machinery expenditure shows significant negative effect for moong possibly because of the indivisibility effect.

In West Bengal, seed, fertilizer, irrigation and human labour show significant positive effect on VoP (Table 3.2). Machinery shows significant positive effect in case of jute and potato but in the case of paddy it shows significant negative effect.

Overall, in all the three states, seed appears to be the major determinant of production followed irrigation and fertilizer. Machinery is mostly insignificant or negative in its effect.

Table 3.2: Econometric Results- Study States (based on CoC data)

Dependent Variable : Value of the Main Product (Rs/Ha) All the variables are in expenditure terms								
State/Crop	Explanatory Variables						R^2	D.W
	SEED	FERT	IRRGN	HLV	ALV	MLV		
Bihar								
1) Paddy		0.36	-0.04*	-0.9***		0.02	0.90	2.26
2) Gram	0.87***	-0.03				0.11	0.91	2.71
3) Maize		0.49***			-0.24**	-0.14	0.87	1.92
4) Potato		0.38**	0.45***		0.05	-0.15*	0.95	2.11
Orissa								
1) Paddy	1.25**		-0.15			-0.11	0.91	2.19
2) Moong	0.88**					-0.09**	0.92	1.81
West Bengal								
1) Paddy	1.01**		0.56***			-0.81*	0.91	2.09
2) Potato		0.67**		0.40***		0.54***	0.82	2.14
3) Jute	0.37***					0.91*	0.88	2.47

Source: Authors' computations

Chapter 4
Demographic Profile and Cropping Pattern of the Study Region

Chapters four to six present analysis of the primary data collected from the sample households in the two study states. The present chapter outlines the demographic profile, cropping pattern and the physical and natural endowments such as irrigation and education.

4.1 Demographic Profile

Bihar: Of the total sample, 42% of the households belong to the marginal category followed by small (27%), medium (17%) and large (14%) (Table 4.1). The adult population comprised 54% males and 46% females. About 75% of the households were OBCs, and 13% belonged to other castes and SC each (Table 4.3). There are no STs in the sample. The percentage of SCs is highest among marginal farmers, and the percentage of 'others' is highest in the large farmer category, showing the association between social and economic status.

West Bengal: In West Bengal, marginal farmers comprise about 80% of the sample population (Table 4.1). Of the adult population, 57% are male and 43% female. The largest caste group is OBCs (45% of the total sample), followed by others (30%) (Table 4.3). It is notable that all the farmers in the ST category are marginal while all the farmers in the SC category are either marginal or small. There are no medium farmers in these caste groups. This is indicative of the close nexus between the social and economic status in the study region of the state.

Overall (Bihar and West Bengal): In the sample population, 59% belong to the marginal category followed by small (20%), medium (13%) and large (7%) (Table 4.1). About 55% of the adult population are male, and 45% are female; these proportions are almost the same across all size-groups. OBCs form the largest caste group in the total population with a share of 60%, followed by others (22%), SCs (12%) and STs (7%) (Table 4.3). The percentage of SCs is highest in the marginal and small farmer categories. All the ST

households belong to the marginal category. All the large farmers belong to either OBCs (60%) or others (40%). No large farmer belongs to either SC or ST category. These trends clearly show that social hierarchy and economic status (land holding) are positively associated in the sample region.

Table 4.1: Demographic Profile

Demographic Profile (Number of HH)						
State	Size Classes	Adults			Children	Total
		Males	Females	Total		
Bihar	Marginal	106	93	199	126	325
	Small	74	60	134	72	206
	Medium	49	45	94	41	135
	Large	37	33	70	37	107
	Total	266	231	497	276	773
West Bengal	Marginal	230	175	405	106	511
	Small	36	26	62	20	82
	Medium	19	14	33	10	43
	Large					
	Total	285	215	500	136	636
Overall	Marginal	336	268	604	232	836
	Small	110	86	196	92	288
	Medium	68	59	127	51	178
	Large	37	33	70	37	107
	Total	551	446	997	412	1409

Source: Primary survey

Table 4.2: Caste Composition

Caste Composition (Number of HH)						
State	Size Classes	SC	ST	OBC	Others	Total
Bihar	Marginal	10		32	3	45
	Small	2		20	2	24
	Medium	1		13	2	16
	Large			9	6	15
	Total	13		74	13	100
West Bengal	Marginal	8	14	34	25	81
	Small	3		9	2	14
	Medium			2	3	5
	Large					
	Total	11	14	45	30	100
Overall	Marginal	18	14	66	28	126
	Small	5		29	4	38
	Medium	1		15	5	21
	Large			9	6	15
	Total	24	14	119	43	200

Source: Primary survey

Table 4.3: % Distribution of Caste Composition

Caste Composition (% Distribution)						
State	Size Classes	SC	ST	OBC	Others	Total
Bihar	Marginal	22		71	7	100
	Small	8		83	8	100
	Medium	6		81	13	100
	Large			60	40	100
	Total	13		74	13	100
West Bengal	Marginal	10	17	42	31	100
	Small	21		64	14	100
	Medium			40	60	100
	Large					
	Total	11	14	45	30	100
Overall	Marginal	14	11	52	22	100
	Small	13		76	11	100
	Medium	5		71	24	100
	Large			60	40	100
	Total	12	7	60	22	100

Source: Primary survey

4.2 Education Profile

Bihar: In most households in all size-groups, the head of the household possessed the education level of 'secondary education and above', 64%, showing better literacy in the sample region (Table 4.5). The percentage of illiterates is the highest in the marginal category. The majority of the adult population (50%) in all size-groups also had education level of 'secondary education and above' (Table 4.7). The percentage of illiterates and primary educated is highest in the marginal category, showing a positive association between land size and educational attainment.

West Bengal: In West Bengal, as regards the education level of the head of the household, the largest share in all size-groups is that of 'secondary education and above'(45%) (Table 4.5). This shows that the sample region is reasonably well-endowed in terms of literacy. There are about 28% illiterates in the marginal and small farmer groups but there are no illiterates in the medium farmer category, perhaps showing the positive association between size of landholding and educational attainment. As for literacy levels of the total adult population (not just the household head), the majority (50%) fall again in the 'secondary education and above' category (Table 4.7). The percentage of illiterates is low in the medium farmer category.

Overall (Bihar and West Bengal): In majority of the households (55% of the total households), the head of the household is educated up to the secondary or higher level (Table 4.5). The percentage of households with an illiterate head is highest in the marginal farmer category (23%), which gradually decreases with increase in the landholding size. The majority of the adult population have education of secondary and higher level (50%) (Table 4.7). This percentage (of population with secondary and higher level of education) is lowest among marginal farmers. The percentage of those educated up to the primary school is highest among marginal farmers. Bihar has fewer illiterates and primary educated persons than West Bengal in the marginal category (Table 4.6). Overall, the education profile of the sample regions in the two states clearly shows the positive association between the land size and educational attainment.

Table 4.4: Education of Head

Education of the head of the household (Number of HH)					
State	Size Classes	Illiterates	Primary	Secondary & Above	Total
Bihar	Marginal	5	17	23	45
	Small	2	4	18	24
	Medium	1	4	11	16
	Large	1	2	12	15
	Total	9	27	64	100
West Bengal	Marginal	24	20	37	81
	Small	4	4	6	14
	Medium		3	2	5
	Large				
	Total	28	27	45	100
Overall	Marginal	29	37	60	126
	Small	6	8	24	38
	Medium	1	7	13	21
	Large	1	2	12	15
	Total	37	54	109	200

Source: Primary survey

Table 4.5: % Distribution of Education of Head

Education of the head of the household (% Distribution)					
State	Size Classes	Illiterates	Primary	Secondary & Above	Total
Bihar	Marginal	11	38	51	100
	Small	8	17	75	100
	Medium	6	25	69	100
	Large	7	13	80	100
	Total	9	27	64	100
West Bengal	Marginal	30	25	46	100
	Small	29	29	43	100
	Medium		60	40	100
	Large				
	Total	28	27	45	100
Overall	Marginal	23	29	48	100
	Small	16	21	63	100
	Medium	5	33	62	100
	Large	7	13	80	100
	Total	19	27	55	100

Source: Primary survey

Table 4.6: Education profile of the adult population

Education profile of the adult population (Number of HH)					
State	Size Classes	Illiterates	Primary	Secondary & Above	Total
Bihar	Marginal	45	74	80	199
	Small	28	24	82	134
	Medium	19	23	52	94
	Large	16	19	35	70
	Total	108	140	249	497
West Bengal	Marginal	99	111	195	405
	Small	14	13	35	62
	Medium	6	7	20	33
	Large				
	Total	119	131	250	500
Overall	Marginal	144	185	275	604
	Small	42	37	117	196
	Medium	25	30	72	127
	Large	16	19	35	70
	Total	227	271	499	997

Source: Primary survey

Table 4.7: % Distribution of Education profile of the adult population

Education profile of the adult population (% Distribution)					
State	Size Classes	Illiterates	Primary	Secondary & Above	Total
Bihar	Marginal	23	37	40	100
	Small	21	18	61	100
	Medium	20	25	55	100
	Large	23	27	50	100
	Total	22	28	50	100
West Bengal	Marginal	24	27	48	100
	Small	23	21	56	100
	Medium	18	21	61	100
	Large				
	Total	24	26	50	100
Overall	Marginal	24	31	46	100
	Small	21	19	60	100
	Medium	20	24	57	100
	Large	23	27	50	100
	Total	23	27	50	100

Source: Primary survey

4.3 Crop Structural Components

4.3.1 Irrigation

Bihar: About 50% of the sample area is unirrigated (Table 4.9). For the irrigated region, tubewell is the major source (45% of total area) and the rest is through 'other sources'. It is notable that tubewell irrigation is the lowest in the marginal category, showing the relatively weaker access of marginal farmers to capital and controlled irrigation.

West Bengal: More than 50% of the sample area is unirrigated (Table 4.9). For the irrigated area, canals are the major source of irrigation (32%), followed by tubewells (13%).

Overall (Bihar and West Bengal): In the sample region, about 51% of the area is unirrigated (Table 4.9). The major source of irrigation is tubewell (42% of total area), followed by canal (3%) and others (4%). It may be noted that there is no area under tank irrigation in the sample region, although there is some evidence in the literature of tank irrigation in eastern states (Pant and Verma 2010), particularly in the Purulia district of West Bengal. This could be due to the stratification methodology of the sample, which is based on the mechanization pattern in the state.

Table 4.8: Irrigation

Irrigation- Area in ha								
State	Size Classes	Irrigated					Un irrigated	Total
		Canal	Tubewell	Tank	Others	Total		
Bihar	Marginal		0.2		0.1	0.2	0.3	0.6
	Small		0.6		0.1	0.7	0.7	1.3
	Medium		1.0		0.2	1.2	0.9	2.1
	Large		2.4		0.1	2.5	2.8	5.2
	Total		4.1		0.4	4.6	4.6	9.2
West Bengal	Marginal	0.2	0.1			0.3	0.3	0.6
	Small	0.4	0.2		0.1	0.7	0.9	1.6
	Medium	1.2	0.4		0.1	1.7	2.0	3.7
	Large							
	Total	0.3	0.1		0.02	0.4	0.5	0.9
Combined	Marginal	0.2	0.2		0.1	0.5	0.6	1.1
	Small	0.4	0.7		0.2	1.3	1.6	2.9
	Medium	1.2	1.4		0.3	2.9	2.9	5.8
	Large		2.4		0.1	2.5	2.8	5.2
	Total	0.3	4.3		0.4	5.0	5.1	10.1

Source: Primary survey

Table 4.9: % Distribution of Irrigation

Irrigation- Area in ha (% Distribution)								
State	Size Classes	Irrigated					Un irrigated	Total
		Canal	Tubewell	Tank	Others	Total		
Bihar	Marginal		29		9	38	62	100
	Small		41		8	50	50	100
	Medium		48		10	58	42	100
	Large		46		1	47	53	100
	Total		45		4	50	50	100
West Bengal	Marginal	36	14			50	50	100
	Small	27	10		4	42	58	100
	Medium	32	11		3	46	54	100
	Large							
	Total	32	13		2	47	53	100
Combined	Marginal	18	22		5	44	56	100
	Small	15	24		6	45	55	100
	Medium	20	24		5	50	50	100
	Large		46		1	47	53	100
	Total	3	42		4	49	51	100

Source: Primary survey

4.3.2 Cropping pattern

Bihar: The major crops in the sample region are paddy and wheat. Maximum area is devoted to these crops and these crops are also sown for longer duration compared to other crops. Gram is another crop whose duration is longer but the area sown is small. The overall CDI is 43%, 40% and 43% respectively during 2008-09, 2009-10 and 2010-11 (Table 4.10, Table 4.11 and Table 4.12). The lower level of CDI in 2009-10 is perhaps due to the severe drought that affected many states in the country. The low magnitude of CDI in all three years of the study period, which is less than 50%, shows that more than 50% of the GCA in the sample region is left uncultivated. Mechanization, supplemented with provision of timely inputs and remunerative output price, may help in improving this low level of land utilization.

West Bengal: Paddy and potato are the major crops grown on relatively larger areas. Paddy is sown for much longer period than potato. The CDI is 39%, 40% and 36% respectively in 2008-09, 2009-10 and 2010-11 (Tables 4.10, 4.11 and 4.12). Such a low level of CDI, which is much less than 50%, indicates the low level of land utilization for cultivation in the sample region. The scope to increase land utilization by the use of increased mechanization, along with other input and output policies, may be urgently explored.

Overall (Bihar and West Bengal): Paddy and wheat are the major crops in the sample region. These crops are grown over larger area relative to other crops and for a longer duration. Gram and lentil are also sown for a longer duration although on a smaller area compared to rice and wheat. The CDI is 41%, 40% and 40% for the years 2008-09, 2009-10 and 2010-11 respectively (Tables 4.10, 4.11 and 4.12). Such a low level of CDI, which is less than 50% in all the three years in both the states, indicates that more than 50% of the GCA in these states remains unutilized for cultivation. This is a serious issue in a land-scarce country and in a region well-endowed with fertile soils and river waters. There exists scope for increasing the land utilization for cultivation by increasing the use machinery, through appropriate policy framework. Such policy should be supplemented with other input and output policies.

Table 4.10: Cropping Pattern-Over All Seasons: 2008-09

Cropping pattern over all seasons: 2008-09				
State	Crop	Area sown (a_i)	Number of months sown (d_i)	% of irrigated area under the crop
Bihar	Paddy	6.0	4.5	80
	Wheat	2.2	4.0	100
	Maize	1.6	1.3	100
	Lentil	1.1	3.8	20
	Moong	1.1	2.7	20
	Gram	0.6	4.2	30
	CDI = 42.95			
West Bengal	Paddy	0.7	4.8	58
	Wheat	0.03	0.7	100
	Rpmst	0.1	1.0	100
	Potato	0.3	1.4	100
	CDI = 38.82			
Overall CDI = 40.89				

Source: Primary survey

Table 4.11: Cropping Pattern-Over All Seasons: 2009-10

Cropping pattern over all seasons: 2009-10				
State	Crop	Area sown (a_i)	Number of months sown (d_i)	% of irrigated area under the crop
Bihar	Paddy	5.6	4.3	62
	Wheat	2.2	4.0	100
	Maize	1.2	1.3	89
	Lentil	1.1	3.1	20
	Moong	1.0	2.1	20
	Gram	1.1	4.7	20
	CDI = 40.44			
West Bengal	Paddy	0.8	4.8	58
	Wheat	0.03	0.7	100
	Mustard	0.1	1.1	100
	Potato	0.3	1.4	100
	CDI = 39.70			
Overall CDI = 40.07				

Source: Primary survey

Table 4.12: Cropping Pattern-Over All Seasons: 2010-11

Cropping pattern over all seasons: 2010-11				
State	Crop	Area sown (a_i)	Number of months sown (d_i)	% of irrigated area under the crop
Bihar	Paddy	6.0	4.5	74
	Wheat	2.1	4.0	100
	Maize	1.6	1.2	100
	Lentil	1.1	3.5	10
	Moong	0.6	2.0	10
	Gram	1.1	4.3	20
	CDI = 42.74			
West Bengal	Paddy	0.7	4.6	59
	Wheat	0.02	0.6	100
	Mustard	0.1	1.0	100
	Any other	0.3	1.5	100
	CDI = 36.31			
Overall CDI = 39.52				

Source: Primary survey

Chapter 5
Pattern and Cost of Mechanization in the Sample Region

In this chapter, we first discuss the pattern of mechanization—overall and operation-wise. This is followed by an analysis of the costs incurred on account of machinery in relation to the total input costs, value of output and marketed surplus. Tables 5.1 to 5.3 provide a snapshot of the pattern and cost of mechanization in the two states and in the region overall. Each column in these tables is further explained in detail in subsequent tables in the chapter.

5.1 Pattern of Mechanization

Bihar: The percentage of farmers using machinery ranges from 21% to 100% for different types of machinery, whereas the percentage of farmers owning such machinery ranges from 7% to 50%, underlining the importance of the hire market for agricultural machinery in Bihar (Table 5.4). Most of the owned machinery fall in the category of 'animal-operated' or 'manually operated' (Table 5.6).

West Bengal: Overall, 99% of the farmers use manual machinery, 58% animal-operated machinery, 50% power-operated and 45% use tractor-operated machinery. None of the sample farmers used self-propelled machinery (Table 5.4). Similar to Bihar, most of the owned machinery fall in the category of 'animal-operated' or 'manual operated' (Table 5.6).

Overall: More than 65% of the sample farmers use machinery of one type or the other (Table 5.4). All use some form of manually operated machinery, and about 70% use tractor-operated machines.

5.2 Pattern of Mechanization: Operation-wise

Bihar: Operation-wise mechanization details show that in the case of ploughing, about 90% is carried out by tractor while animal-operated plough is used only in 10% of the

cases (Tables 5.1 and 5.8). In sowing, manually operated machinery is used in 94% of cases and power-operated machinery in the rest. Irrigation is carried out entirely by power-operated machinery, whereas weeding, plant protection and harvesting are carried out entirely by manually operated machinery. Mostly, threshing is done using manually operated machinery (83%) and the remaining by animal-operated machinery (17%). In the case of marketing and transportation, 79% of the sample farmers preferred the tractor trolley, and the remaining 21% used animal cart.

West Bengal: For ploughing, 51% of the farmers used animal-operated machinery and 49% used tractor-operated machinery (Tables 5.2 and 5.8). For irrigation, only 50% of the farmers used any machinery (Table 5.7), but all of them used power-operated machinery (Tables 5.2 and 5.8). For sowing and weeding, no machinery is used in West Bengal. For plant protection, all except two farmers use machinery. All of them used manually operated machinery. For harvesting, all the farmers used some form of machinery. About 71% used manually operated machinery while the rest used animal-operated machinery. For threshing, all the sample farmers used manually operated machinery. For transportation and marketing, animal-operated (cart) and tractor-operated machinery (tractor trolley) are used by 50% of the farmers each.

Overall: For ploughing, about 70% of the farmers use tractor-plough while rest are using animal plough (Tables 5.3 and 5.8). For sowing, 94% use manually operated machines while 6% use tractor-operated machinery. For irrigation, all the farmers used power-operated machines. For weeding and plant protection, all the farmers used only manually operated machines. For harvesting, mainly manually operated machinery is used (86%) while animal-operated machinery is used by 14% of the farmers. For threshing the corresponding percentages are 92% and 8%. For transportation and marketing, tractor is used by 65% and animal cart by 35% of the farmers.

5.3 Time Use: Operation-wise

Bihar: As for the share of time in using different types of machinery operation-wise, in ploughing, animal-operated machinery's share is 83% while tractor-plough is used for 17% of the total time (Tables 5.1 and 5.10). In case of sowing, manually operated

machinery are used 95% of the time while the share of power-operated machines is 5%. Power-irrigated machines are used all the time in irrigation; similarly, manually-operated machines are used all the time in weeding, plant protection and harvesting. For threshing, manually operated machinery has a share of 87%, followed by animal-operated machinery (13%). In transportation, animal cart is used for 69% of the total time while the remaining time is spent on tractor trolley. For ploughing, animal-operated plough (83%) and tractor-operated plough (17%) are the major implements used and corresponding cost share ism respectively, 65% and 35% (Appendix Table 5.2). Manual seed drill (95%) and power seed drill (5%) are the main machinery used for sowing which shares about 79% and 21% of total cost, respectively (Appendix Table 5.4). Diesel pump is the only machine used for irrigation (Appendix Table 5.6). Manual sickle and paddy thresher are respectively the implements used for harvesting (Appendix Table 5.12) and threshing (Appendix Table 5.14). For transportation and marketing, animal cart (69%) and tractor (31%) are the machines used which shares about 60% and 40% of the total cost, respectively (Appendix Table 5.16).

West Bengal: For ploughing, 95% of the total time spent is spent on manually operated machinery and 5% on tractor-operated machinery (Tables 5.2 and 5.10). In terms of cost, the corresponding percentages are 59% and 41% respectively (Appendix Table 5.2). For sowing and weeding, no time is spent on machinery, as no machinery is used for these operations. Similarly, for plant protection and threshing operations, 100% of the time and cost are on account of manually operated machines, as there are no other types of machines used for these two operations (Appendix Table 5.10 and Appendix Table 5.14). Similarly, for irrigation, 100% of the time and cost are on account of power-operated machines (Appendix Table 5.6). For harvesting, 13% of the time and 29% of the cost are spent on animal-operated machines, while for manually operated machinery the corresponding percentages are 87% and 71% respectively (Appendix Table 5.12). In the case of transportation and marketing, there is a clear disproportionate allocation of time and cost: about 92% of the time is spent on animal-operated machine (cart), but the proportion of total cost is only 16%; similarly, the time use of tractor trolley is only 8% of the total time, while the share in the total cost of tractors is 84% of the total cost of transportation and marketing (Appendix Table 5.16).

Overall: As per time use of different types of machinery in various operations, the share of animal-operated machinery (plough) is 92% in total time used for ploughing; a tractor-operated plough is used for only 8% of the time (Tables 5.3 and 5.10). The corresponding cost share is about 62% and 38%, respectively (Appendix Table 5.2). For sowing, manually operated seed drill is used 95% of the time and tractor-operated seed drill for 5% of the time. The corresponding cost share is about 79% and 21%, respectively (Appendix Table 5.4). Diesel pumps are used 100% of the time in irrigation and manually operated machines are used 100% of the time in weeding and plant protection (Appendix Table 5.8). In harvesting, the manual sickle has a major share of 91%, followed by the animal-operated potato digger (9%) with nearly equal proportion in cost sharing. In the case of threshing, only paddy thresher is used by all the farmers. Manually operated thresher share about 92% followed by animal-operated thresher (8%). In case of transportation and marketing, animal cart has a major share (88%) and tractor (12%) sharing about 26% and 74% of total cost, respectively.

Costs of Mechanization

5.4 Costs of Mechanization in Input Costs

Bihar: There is no clear pattern in the percentage distribution of different input costs, as they vary crop to crop (Table 5.12). The share of irrigation cost in total input costs is highest for wheat and maize. Similarly, the share of hired labour cost is higher for paddy, gram and lentil. The share of seed cost is higher for pulses. Although the share of fertilizer varies across crops, ranging from 8% to 18% for different crops, the average share is about 12%. The share of the machinery costs in Bihar is in comparison to West Bengal. Although Bihar shows higher share in cost in terms of irrigation for most of the crops, it has reasonably low share in hired labour cost as compared to West Bengal except common crop wheat.

West Bengal: As percentage of total input costs, hired manual labour is the highest followed by hired machinery, fertilizer and seed (Table 5.12). Proportion of machinery costs is large for kharif paddy and mustard but quite low for wheat and potato. Wheat and

potato show larger proportion of expenditure on seed, irrigation and fertilizer relative to other crops.

Overall: Hired labour shows the highest share in input costs, in general, followed by hired machinery cost (Table 5.12). Fertilizer cost has a uniform share in input costs of nearly 13%. Seed charges are higher for pulses and potato compared to other crops. Pulses, crops and maize also show nearly 13% cost share for organic manure. The share of manual labour is significantly higher than that of bullock labour for all the crops, whereas in hired machinery cost, the share of tractor and harvest combine is almost equal. Pesticides show a marginal share of 3% for all the crops.

5.5 Costs of Mechanization vis-à-vis Value of Output

Bihar: Percentage of machinery cost to the value of output is quite low in Bihar, ranging from 3% to 14% across different crops (Table 5.13). This is true even for crops with marketed surplus exceeding 50% i.e. paddy (61%) and maize (57%). This implies that either the use of machinery is low or the price of machinery is low. In either case, there exists scope for stepping up the use of machinery in Bihar.

West Bengal: As a proportion of the value of the output, the machinery costs are higher in the case of mustard (33%) and kharif paddy (18%) (Table 5.13). In the case of potato, the absolute cost of machinery is high but low relative to the value of output (11%). In the case of mustard, the value of output is quite low leading to a high proportion of machinery cost vis-à-vis the value of output.

Overall: Costs on machinery are generally higher in absolute terms for crops that have higher marketed ratios (to production), such as paddy and potato (Table 5.13). However, the ratio of machinery costs to total input costs is lower for these crops because of higher VoP.

5.6 Costs of Mechanization Operation-wise

Bihar: Costs of mechanization depend to a large extent on the pattern of mechanization and, therefore, vary across operations. For ploughing, the share of animal-operated machinery is 64% of the total costs of mechanization whereas the share of tractor-operated-machinery is 36% (Appendix Table 5.18). In sowing, manually operated machinery has a higher share at 79%, followed by power-operated machinery (21%). In irrigation, the entire cost is on account of power-operated machinery as no other type of machinery is used. For weeding, plant protection and harvesting, all the costs are due to manually operated machinery as all these operations use it. For threshing, a major share of the costs is because of manually operated machinery (92%), followed by animal-operated machinery. For transportation and marketing, 60% of the costs are because of animal-operated machinery and the remaining for tractor trolley.

West Bengal: The types of machinery used and the costs incurred also depend upon the type of operation. For ploughing, the costs incurred are mainly on account of animal-operated machinery (59%) and tractors (41%) (Appendix Table 5.2 and Appendix Table 5.18). All the expenditure is on account of hire charges. No machinery is used for sowing and weeding and therefore no expenditure is incurred on account of machinery for these operations. For irrigation, diesel pumps are used and almost 80% of the expenditure on diesel pumps is on account of hire charges followed by input costs (18%) and the rest on service and maintenance (Appendix Table 5.17)**.** For plant protection, only manually operated machinery is used. The expenditure on this machinery is mostly on hire charges (70%) and the remaining on service and maintenance (30%) (Appendix Table 5.17)**.** Whereas threshing is carried out totally using the manual threshers, harvesting shares about 70% cost of mechanization through manually operated machines and rest is shared by animal-operated machinery (Appendix Table 5.18). Transportation and marketing are carried out using bullocks and tractor trolley. About 84% of the expenditure is incurred on tractor trolley and the remaining 16% is incurred on account of bullocks.

Overall: For ploughing, share of animal-operated machinery (mainly animal plough) in total cost is 61% followed by tractor cost (39%) (Appendix Table 5.18). For sowing, the major portion of the cost is accounted for by manually operated machinery (79%)

followed by power-operated machinery (21%). In irrigation, the entire machinery cost is on account of power-operated machinery as no other type of machinery is used for irrigation. Similarly, for weeding and plant protection, the entire expenditure is on account of manually operated machinery. Harvesting and threshing are predominantly carried out using manual operated machinery with the proportion of costs being 96% and 93%, respectively. The animal-operated machinery in these two operations only accounted for 4% and 7% of the costs respectively. For transportation and marketing however, tractors accounted for a large proportion (74%) and animal cart accounted for only 26%.

Table 5.1: Pattern and Cost of Mechanization in Bihar: Summary

S. No	Operation	Type of machinery used	% distribution of Farmer	% of distribution total time use	% of distribution total cost
1	Ploughing	Animal	10	83	65
		Tractor	90	17	35
2	Sowing	Manual	94	95	79
		Power	6	5	21
3	Irrigation	Power	100	100	100
4	Weeding	Manual	100	100	100
5	Plant protection	Manual	100	100	100
6	Harvesting	Manual	100	100	100
7	Threshing	Animal	17	13	8
		Manual	83	87	92
8	Transportation and Marketing	Animal	21	69	60
		Tractor	79	31	40

Source: Primary survey

Table 5.2: Pattern and Cost of Mechanization in West Bengal: Summary

S. No	Operation	Type of machinery	% distribution of Farmers	% of distribution total time use	% of distribution total cost
1	Ploughing	Animal	51	95	59
		Tractor	49	5	41
3	Irrigation	Power	100	100	100
5	Plant protection	Manual	100	100	100
6	Harvesting	Animal	29	13	29
		Manual	71	87	71
7	Threshing	Manual	100	100	100
8	Transportation and Marketing	Animal	50	92	16
		Tractor	50	8	84

Source: Primary survey

Table 5.3: Pattern and Cost of Mechanization - Overall: Summary

Comparative Statement: Overall (Bihar and West Bengal)					
S. No	Operation	Type of machinery	% distribution of Farmers	% distribution of total time use	% distribution of total cost
1	Ploughing	Animal	31	92	61
		Tractor	69	8	39
2	Sowing	Manual	94	95	79
		Power	6	5	21
3	Irrigation	Power	100	100	100
4	Weeding	Manual	100	100	100
5	Plant protection	Manual	100	100	100
6	Harvesting	Animal	14	9	4
		Manual	86	91	96
7	Threshing	Animal	8	8	7
		Manual	92	92	93
8	Transportation and Marketing	Animal	35	88	26
		Tractor	65	12	74

Source: Primary survey

Table 5.4: Pattern of Mechanization: Extent of Farm Machinery Use

Extent of Farm Machinery Use						
	Machinery type	No of farmers using the machinery	No of farmers owning the machinery	Total no of farmers	No of farmers using the machinery as % of Total no of farmers	No of farmers owning the machinery as % of Total no of farmers
Bihar	Manual	100	50	100	100	50
	Animal-operated	21	21	100	21	21
	Power-operated	100	11	100	100	11
	Tractor-operated	90	7	100	90	7
	Self-propelled					
West Bengal	Manual	99	32	100	99	32
	Animal-operated	58	43	100	58	43
	Power-operated	50	9	100	50	9
	Tractor-operated	45	0	100	45	0
	Self-propelled					
Overall	Manual	199	82	200	100	41
	Animal-operated	79	64	200	40	32
	Power-operated	150	20	200	75	10
	Tractor-operated	135	7	200	68	4
	Self-propelled					

Source: Primary survey

Table 5.5: Pattern of Mechanization: Number of Farmers Owning Machinery – Operation-wise

Number of Farmers Owning Machinery – Operation-wise							
State	Operation	Animal-Operated	Manually Operated	Power-Operated	Tractor-Operated	Any Other	Total
Bihar	Ploughing	21			7		28
	Sowing		28				28
	Irrigation			11			11
	Weeding		30				30
	Plant Protection		42				42
	Harvesting		50				50
	Threshing	17	50				67
	Transportation and Marketing	5			7		12
	Any other						
West Bengal	Ploughing	80					80
	Sowing						
	Irrigation			9			9
	Weeding						
	Plant Protection		9				9
	Harvesting		59				59
	Threshing		29				29
	Transportation & Marketing	50	29				79
	Any other						
Overall	Ploughing	101			7		108
	Sowing		28				28
	Irrigation			20			20
	Weeding		30				30
	Plant Protection		51				51
	Harvesting		109				109
	Threshing	17	79				96
	Transportation and Marketing	55	29		7		91
	Any other						

Source: Primary survey

Table 5.6: Pattern of Mechanization: % Distribution of Number of Farmers Owning Machinery – Operation-wise

Number of Farmers Owning Machinery – Operation-wise (% Distribution)							
State	Operation	Animal-Operated	Manually Operated	Power-Operated	Tractor-Operated	Any Other	Total
Bihar	Ploughing	75			25		100
	Sowing		100				100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		100				100
	Harvesting		100				100
	Threshing	25	75				100
	Transportation and Marketing	42			58		100
	Any other						
West Bengal	Ploughing	100					100
	Sowing						
	Irrigation			100			100
	Weeding						
	Plant Protection		100				100
	Harvesting		100				100
	Threshing		100				100
	Transportation & Marketing	63	37				100
	Any other						
Overall	Ploughing	94			6		100
	Sowing		100				100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		100				100
	Harvesting		100				100
	Threshing	18	82				100
	Transportation & Marketing	60	32		8		100
	Any other						

Source: Primary survey

Table 5.7: Pattern of Mechanization: Number of Farmers Using Machinery – Operation-wise

Number of Farmers Using Machinery – Operation-wise							
State	Operation	Animal-Operated	Manually Operated	Power-Operated	Tractor-Operated	Any Other	Total
Bihar	Ploughing	10			90		100
	Sowing		94	6			100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		68				68
	Harvesting		100				100
	Threshing	17	83				100
	Transportation and Marketing	21			79		100
	Any other						
West Bengal	Ploughing	51			49		100
	Sowing						
	Irrigation			50			50
	Weeding						
	Plant Protection		98				98
	Harvesting	29	71				100
	Threshing		100				100
	Transportation & Marketing	50			50		100
	Any other						
Overall	Ploughing	61			139		200
	Sowing		94	6			100
	Irrigation			150			150
	Weeding		100				100
	Plant Protection		166				166
	Harvesting	29	171				200
	Threshing	17	183				200
	Transportation & Marketing	71			129		200
	Any other						

Source: Primary survey

Table 5.8: Pattern of Mechanization: % Distribution of Number of Farmers Using Machinery – Operation-wise

Number of Farmers Using Machinery – Operation-wise (% Distribution)							
State	Operation	Animal-Operated	Manually Operated	Power-Operated	Tractor-Operated	Any Other	Total
Bihar	Ploughing	10			90		100
	Sowing		94	6			100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		100				100
	Harvesting		100				100
	Threshing	17	83				100
	Transportation and Marketing	21			79		100
	Any other						
West Bengal	Ploughing	51			49		100
	Sowing						
	Irrigation			100			100
	Weeding						
	Plant Protection		100				100
	Harvesting	29	71				100
	Threshing		100				100
	Transportation & Marketing	50			50		100
	Any other						
Overall	Ploughing	31			69		100
	Sowing		94	6			100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		100				100
	Harvesting	14	86				100
	Threshing	8	92				100
	Transportation & Marketing	36			65		100
	Any other						

Source: Primary survey

Table 5.9: Pattern of Mechanization: Total Number of Hours of Usage – Operation-wise

Total Number of Hours of Usage – Operation-wise (hrs./ha.)							
State	Operation	Animal-Operated	Manually Operated	Power-Operated	Tractor-Operated	Any Other	Total
Bihar	Ploughing	35			7		42
	Sowing		74	4			78
	Irrigation			32			32
	Weeding		32				32
	Plant Protection		16				16
	Harvesting		125				125
	Threshing	16	110				126
	Transportation and Marketing	10			5		15
	Any other						0
West Bengal	Ploughing	115			6		121
	Sowing						0
	Irrigation			26			26
	Weeding						0
	Plant Protection		12				12
	Harvesting	34	239				173
	Threshing		67				67
	Transportation & Marketing	58			5		63
	Any other						0
Overall	Ploughing	150			13		163
	Sowing		74	4			78
	Irrigation			58			58
	Weeding		32				32
	Plant Protection		28				28
	Harvesting	34	364				298
	Threshing	16	177				193
	Transportation & Marketing	68			9		77
	Any other						

Source: Primary survey

Table 5.10: Pattern of Mechanization: % Distribution of Total Number of Hours of Usage – Operation-wise

Total Number of Hours of Usage – Operation-wise (hrs./ha.) (% Distribution)							
State	Operation	Animal-Operated	Manually Operated	Power-Operated	Tractor-Operated	Any Other	Total
Bihar	Ploughing	83			17		100
	Sowing		95	5			100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		100				100
	Harvesting		100				100
	Threshing	13	87				100
	Transportation and Marketing	69			31		100
	Any other						
West Bengal	Ploughing	95			5		100
	Sowing						
	Irrigation			100			100
	Weeding						
	Plant Protection		100				100
	Harvesting	13	87				100
	Threshing		100				100
	Transportation & Marketing	92			8		100
	Any other						
Overall	Ploughing	92			8		100
	Sowing		95	5			100
	Irrigation			100			100
	Weeding		100				100
	Plant Protection		100				100
	Harvesting	9	91				100
	Threshing	8	92				100
	Transportation & Marketing	88			12		100
	Any other						

Source: Primary survey

Table 5.11: Costs of Mechanization: Input Costs (Average of 2008-09, 2009-10 and 2010-11)

State	Crop	Seed	Irrigation	Organic Manure	Fertilizer	Hired Labour			Hired Machinery costs				Pesticides/ Weedicides	other cost	Total cost
						Bullock	Manual	Total	Tractor	Harvest Combine	other	Total			
Bihar	Paddy	989	3985	2500	2280	4151	7892	12043	2412	2964		5376	1020		28194
	Wheat	3854	13403	2950	4794	1837	4250	6087	4053	5256		9309	1541		41938
	Maize	1360	8800	4100	4980	1750	2980	4730	1301	2490		3791	599		28360
	Gram	3375	1250	1350	1600	1151	1805	2956	1000	500		1500	250		12281
	Lentil	1225	500	1150	980	900	1250	2150	1000	598		1598	152		7755
West Bengal	Kharif Paddy	1168	502	1238	3115	1397	11203	12600	3013	3670		6683	704		26011
	Boro Paddy	926	2485		4015	1000	15458	16458	3103			3103	1243		28231
	Potato	17423	12585	2997	16393	3709	23272	26981	5316	3224		8540	3036		87954
	Mustard	375	1478	1982	2343	891	7497	8388	1999	3747		5746	819		21130
	Wheat	2669	1492	1507	1675		946	946	1754			1754	796		10839
Overall	Paddy	989	3985	2500	2280	4151	7892	12043	2412	2964		5376	1020		28194
	Kharif Paddy	1168	502	1238	3115	1397	11203	12600	3013	3670		6683	704		26011
	Boro Paddy	926	2485		4015	1000	15458	16458	3103			3103	1243		28231
	Wheat	6523	14895	4457	6469	1837	5196	7033	5807	5256		11063	2337		52777
	Maize	1360	8800	4100	4980	1750	2980	4730	1301	2490		3791	599		28360
	Gram	3375	1250	1350	1600	1151	1805	2956	1000	500		1500	250		12281
	Lentil	1225	500	1150	980	900	1250	2150	1000	598		1598	152		7755
	Mustard	375	1478	1982	2343	891	7497	8388	1999	3747		5746	819		21130
	Potato	17423	12585	2997	16393	3709	23272	26981	5316	3224		8540	3036		87954

Source: Primary survey

Table 5.12: Costs of Mechanization: % Distribution of Input Costs (Average of 2008-09, 2009-10 and 2010-11)

State	Crop	Seed	Irrigation	Organic Manure	Fertilizer	Hired Labour			Hired Machinery costs				Pesticides/ Weedicides	other cost	Total cost
						Bullock	Manual	Total	Tractor	Harvest Combine	other	Total			
Bihar	Paddy	4	14	9	8	15	28	43	9	11		19	4		100
	Wheat	9	32	7	11	4	10	15	10	13		22	4		100
	Maize	5	31	14	18	6	11	17	5	9		13	2		100
	Gram	27	10	11	13	9	15	24	8	4		12	2		100
	Lentil	16	6	15	13	12	16	28	13	8		21	2		100
West Bengal	Kharif Paddy	4	2	5	12	5	43	48	12	14		26	3		100
	Boro Paddy	3	9		14	4	55	58	11			11	4		100
	Potato	20	14	3	19	4	26	31	6	4		10	3		100
	Mustard	2	7	9	11	4	35	40	9	18		27	4		100
	Wheat	25	14	14	15		9	9	16			16	7		100
Overall	Paddy	4	14	9	8	15	28	43	9	11		19	4		100
	Kharif Paddy	4	2	5	12	5	43	48	12	14		26	3		100
	Boro Paddy	3	9		14	4	55	58	11			11	4		100
	Wheat	12	28	8	12	3	10	13	11	10		21	4		100
	Maize	5	31	14	18	6	11	17	5	9		13	2		100
	Gram	27	10	11	13	9	15	24	8	4		12	2		100
	Lentil	16	6	15	13	12	16	28	13	8		21	2		100
	Mustard	2	7	9	11	4	35	40	9	18		27	4		100
	Potato	20	14	3	19	4	26	31	6	4		10	3		100

Source: Primary survey

Table 5.13: Cost of Mechanization Vis-À-Vis Value of Output (average of 2008-09, 2009-10 and 2010-11)

Cost of Mechanization Vis-À-Vis Value of Output (average of 2008-09, 2009-10 and 2010-11)							
State	Crop	Value of Output	Hired Machinery Costs	Marketed Surplus	% of Machinery Costs to Value of Output	% of Machinery Costs to Marketed Surplus	% of Marketed Surplus to Value of Output
Bihar	Paddy	59304	5376	36000	9	15	61
	Wheat	65700	9309	21015	14	44	32
	Maize	37863	3791	21505	10	18	57
	Gram	24885	800	10000	3	8	40
	Lentil	14820	1000	6250	7	16	42
West Bengal	Kharif Paddy	37234	6683	22146	18	30	59
	Boro Paddy	46103	3103	38844	7	8	84
	Potato	80667	8540	70331	11	12	87
	Mustard	17423	5746	5221	33	110	30
	Wheat	18337	1754	12833	10	14	70
Overall	Paddy	59304	5376	36000	9	15	61
	Kharif Paddy	37234	6683	22146	18	30	59
	Boro Paddy	46103	3103	38844	7	8	84
	Wheat	84037	11063	33848	13	33	40
	Maize	37863	3791	21505	10	18	57
	Gram	24885	800	10000	3	8	40
	Lentil	14820	1000	6250	7	16	42
	Mustard	17423	5746	5221	33	110	30
	Potato	80667	8540	70331	11	12	87

Source: Primary survey

Chapter 6

Farmer's Perceptions

This chapter summarizes the information gathered from the farmers' feedback. The information is related to their reasons for using (or not using) machines, operations for which they mostly use machines, appropriate machines for different operations, their awareness about government mechanization programs in operation, problems with the machinery and their suggestions for improving the status of mechanization.

6.1 *Reasons for Using Machinery*

Bihar: Farmers were questioned on their reasons for using machinery. The majority of the farmers, about 60%, reported quicker operations as the main reasons for using machinery (Table 6.2). The other reasons cited are that using machines is economical (35%) and that machines help attain higher yield (6%). Machinery is mainly used for irrigation (50%), ploughing (47%) and transportation (3%) (Table 6.4).

West Bengal: The majority of the farmers, about 70%, reported quicker operations as their main reason for using machinery, followed by higher yield (19%) and economy (11%) (Table 6.2). Ploughing (50%), threshing (25%) and irrigation (20%) are reported to be the operations for which machines are mainly used (Table 6.4).

Overall: Farmers reported that the main reason for using machinery is quicker operations (65%) followed by economy (23%), higher yield (12%) (Table 6.2). The operations for which machines are mostly used are ploughing (49%), irrigation (35%), threshing (13%) and transportation (4%) (Table 6.4).

6.2 *Appropriate Machines – Operation-wise*

Bihar: The farmers were asked to list machines that they considered most appropriate for each operation. Farmers listed tractor-operated plough (60%), animal-operated plough (15%) and animal-operated disc harrow (10%) as the appropriate machines for ploughing (Table 6.5 and Appendix Table 6.1). It is notable that farmers have listed

tractor-operated machinery (plough and disc harrow), which is in accordance with actual use. This shows that farmers are aware of the technological options and are using them too. For sowing, manual seed drill (65%), animal-operated seed drill (17%), tractor-operated zero till drill (10%) and tractor-operated seed drill (8%) are the preferred machines (Appendix Table 6.2). In sowing, there is not much discrepancy between preference and actual use. In irrigation, too, all the farmers expressed their preference for the diesel pump (Appendix Table 6.3). In weeding, plant protection and harvesting also, although the majority preferred manually operated machinery, there is a small proportion of farmers in each of these operations that preferred self-propelled machinery (Appendix Tables 6.4, 6.5 and 6.6). This demonstrates that farmers, at least some of them, are aware of the various options available. For threshing, power-operated thresher (50%), paddy thresher (25%) and maize thresher (25%) are the preferred machines (Appendix Table 6.7). This pattern of preference is again different from that of actual use where all the farmers are using animal / manual operated thresher. In case of marketing and transportation, a majority of the farmers expressed preference for the tractor trolley (80%), which is in accordance with actual use (79%) (Appendix Table 6.8).

West Bengal: For ploughing, the animal-operated plough was rated the most appropriate by 50% of the farmers, while the tractor-plough and tractor rotavator were rated the most appropriate by 18% and 32% of farmers, respectively (Appendix Table 6.1). It is to be noted that although 32% of the farmers list the tractor rotavator, none has actually used it for ploughing. For sowing, farmers did not prefer any machinery. For irrigation, 46% listed the diesel pump as the appropriate machine, and 54% listed the electric pump (Appendix Table 6.3). This is again different from the actual use pattern where none of the farmers used an electric pump for irrigation, showing that farmers are constrained from using the machinery of their choice. For weeding and plant protection, all the farmers preferred manually operated small machines (Appendix Table 6.4 and Appendix Table 6.5). For harvesting, 77% of the farmers preferred manual sickle while about 23%, mostly potato farmers, preferred potato digger (Appendix Table 6.6). For threshing, all the farmers preferred paddy thresher (Appendix Table 6.7). For transportation, all the farmers listed tractor trolley as the

most appropriate machine, although 50% of the sample farmers are actually using animal cart (Appendix Table 6.8).

Overall: When asked to name the appropriate machines for different operations, 39% of the farmers reported tractor-operated plough as the most appropriate machine for ploughing followed by animal plough (33%), tractor rotavator (16%), animal disc harrow (5%), power tiller rotavator (5%) and tractor disc harrow (3%) (Appendix Table 6.1). It is to be noted that the sample farmers actually used only animal and tractor-plough, although they have expressed preference for other machinery (such as rotavator, disc harrow, etc.) as well. This indicates that they are aware of the options available but unable to use their preferred machinery because of other constraints. For sowing and planting, manual seed drill (65%) is the most preferred machine followed by animal seed drill (17%), zero till drill (10%) and tractor seed drill (8%) (Appendix Table 6.2). Again, in this case, actual use is limited to manual and tractor seed drill, showing the divergence between preference and actual use. For irrigation, the preferred machines are diesel pump (73%) and electric pump (27%) (Appendix Table 6.3). It is to be noted here that 27% of the farmers prefer electric pump, although none is at present using one. For weeding and plant protection, although the majority expressed their preference for manually operated machinery, a small percentage (5% and 13% respectively) reported self-propelled machinery as most appropriate (Appendix Table 6.4 and Appendix Table 6.5). For harvesting, 69% preferred manual sickle, followed by animal-operated potato digger (12%) as preferred machine (Appendix Table 6.6). For threshing paddy thresher (63%) is the most preferred machine which is in accordance with the actual use (Appendix Table 6.7). In case of marketing and transportation, 90% of the farmers indicated tractor trolley as the most appropriate which is in accordance with the actual use (Appendix Table 6.8).

6.3 Major Problems with the Machinery

Bihar: Majority of the farmers did not report any problem. But most of the problems related to i) hire facility not available ii) expensive to hire and iii) expensive to purchase (See Appendix Table 6.9 to Appendix Table 6.16).

West Bengal: Most of the farmers did not report any major problems with machinery for most operations. But generally "expensive to purchase" and "hire facility not available" were the most-reported problems. The other problems reported, mainly in case of paddy thresher are "high maintenance cost" and "yield not as expected" (Appendix Table 6.9 to Appendix Table 6.16).

Overall: Majority of the farmers did not report any problem. The major problems that have been reported are "hire facility not available", "expensive to hire" and "expensive to purchase" (Appendix Table 6.9 to Appendix Table 6.16).

6.4 Usefulness of the Machinery

Bihar: Farmers reported better land utilization (29%) as the main benefit of use of machines, followed by reduced drudgery (27%), higher income (12%), higher yield (11%) and higher social esteem (10%) (Table 6.6).

West Bengal: Only 50% of the farmers found usage of machinery useful. Higher yield (25%), better land utilization (19%) and reduced drudgery (6%) have been reported as some of the uses (Table 6.6).

Overall: Of all farmers, 75% found using machines useful. Better land utilization (24%), higher yield (18%) and reduced drudgery (17%) are some of the major uses reported (Table 6.6).

6.5 Awareness and Assistance Under Government Programs

Bihar: About 60% of farmers are aware of the government programmes, and 18% received some form of assistance under the programmes (Table 6.7), such as subsidy on consumables (8%), subsidy on purchase of a machine (4%) and demonstration (4%) each and training (2%). As Table 6.8 shows, 40% of the farmers found government programmes useful. Out of these, 28% reported to have learnt new techniques and 12% received cash subsidies.

West Bengal: None of the respondents is aware of the government mechanization programmes. None has received any assistance.

Overall: Only 30% of farmers are aware of government mechanization programmes, and only 9% have received any kind of assistance under such programmes (Table 6.7); among such assistance, subsidy on consumables (4%) ranks first. Of the 30% of the farmers aware of the programmes, only 20% found them useful (Table 6.8), 14% learnt new techniques and 6% got cash / subsidy benefits.

6.6 Increase in Production due to Mechanization

Bihar: Farmers reported an increase in production of about 2% in paddy and wheat that is attributable to the use of machines (Table 6.9).

West Bengal: Farmers in this state reported an increase in production due to machinery use ranging from 2% in potato to 10% in mustard. Rice and wheat have shown an increase of 5% each.

Overall: Farmers reported about 3.5% increase in production of wheat and rice due to mechanization (Table 6.9). The corresponding increases for gram and potato are lower at 1.5% and 1.9% respectively. Mustard is reported to have recorded the maximum increase of 10%.

Table 6.1: Farmer's Perception: Reasons for Using Machinery

Reasons for Using Machinery				
State	Reason	Rank 1	Rank 2	Rank 3
Bihar	Higher Yield	6	6	9
	Economical	35	50	40
	Quicker operations	59	40	49
	Reduces drudgery		4	2
	Any other			
	Total	100	100	100
West Bengal	Higher Yield	19	29	16
	Economical	11	15	39
	Quicker operations	70	14	8
	Reduces drudgery		41	34
	Any other		1	3
	Total	100	100	100
Overall	Higher Yield	25	35	25
	Economical	46	65	79
	Quicker operations	129	54	57
	Reduces drudgery		45	36
	Any other		1	3
	Total	200	200	200

Source: Primary survey

Table 6.2: Farmer's Perception: % Distribution of Reasons for Using Machinery

Reasons for Using Machinery (% Distribution)				
State	Reason	Rank 1	Rank 2	Rank 3
Bihar	Higher Yield	6	6	9
	Economical	35	50	40
	Quicker operations	59	40	49
	Reduces drudgery		4	2
	Total	100	100	100
West Bengal	Higher Yield	19	29	16
	Economical	11	15	39
	Quicker operations	70	14	8
	Reduces drudgery		41	34
	Any other		1	3
	Total	100	100	100
Overall	Higher Yield	13	18	13
	Economical	23	33	40
	Quicker operations	65	27	29
	Reduces drudgery		23	18
	Any other		1	2
	Total	100	100	100

Source: Primary survey

Table 6.3: Farmer's Perception: Operations for which machines are used

Operations for which machines are used				
State	Operation	Rank 1	Rank 2	Rank 3
Bihar	Ploughing	47	41	40
	Sowing			
	Irrigation	50	45	50
	Weeding			
	Plant Protection			
	Harvesting			
	Threshing		10	8
	Transportation and Marketing	3	4	2
	Any other			
	Total	100	100	100
West Bengal	Ploughing	50	37	23
	Sowing			
	Irrigation	20	50	15
	Weeding			
	Plant Protection			
	Harvesting			
	Threshing	25	13	24
	Transportation & Marketing	5		38
	Any other			
	Total	100	100	100
Overall	Ploughing	97	78	63
	Sowing			
	Irrigation	70	95	65
	Weeding			
	Plant Protection			
	Harvesting			
	Threshing	25	23	32
	Transportation & Marketing	8	4	40
	Any other			
	Total	200	200	200

Source: Primary survey

Table 6.4: Farmer's Perception: % Distribution of Operations for which machines are used

Operations for which the machines are used (% Distribution)				
State	Operation	Rank 1	Rank 2	Rank 3
Bihar	Ploughing	47	41	40
	Sowing			
	Irrigation	50	45	50
	Weeding			
	Plant Protection			
	Harvesting			
	Threshing		10	8
	Transportation and Marketing	3	4	2
	Any other			
	Total	100	100	100
West Bengal	Ploughing	50	37	23
	Sowing			
	Irrigation	20	50	15
	Weeding			
	Plant Protection			
	Harvesting			
	Threshing	25	13	24
	Transportation & Marketing	5		38
	Any other			
	Total	100	100	100
Overall	Ploughing	49	39	32
	Sowing			
	Irrigation	35	48	33
	Weeding			
	Plant Protection			
	Harvesting			
	Threshing	13	12	16
	Transportation & Marketing	4	2	20
	Any other			
	Total	100	100	100

Source: Primary survey

Table 6.5: Uses of machines: Actually used and Preferred –Summary

Uses of machines: Actually used and Preferred		
Operation	Actual Use	Preferred
Ploughing		
Bihar	Animal plough (10%), tractor-plough (90%)	Animal plough (15%), tractor-plough (60%), disc harrow (10%), others (15%)
West Bengal	Animal plough (51%), tractor-plough (49%)	Animal plough (50%), tractor-plough (18%), tractor rotavator (32%)
Overall	Animal plough (31%), tractor-plough (69%)	Animal plough (32%), tractor-plough (39%), tractor rotavator (16%), disc harrow (5%), others (8%)
Sowing		
Bihar	Manual seed drill (94%), tractor seed drill (6%)	Manual seed drill (82%), tractor seed drill (18%)
West Bengal	No machinery (100%)	No machinery (100%)
Overall	Manual seed drill (94%), tractor seed drill (6%)	Manual seed drill (82%), tractor seed drill (18%)
Irrigation		
Bihar	Diesel pump (100%)	Diesel pump (100%)
West Bengal	Diesel pump (100%)	Diesel pump (46%), electric pump (54%)
Overall	Diesel pump (100%)	Diesel pump (73%), electric pump (27%)
Plant Protection		
Bihar	Manual machinery (100%)	Manual machinery (100%)
West Bengal	Manual machinery (100%)	Manual machinery (100%)
Overall	Manual machinery (100%)	Manual machinery (100%)
Harvesting		
West Bengal	Sickle (71%), animal potato digger (29%)	Sickle (77%), animal potato digger (23%)
Bihar	Sickle (100%)	Sickle (88%), reaper (12%)
Overall	Sickle (86%), animal potato digger (14%)	Sickle (69%), animal potato digger (25%), reaper (6%)
Threshing		
Bihar	Animal/manual paddy thresher (100%)	Animal/manual paddy thresher (50%), power thresher (50%)
West Bengal	Animal/manual paddy thresher (100%)	Animal/manual paddy thresher (100%)
Overall	Animal/manual paddy thresher (100%)	Animal/manual paddy thresher (75%), power thresher (25%)
Marketing		
Bihar	Cart (21%), tractor trolley (79%)	Cart (20%), tractor trolley (80%)
West Bengal	Cart (50%), tractor trolley (50%)	Tractor trolley (100%)
Overall	Cart (35%), tractor trolley (65%)	Cart (10%), tractor trolley (90%)

Source: Primary survey

Table 6.6: Farmer's Perception: Usefulness of the machinery

Usefulness of the Machinery			
State	Type of use	Farmers finding the machinery useful	% of farmers to total number of farmers
Bihar	Higher yield	11	11
	Better land utilization	29	29
	More number of crops	5	05
	Reduced drudgery	27	27
	Higher social esteem	10	10
	Higher income	12	12
	Any other	6	6
West Bengal	Higher Yield	25	25
	Better land utilization	19	19
	More number of crops	0	0
	Reduced drudgery	6	6
	Higher social esteem	0	0
	Higher income	0	0
	Any other	0	0
Overall	Higher yield	36	18
	Better land utilization	48	24
	More number of crops	5	3
	Reduced drudgery	33	17
	Higher social esteem	10	5
	Higher income	12	6
	Any other	6	3

Source: Primary survey

Table 6.7: Awareness and Assistance received under government programme

Awareness and Assistance received under government programmes				
State	Awareness/Assistance	Type	No of farmers	% of farmers to total number of farmers
Bihar	Farmers aware of the programmes		60	60
	Farmers not aware of the programmes		40	40
	Farmers who received assistance under the programmes		18	18
	Type of assistance received	Subsidy on purchase of machine	4	
		Subsidy on consumables	8	
		Demonstration of best practices	4	
		Training to use machines	2	
		Cash incentives to use machines		
		Complementary input provision		
		Any other		
West Bengal	Farmers aware of the programmes		0	0
	Farmers not aware of the programmes		100	100
	Farmers who received assistance under the programmes		0	0
	Type of assistance received	Subsidy on purchase of machine		
		Subsidy on consumables		
		Demonstration of best practices		
		Training to use machines		
		Cash incentives to use machines		
		Complementary input provision		
		Any other		
Overall	Farmers aware of the programmes		60	30
	Farmers not aware of the programmes		140	70
	Farmers who received assistance under the programmes		18	9
	Type of assistance received	Subsidy on purchase of machine	4	2
		Subsidy on consumables	8	4
		Demonstration of best practices	4	2
		Training to use machines	2	1
		Cash incentives to use machines	0	0
		Complementary input provision	0	0
		Any other	0	0

Source: Primary survey

Table 6.8: Usefulness of the government Programs

Usefulness of the government Programs				
State	Usefulness/type of use	Type	No of farmers	% of farmers to total number of farmers
Bihar	Farmers who found the programmes useful		40	40
	Farmers who have not found the programmes useful		20	20
	Type of use	Learnt new techniques of mech.	28	28
		Got cash/subsidy for machines	12	12
		Any other		
West Bengal	Farmers who found the programmes useful	NA	NA	NA
	Farmers who have not found the programmes useful	NA	NA	NA
	Type of use	Learnt new techniques of mech.	NA	NA
		Got cash/subsidy for machines	NA	NA
		Any other	NA	NA
Overall	Farmers who found the programmes useful		40	20
	Farmers who have not found the programmes useful		20	10
	Type of use	Learnt new techniques of mech.	28	14
		Got cash/subsidy for machines	12	6
		Any other		

Source: Primary survey

Table 6.9: Increase in area after mechanization

Increase in area after mechanization				
State	Crop	% of area increase	% of production increase	% of production increase reported to be due to machines
Bihar	Paddy	1	2	2
	Wheat		2	2
	Maize			
	Lentil			
	Gram	5	2	2
West Bengal	Paddy		5	5
	Wheat		5	5
	Potato		2	2
	Mustard		10	10
Overall	Paddy	1	3	3
	Wheat		4	4
	Maize			
	Lentil			
	Gram	5	2	2
	Potato		2	2
	Mustard		10	10

Chapter 7
Summary and Conclusions

The level of mechanization in the three study states of the eastern region is very low, and all are below the national average of farm power availability (Table 2.1). Orissa and Bihar are way below the national average, while West Bengal is closer. The total share of the three eastern study states in tractor sales was quite low between 1997-98 and 2012-13, less than 10% of the total national sales, showing the poor state of tractorization in these states (Table 2.3).

In Bihar, the major crops in the sample region are paddy and wheat. Maximum area is devoted to these crops, which are sown for longer periods than other crops. Gram is another crop whose duration is longer but the area sown is small. In West Bengal, paddy and potato are the major crops grown on relatively larger areas. Paddy is sown for a much longer period than potato. The CDI is less than 50% in all three study years in both the study states, indicating that more than 50% of the land is uncultivated. The scope to increase land utilization by the use of increased mechanization, along with other input and output policies, may be urgently explored.

The percentage of farmers using machinery ranges from 21% to 100% for different types of machinery, whereas the percentage of farmers owning such machinery ranges from 7% to 50%, underlining the importance of the hire market for agricultural machinery in Bihar (Table 5.4). The cost of machinery is disproportionately high in West Bengal, probably because of the lack of custom hiring facilities. The cost of mechanization appears lower in Bihar.

Machines are mainly used for only three operations—ploughing, irrigation and marketing (Tables 5.1 to Table 5.3). The percentage of farmers using machines for these operations is higher. But the proportion of expenditure is lower for ploughing while for marketing it is higher (Table 5.3). Therefore, it may be necessary to encourage more use of tractors and power tillers in ploughing through custom hiring centres. Also, there is a discrepancy between the preference for tools and machines for many operations, particularly for ploughing, irrigation, harvesting, threshing and

marketing, and their actual use (Table 6.5). Efforts should be made to provide the appropriate and preferred tools and machinery to the farmers.

As per the Cost of Cultivation statistics (CoC), in Bihar, the share of machinery costs in total input costs is much higher than in West Bengal (Table 2.5). The share of machine labour relative to hired human labour is also higher, and the growth rate of cost of machinery is lower than that of human labour for some crops, particularly pulses (Table 2.8). This is mainly because of faster growth in the wage rates of hired labour. These growth trends in the costs of machinery and labour indicate some scope for substitution of labour with machinery in Bihar for pulses. In West Bengal, the share of machine labour in total input costs is quite low, ranging from 3% in jute to a maximum of 5% in paddy (Table 2.10). The total cost of production is higher than the VoP for two major crops—paddy and potato—but the operational costs are lower (Tables 2.11 and 2.12). This indicates that in West Bengal, paddy and potato farmers operate at mere subsistence level with gross revenue covering only the operational costs.

Our primary survey results broadly support the findings from the CoC data. Share of expenditure on machinery is far lower than that of human labour, which is about 50% for major crops (Table 5.12). Costs on machinery are generally higher in absolute terms for crops that have higher marketed surplus relative to production such as paddy and potato (Table 5.11). Wheat and mustard also show higher machinery costs but have lower ratio to VoP because of higher VoP. In Bihar, the share of machinery costs in VoP is quite low even for crops with marketed surplus exceeding 50% i.e. paddy and maize (Table 5.12). This implies that, in Bihar, either the use of machinery is low or its price, indicating the scope for increasing the use of machinery.

Our econometric analysis shows that machines play only a minor role in increasing GCA or yield, and that the major determinants are irrigation, seed and fertilizer. Irrigation (GIA) and fertilizer use (NPK) are significant in explaining GCA. Mechanization shows no effect (or negative effect). The variable significantly affecting yield is irrigated area.

Policy Implications

1) Given the very low level of mechanization in the two states and the low CDI, mechanization needs to be promoted through appropriate policies supplemented with suitable input and output policies.

2) Custom hiring centres need to be established as a large number of farmers expressed lack of such facility as a major problem.

3) Provision of other inputs, particularly irrigation, seed and fertilizer needs to be improved as our econometric results show that these inputs affect the area and yield levels more than the machinery use.

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Appendix Tables

(All the tables are based on primary survey)

Appendix Table 5.1: Operation-wise Machinery Use: Ploughing and Seedbed Preparation

Ploughing and Seedbed Preparation				
State	Source of Power	Machine	Total Number of hours	Total Cost
Bihar	Animal-operated			
		Plough	35	7650
		Disc Harrow		
		Cultivator		
	Power tiller operated			
		Rotavator		
	Tractor-operated			
		Plough	7	4146
		Disc Harrow		
		Cultivator		
		Rotavator		
	Total		43	11796
West Bengal	Animal-operated			
		Plough	115	6865
		Disc Harrow		
		Cultivator		
	Power tiller operated			
		Rotavator		
	Tractor-operated			
		Plough	6	4837
		Disc Harrow		
		Cultivator		
		Rotavator		
	Total		121	11702
Overall	Animal-operated			
		Plough	150	14515
		Disc Harrow		
		Cultivator		
	Power tiller operated			
		Rotavator		
	Tractor-operated			
		Plough	13	8983
		Disc Harrow		
		Cultivator		
		Rotavator		
	Total		164	23498

Appendix Table 5.2: Operation-wise Machinery Use: % Distribution of Ploughing and Seedbed Preparation

Ploughing and Seedbed Preparation (% Distribution)				
State	Source of Power	Machine	Total Number of hours	Total Cost
Bihar	Animal-operated			
		Plough	82	65
		Disc Harrow		
		Cultivator		
	Power tiller operated			
		Rotavator		
	Tractor-operated			
		Plough	17	35
		Disc Harrow		
		Cultivator		
		Rotavator		
	Total		100	100
West Bengal	Animal-operated			
		Plough	95	59
		Disc Harrow		
		Cultivator		
	Power tiller operated			
		Rotavator		
	Tractor-operated			
		Plough	5	41
		Disc Harrow		
		Cultivator		
		Rotavator		
	Total		100	100
Overall	Animal-operated			
		Plough	92	62
		Disc Harrow		
		Cultivator		
	Power tiller operated			
		Rotavator		
	Tractor-operated			
		Plough	8	38
		Disc Harrow		
		Cultivator		
		Rotavator		
	Total		100	100

Appendix Table 5.3: Operation-wise Machinery Use: Sowing and Planting

Sowing and Planting				
State	Source of Power	Machine	Total Number of hours	Total Cost
Bihar	Manually operated			
		Seed drill	74	7413
	Animal-operated			
		Seed drill		
		Drill plough		
		Mustard drill		
		Row planter		
		Sugarcane planter		
		Potato planter		
	Power tiller/Tractor-operated			
		Seed drill	4	1976
		Zero till drill		
		Sugarcane planter		
		Potato planter		
		Cultivator		
		Rotavator		
	Total		78	9389
Overall	Manually operated			
		Seed drill	74	7413
	Animal-operated			
		Seed drill		
		Drill plough		
		Mustard drill		
		Row planter		
		Sugarcane planter		
		Potato planter		
	Power tiller/Tractor-operated			
		Seed drill	4	1976
		Zero till drill		
		Sugarcane planter		
		Potato planter		
		Cultivator		
		Rotavator		
	Total		78	9389

Appendix Table 5.4: Operation-wise Machinery Use: % Distribution of Sowing and Planting

Sowing and Planting (% Distribution)				
State	Source of Power	Machine	Total Number of hours	Total Cost
Bihar	Manually operated			
		Seed drill	95	79
	Animal-operated			
		Seed drill		
		Drill plough		
		Mustard drill		
		Row planter		
		Sugarcane planter		
		Potato planter		
	Power tiller/Tractor-operated			
		Seed drill	5	21
		Zero till drill		
		Sugarcane planter		
		Potato planter		
		Cultivator		
		Rotavator		
	Total		100	100
Overall	Manually operated			
		Seed drill	95	79
	Animal-operated			
		Seed drill		
		Drill plough		
		Mustard drill		
		Row planter		
		Sugarcane planter		
		Potato planter		
	Power tiller/Tractor-operated			
		Seed drill	5	21
		Zero till drill		
		Sugarcane planter		
		Potato planter		
		Cultivator		
		Rotavator		
	Total		100	100

Appendix Table 5.5: Operation-wise Machinery Use: Irrigation

Irrigation			
State	Machine	Total Number of hours	Total Cost
Bihar	Diesel pump	32	4268
	Electric Pump		
	Total	32	4268
West Bengal	Diesel pump	24	4935
	Electric Pump		
	Total	24	4935
Overall	Diesel pump	56	9203
	Electric Pump		
	Total	56	9203

Appendix Table 5.6: Operation-wise Machinery Use: % Distribution of Irrigation

Irrigation (% Distribution)			
State	Machine	Total Number of hours	Total Cost
Bihar	Diesel pump	100	100
	Electric Pump		
	Total	100	100
West Bengal	Diesel pump	100	100
	Electric Pump		
	Total	100	100
Overall	Diesel pump	100	100
	Electric Pump		
	Total	100	100

Appendix Table 5.7: Operation-wise Machinery Use: Weeding and Inter-culture

Weeding and Inter-culture			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Manually operated	32	1250
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	32	1250
Overall	Manually operated	32	1250
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	32	1250

Appendix Table 5.8: Operation-wise Machinery Use: % Distribution of Weeding and Inter-culture

Weeding and Inter-culture (% Distribution)			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Manually operated	100	100
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	100	100
Overall	Manually operated	100	100
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	100	100

Appendix Table 5.9: Operation-wise Machinery Use: Plant Protection Equipment

Plant Protection Equipment			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Manually operated	16	384
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	16	384
West Bengal	Manually operated	12	71
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	12	71
Overall	Manually operated	28	455
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	28	455

Appendix Table 5.10: Operation-wise Machinery Use: % Distribution of Plant Protection Equipment

Plant Protection Equipment (% Distribution)			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Manually operated	100	100
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	100	100
West Bengal	Manually operated	100	100
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	100	100
Overall	Manually operated	100	100
	Animal-operated		
	Power tiller/Tractor-operated		
	Self-Propelled		
	Total	100	100

Appendix Table 5.11: Operation-wise Machinery Use: Harvesting

Harvesting			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Manual Sickle	125	3870
	Animal-operated gnut/potato digger		
	Tractor-operated reaper		
	Self-Propelled reaper		
	Total	125	3870
West Bengal	Manual Sickle	239	426
	Animal-operated potato digger	34	172
	Tractor-operated reaper		
	Self-Propelled reaper		
	Total	273	598
Overall	Manual Sickle	364	4296
	Animal-operated potato digger	34	172
	Tractor-operated reaper		
	Self-Propelled reaper		
	Total	398	4468

Appendix Table 5.12: Operation-wise Machinery Use: % Distribution of Harvesting

Harvesting (% Distribution)			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Manual Sickle	100	100
	Animal-operated gnut/potato digger		
	Tractor-operated reaper		
	Self-Propelled reaper		
	Total	100	100
West Bengal	Manual Sickle	87	71
	Animal-operated potato digger	13	29
	Tractor-operated reaper		
	Self-Propelled reaper		
	Total	100	100
Overall	Manual Sickle	91	96
	Animal-operated potato digger	9	4
	Tractor-operated reaper		
	Self-Propelled reaper		
	Total	100	100

Appendix Table 5.13: Operation-wise Machinery Use: Threshing

Threshing			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Power-operated thresher		
	Tractor-operated thresher		
	Paddy thresher	126	3724
	Maize thresher		
	Groundnut thresher		
	Any other (specify)		
	Total	126	3724
West Bengal	Power-operated thresher		
	Tractor-operated thresher		
	Paddy thresher	67	639
	Maize thresher		
	Groundnut thresher		
	Any other (specify)		
	Total	67	639
Overall	Power-operated thresher		
	Tractor-operated thresher		
	Paddy thresher	193	4363
	Maize thresher		
	Groundnut thresher		
	Any other (specify)		
	Total	193	4363

Appendix Table 5.14: Operation-wise Machinery Use: % Distribution of Threshing

Threshing (% Distribution)			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Power-operated thresher		
	Tractor-operated thresher		
	Paddy thresher	100	100
	Maize thresher		
	Groundnut thresher		
	Any other (specify)		
	Total	100	100
West Bengal	Power-operated thresher		
	Tractor-operated thresher		
	Paddy thresher	100	100
	Maize thresher		
	Groundnut thresher		
	Any other (specify)		
	Total	100	100
Overall	Power-operated thresher		
	Tractor-operated thresher		
	Paddy thresher	100	100
	Maize thresher		
	Groundnut thresher		
	Any other (specify)		
	Total	100	100

Appendix Table 5.15: Operation-wise Machinery Use: Transportation and Marketing

Transportation and Marketing			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Animal-Operated	10	600
	Tractor trolley	5	393
	Total	15	993
West Bengal	Animal-Operated	58	530
	Tractor trolley	5	2757
	Total	63	3287
Overall	Animal-Operated	68	1131
	Tractor trolley	9	3150
	Total	77	4280

Appendix Table 5.16: Operation-wise Machinery Use: % Distribution of Transportation and Marketing

Transportation and Marketing (% Distribution)			
State	Source of Power	Total Number of hours	Total Cost
Bihar	Animal-Operated	69	60
	Tractor trolley	31	40
	Total	100	100
West Bengal	Animal-Operated	92	16
	Tractor trolley	8	84
	Total	100	100
Overall	Animal-Operated	88	26
	Tractor trolley	12	74
	Total	100	100

Appendix Table 5.17: Costs of Mechanization: Operation-wise cost

State	Operation	Animal-Operated				Manually Operated			Power-Operated				Tractor Operated.		Total			
		Hire charges	Input costs	Service - maintenance	Total cost	Hire charge	Service maintenance	Total cost	Hire charges	Input costs	Service maintenance	Total cost	Hire charges	Total cost	Hire charges	Input costs	Service maintenance	Total cost
Bihar	Ploughing	7650			7650								4380	4380	12030			12030
	Sowing & transplantation					7413		7413	1976			1976			9389			9389
	Irrigation								4268			4268			4268			4268
	Weeding					1250		1250							1250			1250
	Plant Protection					384		384							384			384
	Harvesting					3870		3870							3870			3870
	Threshing	314			314	3410		3410							3724			3724
	Transport. and Marketing	600			600								393	393	993			993
West Bengal	Ploughing	6865			6865								4837	4837	11702			11702
	Sowing																	
	Irrigation								3783	869	283	4935			3783	869	283	4935
	Weeding																	
	Plant Protection					49	22	71							49		22	71
	Harvesting	161	11		172	402	24	426							563	11	24	598
	Threshing					588	52	639							588		52	639
	Transport. & Marketing	480		50	530								2757	2757	3237		50	3287
Overall	Ploughing	14515			14515								9217	9217	23732			23732
	Sowing					7413		7413	1976			1976			9389			9389
	Irrigation								8051	869	283	9203			8051	869	283	9203
	Weeding					1250		1250							1250			1250
	Plant Protection					433	22	455							433		22	455
	Harvesting	161	11		172	4272	24	4296							4433	11	24	4468
	Threshing	314			314	3998	52	4049							4312		52	4363
	Transport. & Marketing	1080		50	1131								3150	3150	4230		50	4280

Appendix Table 5.18: Costs of Mechanization: % Distribution of Operation-wise cost

State	Operation	Animal-Operated				Manually Operated			Power-Operated				Tractor Operated		Total			
		Hire charges	Input costs	Service maintenance	Total cost	Hire charges	Service maintenance	Total cost	Hire charges	Input costs	Service maintenance	Total cost	Hire charges	Total cost	Hire charges	Input costs	Service maintenance	Total cost
Bihar	Ploughing	64			64								36	36	100			100
	Sowing					79		79	21			21			100			100
	Irrigation								100			100			100			100
	Weeding					100		100							100			100
	Plant Protection					100		100							100			100
	Harvesting					100		100							100			100
	Threshing	8			8	92		92							100			100
	Transport. and Marketing	60			60								40	40	100			100
West Bengal	Ploughing	59			59								41	41	100			100
	Sowing																	
	Irrigation								100	100	100	100			100	100	100	100
	Weeding																	
	Plant Protection					100	100	100							100		100	100
	Harvesting	29	100		29	71	100	71							100	100	100	100
	Threshing					100	100	100							100		100	100
	Transport. & Marketing	15		100	16								85	84	100		100	100
Overall	Ploughing	61			61								39	39	100			100
	Sowing					79		79	21			21			100			100
	Irrigation								100	100	100	100			100	100	100	100
	Weeding					100		100							100			100
	Plant Protection					100	100	100							100		100	100
	Harvesting	4	100		4	96	100	96							100	100	100	100
	Threshing	7			7	93	100	93							100		100	100
	Transport. & Marketing	26		100	26								74	74	100		100	100

Appendix Table 6.1: Opinion-Operation-wise: Ploughing

Ploughing					
State	Source of Power	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Animal-operated				
		Plough	15	100	15
		Disc Harrow	10	100	10
		Cultivator			
	Power tiller operated				
		Rotavator	9	100	9
	Tractor-operated				
		Plough	60	100	60
		Disc Harrow	6	100	6
		Cultivator			
		Rotavator			
West Bengal	Animal-operated				
		Plough	50	100	50
		Disc Harrow			
		Cultivator			
	Power tiller operated				
		Rotavator			
	Tractor-operated				
		Plough	18	100	18
		Disc Harrow			
		Cultivator			
		Rotavator	32	100	32
Overall	Animal-operated				
		Plough	65	200	33
		Disc Harrow	10	100	5
		Cultivator			
	Power tiller operated				
		Rotavator	9	200	5
	Tractor-operated				
		Plough	78	200	39
		Disc Harrow	6	200	3
		Cultivator			
		Rotavator	32	200	16

Appendix Table 6.2: Opinion-Operation-wise: Sowing and Planting

Sowing and Planting					
State	Source of Power	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Manually operated	Seed drill	65	100	65
	Animal-operated	Seed drill	17	100	17
		Drill plough			
		Mustard drill			
		Row planter			
		Sugarcane planter			
		Potato planter			
	Power tiller/Tractor-operated	Seed drill	8	100	8
		Zero till drill	10	100	10
		Sugarcane planter			
		Potato planter			
		Cultivator			
		Rotavator			
West Bengal	Manually operated	Seed drill	0	100	0
	Animal-operated	Seed drill	0	100	0
		Drill plough			
		Mustard drill			
		Row planter			
		Sugarcane planter			
		Potato planter			
	Power tiller / Tractor-operated	Seed drill	0	100	0
		Zero till drill	0	100	0
		Sugarcane planter			
		Potato planter			
		Cultivator			
		Rotavator			
Overall	Manually operated	Seed drill	65	200	65
	Animal-operated	Seed drill	17	200	17
		Drill plough			
		Mustard drill			
		Row planter			
		Sugarcane planter			
		Potato planter			
	Power tiller / Tractor-operated	Seed drill	8	200	8
		Zero till drill	10	200	10
		Sugarcane planter			
		Potato planter			
		Cultivator			
		Rotavator			

Appendix Table 6.3: Opinion-Operation-wise: Irrigation

Irrigation				
State	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Diesel Pump	100	100	100
	Electric Pump			
West Bengal	Diesel Pump	46	100	46
	Electric Pump	54	100	54
Overall	Diesel Pump	146	200	73
	Electric Pump	54	200	27

Appendix Table 6.4: Opinion-Operation-wise: Weeding and Inter-culture

Weeding and Inter-culture				
State	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Manually operated	89	100	89
	Animal-operated			
	Power tiller/Tractor-operated			
	Self-Propelled	9	100	9
West Bengal	Manually operated	100	100	100
	Animal-operated			
	Power tiller/Tractor-operated			
	Self-Propelled	0	100	0
Overall	Manually operated	189	200	95
	Animal-operated			
	Power tiller/Tractor-operated			
	Self-Propelled	9	200	5

Appendix Table 6.5: Opinion-Operation-wise: Plant Protection equipment

Plant Protection equipment				
State	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Manually operated	75	100	75
	Animal-operated			
	Power tiller/Tractor-operated			
	Self-Propelled	25	100	25
West Bengal	Manually operated	100	100	100
	Animal-operated			
	Power tiller/Tractor-operated			
	Self-Propelled	0	100	0
Overall	Manually operated	175	200	87
	Animal-operated			
	Power tiller/Tractor-operated			
	Self-Propelled	25	200	13

Appendix Table 6.6: Opinion-Operation-wise: Harvesting

Harvesting				
State	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Manual Sickle	61	100	61
	Animal-operated gnut/potato digger	0		0
	Tractor-operated reaper			
	Self-Propelled reaper	12	100	12
West Bengal	Manual Sickle	77	100	77
	Animal-operated potato digger	23	100	23
	Tractor-operated reaper			
	Self-Propelled reaper	0	100	0
Overall	Manual Sickle	138	200	69
	Animal-operated potato digger	23	200	12
	Tractor-operated reaper			
	Self-Propelled reaper	12	200	6

Appendix Table 6.7: Opinion-Operation-wise: Threshing

Threshing				
State	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Power-operated thresher	50	100	50
	Tractor-operated thresher			
	Paddy thresher	25	100	25
	Maize thresher	25	100	25
	Groundnut thresher			
	Any other (specify)			
West Bengal	Power-operated thresher	0	100	0
	Tractor-operated thresher			
	Paddy thresher	100	100	100
	Maize thresher	0	100	0
	Groundnut thresher			
	Any other (specify)			
Overall	Power-operated thresher	50	200	25
	Tractor-operated thresher			
	Paddy thresher	125	200	63
	Maize thresher	25	200	13
	Groundnut thresher			
	Any other (specify)			

Appendix Table 6.8: Opinion-Operation-wise: Marketing and Transportation

Marketing and Transportation				
State	Most Appropriate Machine	Number of farmers	Total no of farmers	% of farmers to Total no of farmers
Bihar	Animal-Operated	20	100	20
	Tractor trolley	80	100	80
West Bengal	Animal-Operated	0	100	0
	Tractor trolley	100	100	100
Overall	Animal-Operated	20	200	10
	Tractor trolley	180	200	90

Appendix Table 6.9: Problems -Operation-wise: Ploughing

Ploughing										
State	Power Source	Machine	Expensive to purchase	Hire facility not available	Expensive to hire	High maintenance cost	Repair facilities unavailable	Not easy to use	% of farmers not reporting any reason	Total
Bihar	Animal-operated	Plough		5	31				64	100
		Disc Harrow							100	100
		Cultivator							100	100
	Power Tiller	Rotavator		9				2	89	100
	Tractor	Plough	37	10	8	3			42	100
		Disc Harrow		3					97	100
		Cultivator		2					98	100
		Rotavator		2					98	100
	Manual	Seed drill		11					89	100
	Animal	Seed cum fertilizer drill		7			7		86	100
		Drill Plough							100	100
		Mustard drill							100	100
		Row planter		4					96	100
		Sugarcane planter							100	100
		Potato planter							100	100
West Bengal	Animal-operated	Plough	10	14					76	100
		Disc Harrow							100	100
		Cultivator							100	100
	Power Tiller	Rotavator							100	100
	Tractor	Plough	26	26	14				34	100
		Disc Harrow							100	100
		Cultivator							100	100
		Rotavator							100	100
	Manual	Seed drill							100	100
	Animal	Seed cum fertilizer drill							100	100
		Drill Plough							100	100
		Mustard drill							100	100
		Row planter							100	100
		Sugarcane planter							100	100
		Potato planter							100	100
Overall	Animal-operated	Plough	5	10	16				70	100
		Disc Harrow							100	100
		Cultivator							100	100
	Power Tiller	Rotavator		5				1	95	100
	Tractor	Plough	32	18	11	2			38	100
		Disc Harrow		2					99	100
		Cultivator		1					99	100
		Rotavator		1					99	100
	Manual	Seed drill		6					95	100
	Animal	Seed cum fertilizer drill		4			4		93	100
		Drill Plough							100	100
		Mustard drill							100	100
		Row planter		2					98	100
		Sugarcane planter							100	100
		Potato planter							100	100

Appendix Table 6.10: Problems -Operation-wise: Sowing and Planting

Sowing and Planting								
State	Power Source	Machine	Expensive to purchase	Hire facility not available	Expensive to hire	High maintenance cost	% of farmers not reporting any reason	Total
Bihar	Manual	Seed drill		5	10		85	100
	Animal	Seed-cum-fertilizer-drill					100	100
		Drill Plough					100	100
		Mustard drill					100	100
		Row planter		2			98	100
		Sugarcane planter					100	100
		Potato planter					100	100
	Tractor	Seed cum fertilizer. drill	2	17	12	2	67	100
		Zero till drill	1	2			97	100
		Sugarcane planter					100	100
		Potato planter					100	100
West Bengal	Manual	Seed drill					100	100
	Animal	Seed cum fertilizer. drill					100	100
		Drill Plough					100	100
		Mustard drill					100	100
		Row planter					100	100
		Sugarcane planter					100	100
		Potato planter					100	100
	Tractor	Seed cum fertilizer. drill					100	100
		Zero till drill					100	100
		Sugarcane planter					100	100
		Potato planter					100	100
Overall	Manual	Seed drill		3	5		93	100
	Animal	Seed cum fertilizer. drill					100	100
		Drill Plough					100	100
		Mustard drill					100	100
		Row planter		1			99	100
		Sugarcane planter					100	100
		Potato planter					100	100
	Tractor	Seed cum fertilizer. drill	1	9	6	1	84	100
		Zero till drill	1	1			99	100
		Sugarcane planter					100	100
		Potato planter					100	100

Appendix Table 6.11: Problems -Operation-wise: Irrigation

Irrigation										
State	Machine	Expensive to purchase	Hire facility not available	Expensive to hire	High maintenance cost	Repair & service facilities expensive	Yield not as expected	No government support	% of farmers not reporting any reason	Total
Bihar	Diesel Pump	8	5	10	7	10			60	100
	Electric pump								100	100
West Bengal	Diesel Pump		41				6	3	50	100
	Electric pump		41						59	100
Overall	Diesel Pump	4	23	5	4	5	3	2	55	100
	Electric pump		21						80	100

Appendix Table 6.12: Problems -Operation-wise: Weeding

Weeding					
State	Machine	Hire facility not available	Expensive to hire	% of farmers not reporting any reason	Total
Bihar	Manually operated	10	25	65	100
	Animal-operated			100	100
	Tractor/ power tiller operated			100	100
	Self-propelled	10		90	100
West Bengal	Manually operated			100	100
	Animal-operated			100	100
	Tractor/ power tiller operated			100	100
	Self-propelled			100	100
Overall	Manually operated	5	13	83	100
	Animal-operated			100	100
	Tractor/ power tiller operated			100	100
	Self-propelled	5		95	100

Appendix Table 6.13: Problems -Operation-wise: Plant Protection

Plant Protection							
State	Machine	Expensive to purchase	Hire facility not available	Expensive to hire	Yield not as expected	% of farmers not reporting any reason	Total
Bihar	Manually operated		5	7		88	100
	Power tiller operated					100	100
	Tractor-operated					100	100
	Self-propelled	3	3			94	100
West Bengal	Manually operated	23			9	67	100
	Power tiller operated					100	100
	Tractor-operated					100	100
	Self-propelled					100	100
Overall	Manually operated	12	3	4	5	78	100
	Power tiller operated					100	100
	Tractor-operated					100	100
	Self-propelled	2	2			97	100

Appendix Table 6.14: Problems -Operation-wise: Harvesting

Harvesting							
State	Machine	Hire facility not available	Expensive to hire	Yield not as expected	Not easy to use	% of farmers not reporting any reason	Total
Bihar	Manual sickle	20	5		11	64	100
	Animal-operated groundnut-cum-potato digger					100	100
	Tractor-operated reaper					100	100
	Self-propelled reaper	9				91	100
West Bengal	Manual sickle			9		91	100
	Animal-operated potato digger					100	100
	Tractor-operated reaper					100	100
	Self-propelled reaper					100	100
Overall	Manual sickle	10	3	5	6	78	100
	Animal-operated potato digger					100	100
	Tractor-operated reaper					100	100
	Self-propelled reaper	5				96	100

Appendix Table 6.15: Problems -Operation-wise: Threshing

Threshing							
State	Machine	Expensive to purchase	Hire facility not available	High maintenance cost	Yield not as expected	% of farmers not reporting any reason	Total
Bihar	Power-operated thresher					100	100
	Tractor-operated thresher					100	100
	Paddy thresher	10	50			40	100
	Maize thresher		25			75	100
	Groundnut thresher					100	100
West Bengal	Power-operated thresher					100	100
	Tractor-operated thresher					100	100
	Paddy thresher	32	8	13	9	38	100
	Maize thresher					100	100
	Groundnut thresher					100	100
Overall	Power-operated thresher					100	100
	Tractor-operated thresher					100	100
	Paddy thresher	21	29	7	5	39	100
	Maize thresher		13			88	100
	Groundnut thresher					100	100

Appendix Table 6.16: Problems -Operation-wise: Marketing

Marketing							
State	Machine	Expensive to purchase	Hire facility not available	Expensive to hire	No government support	% of farmers not reporting any reason	Total
Bihar	Bullock	2	2	12	4	80	100
	Camel					100	100
	Horse					100	100
	Donkey					100	100
	Any other animal					100	100
	Tractor trolley	8		2		90	100
West Bengal	Bullock					100	100
	Camel					100	100
	Horse					100	100
	Donkey					100	100
	Any other animal					100	100
	Tractor trolley	9				91	100
Overall	Bullock	1	1	6	2	90	100
	Camel					100	100
	Horse					100	100
	Donkey					100	100
	Any other animal					100	100
	Tractor trolley	9		1		91	100

ACTION TAKEN REPORT ON REVIEWER'S COMMENTS

"Effect of Farm Mechanization on Agricultural Growth and Comparative Economics of Labour and Machinery in India"

Submitted by IEG, New Delhi

Reviewer Comments:

The present report titled "Effect of Farm Mechanization on Agricultural Growth and Comparative Economics of Labour and Machinery in India" is a relevant attempt by the authors to the present situation of modernization in agriculture in the country. This is a good and timely attempt on mechanization when these issues are being hotly debated in the country especially with respect to Bringing Green Revolution to the Eastern India. This report needs to be revised with the following changes;

- In Chapter 1, page no. 1, the reference Biggas et al., 2011 has to be placed after the next sentence (....80% mechanized.)
    - Appropriate correction has been carried out
- As the number of reviews related to the topic are available in plenty, authors need to include few more reviews on the objectives dealt in the study.
    - Review of literature has been expanded by including some important studies
- In Chapter 2, the government initiatives in promoting mechanization in the study states, only Bihar state programmes have been listed while West Bengal has not been attempted. Hence, authors need to quote some of the programmes in the West Bengal too for better understanding about the mechanization in both the states.
    - Government programs relating to farm mechanization in West Bengal have been added in Chapter 2 as suggested.
- With regard to machinery costs in the Chapter 2, the overall share of machinery cost in operational cost and total cost (Table 2.15 & Table 2.16) are combined by simply adding the total costs in two different states for similar crops. Since there is a huge gap in similar costs across the states for the same crops, my apprehension is that the overall share of machinery costs may not be appropriate with this method. Instead, it is better to compare costs between states or otherwise if one has to calculate aggregate cost, it should be weighted average and not the simple average.

- A weighing scheme has to be based on a detailed study of the factor supply and demand patterns at crop level. For example, lower wage cost vis-à-vis machinery for a particular crop in a state could be due to any one or a combination of the following factors - excess supply of labour, lower demand for labour, lower labour productivity or a statutory lower wage rate. Any weighing scheme will need to take into proper account of these factors, which is beyond the scope of the present study. Therefore, we have confined ourselves to simple averaging across states.

- In Chapter 3 (page no. 20), as authors rightly mentioned that due to classic omitted variable problem the results are biased. If that is the problem, the authors should have explained and tried to overcome these problem by including other variables to attribute to the real issue. In my opinion, authors have not considered mechanization involved within irrigation such as drip/sprinkler and other minor irrigation equipments.

    - Discussed at the relevant place in chapter 3.

- In Chapter 4 (Table 4.8 and Table 4.9), tank irrigation seems to be nil in the selected states but the literatures shows that (for instance a book by Niranjan Pant and R.K. Verma, 2010) there is some proportion of the irrigated area under smaller tank sources and hence need to substantiate authors' statement with proper justification.

    - Appropriate modification carried out.

- In Chapter 5 (page no. 35), under Costs of Mechanization in input costs (para 1) for Bihar state authors have stated that fertiliser contributes a constant share of about 12% for all crops **but in the table it ranges from 8 to 18% for different crops.** Authors need to correct the same. Many tables in the Chapter are not explained/quoted in the write up (for instance, Table 5.1, 5.3, 5.5, 5.6, 5.9... etc). It is desired to ensure all the tables are explained/linked/quoted in the report.

    - Appropriate corrections carried out.

- In Chapter 6 (page no. 52), explanation for increase in production due to mechanization (Table 6.9) for West Bengal is missing, that is needed to be incorporated.

    - Appropriate correction carried out.

- In Summary and Conclusions (page no. 60, para 3), authors have abbreviated as MS, need to be expanded.

- Necessary explanation incorporated

- Under policy implications (page no.61), the points need to be numbered from 1 to 3 (as it is printed as 3 to 5). Same corrections should be done in Executive Summary and Policy Implications.

    - Appropriate correction carried out.

- Apart from all the above points, there are many typographical/grammatical errors in the report. Therefore, the report should be sent to the professional editor for proper editing before submitting it as final report after incorporating the above suggestions.

    - The report has been edited by a professional editor as suggested

Final remarks: The draft report can be accepted for publication and further submission to the ministry after it's been revised in accordance with the comments/suggestions.