

Double Cropping of Rice and Wheat in India — a Case Study in Khardaha —

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カルダハ村における米—小麦の二毛作

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I. Rationale of the Study

In this study, the author sets the focus on the development of double cropping system of rice and wheat in Khardaha, a village in northern India. The change of agriculture in India for the last two decades has promoted the regional specialization of farming systems because the regions where the modern farming technology is applicable are limited. At the same time, the commercial and subsistence farms are being differentiated within regions. This urges the collection of detailed information on the local farming systems from geographical viewpoints.

The dynamic phase of farming system is explained in close relation to the resource availability, as the imbalance between population and resources stimulates the change of farming technology. It is a classic economic hypothesis that cultivation techniques are chosen so that the costs of resources keep balance with one another, and whether farmers adopt a labor intensive technique or a capital intensive one is dependent on the

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availability of resources both internal and external.

The green revolution is a technological innovation which has brought some improvement in land productivity with modern improved varieties. In economic terms, those modern varieties increase marginal productivity of land so that more input can return more output. Improvement of fertilizer responsiveness stimulates input of fertilizers, while shortening of growth duration encourages multiple cropping which enables year-round labor input. Those modern varieties have diffused with a set of modern techniques such as irrigation facilities and fertilizer application. They have enhanced a traditional aspect of the farming systems in Asia, or intensive land use.

From economic viewpoints, land use represents the intensity of labor and capital inputs while cropping calendar illustrates the seasonal fluctuation of inputs. Selection of crops and varieties is dependent on the ecological conditions of the fields as well as the economic conditions of the markets. Such techniques as land preparation and plant establishment are essential because environment is crucial for the young plants. For example, wheat is broadcast in the fields, while rice is usually established by transplanting. This makes the most important difference between them with respect to the intensity of cultivation.

The economic aspects of rice cultivation are characterized by the intensive labor input and land use. Considerable costs are required for leveling and bunding fields as well as for the implementation of irrigation facilities. Because of this scarcity in land resources, multiple cropping is common where climatic conditions permit and labor is available. Transplanting promotes multiple cropping through reduction of growth duration in the main fields although it requires much labor input.

On the other hand, wheat cultivation is influenced by the scale of capital input. Wheat is more responsive to fertilizer than rice, and farming machines are available to extend the cropping area when there is a shortage of labor force. The profitability of wheat is variable by the size of farm, especially in the case of mechanized cultivation, because the depreciation of machines is calculated as a fixed cost while the gross returns are proportional to the operational area.

The interpretation of local cropping systems are based on the information about varietal, spatial and temporal arrangements of farming operations. The data was collected through intensive interviews to the farmers with questionnaires including

following questions:

1. Family members (status, occupation, income)
2. Labor supply and demand (monthly quantity, daily wage)
3. Cultivated plots (area, crops, yield)
4. Land tenure (area, contract, partner)
5. Land acquisition (inheritance, purchase)
6. Livestock (number, purpose, value)
7. Marketing of products (price, quantity)
8. Adoption of modern techniques (machines, chemicals)

II. Land Use in Khardaha

The land use in Khardaha has been intensified drastically for the last twenty years by the development of irrigation facilities. The cultivated area is unchanged while the irrigated fields have been expanded on a large scale. The change is owing mainly to the diffusion of private electric pumps.

According to the *khasara*, or the crop record of village, about 80 percent of the *mouza*, or the cadastral area, has been utilized as cultivated land since 1970 (Table 1). The irrigated land had been expanded before 1985 although its area changes from year to year. The area of non-agricultural land has gradually increased since 1970, while the area of fallow land has sharply reduced.

Along with the expansion of irrigated area, the gross cropped area has also increased from 122 hectares in 1970 to 150 hectares in 1985, and 137 hectares in 1990 (Table 2). This has resulted from the increase of the area planted to *rabi* crops, or the dry season crops. The area of the *rabi* crops has increased by more than 30 percent, and has become almost equal to that of the *kharif* crops, or the wet season crops. The ratio of cropped area to agriculture area has improved from 127 in 1970 to 165 in 1985, and 154 in 1990, resulting from the decrease of fallow land and the expansion of double cropping fields.

Mixed cropping has almost disappeared. Especially mixed cropping of *arhar* (pigeon pea, *Cajanus cajan*) with *jowar* (sorghum, *Sorghum bicolor*) or *bajra* (pearl millet, *Pennisetum clandestinum*) in the wet season has decreased from 6.5 hectares in 1970 to 1.2 hectares in 1990. The area planted to legumes in the dry season seems relatively fixed at 12 to 8 hectares although its percentage has slightly declined.

Table 1 Change of land use in Khadaha

Year		Cultivated Land		Fallow	Non-agri-cultural
		Irrigated	Rainfed		
1970	ha	48.4	36.2	11.5	11.7
	(%)	(44.9)	(33.6)	(10.7)	(10.8)
1985	ha	74.0	10.6	6.1	17.1
	(%)	(68.6)	(9.8)	(5.7)	(15.9)
1990	ha	71.4	15.5	2.8	18.1
	(%)	(66.2)	(14.4)	(2.6)	(16.8)

Note: The total *mouza* area of Khardaha is 107.8 ha.

Table 2 Change of cropped area in Khardaha

Year	Gross Area (ha)	<i>Kharif</i> Crops (%)				<i>Rabi</i> Crops (%)			
		Total	Rice	Maize	Other Grains	Total	Wheat	Barley	Legume
1970	122.3	57.5	28.4	13.0	9.0	42.5	6.7	23.4	9.7
1985	149.7	50.6	30.2	7.2	3.6	49.4	39.3	—	5.2
1990	137.0	50.8	36.4	1.2	2.7	49.2	36.8	—	7.4

The major crops have changed drastically although much of the area is still allocated to the cultivation of field crops. In 1970, rice was the most dominant crop (28.4 percent), followed by barley (23.4 percent). At that time, wheat occupied only 8.0 percent including mixed cropping with barley. Before 1985, barley had been replaced completely by wheat, which is most prevalent (36.8 percent) in 1990. Wheat became major only recently in this village.

As regards *kharif* crops, coarse grains such as *jowar* and *bajra* had decreased before maize was also replaced by rice in the 1980s. Rice is a traditional crop in this village, and it was grown mainly in the rainfed lowland in the 1960s. In 1990, it is the second predominant crop (36.4 percent) which can be grown anywhere in this village with irrigation.

The area by cropping pattern is estimated according to the crop record (Table 3). Double cropping of rice and wheat is widely practiced, counting almost 40 percent of the cultivated area. The area under single cropping occupies only 20 percent, localized on some parts of the village. The land level still poses some constraints to the double cropping in this village although utilization of private pumps can moderate them. For example, the irrigation canal, running from the west to the east in the center of the

Table 3 Land use by cropping pattern in Khardaha, 1990

Sub-division	Total Area (ha)	Cultivated (ha)	Area by Cropping Pattern (%)		
			Rice & Wheat	Rice Only	Wheat Only
Northeast	22.0	14.0	34.7	0.6	11.9
Northwest	23.2	19.2	57.9	7.5	7.9
Center	19.4	15.2	35.5	—	8.9
Southeast	20.7	14.8	28.6	0.9	5.7
South	22.6	21.9	35.6	22.4	1.5
Total	107.9	85.1	39.2	7.7	6.7

Note: The figures include the errors by estimation.

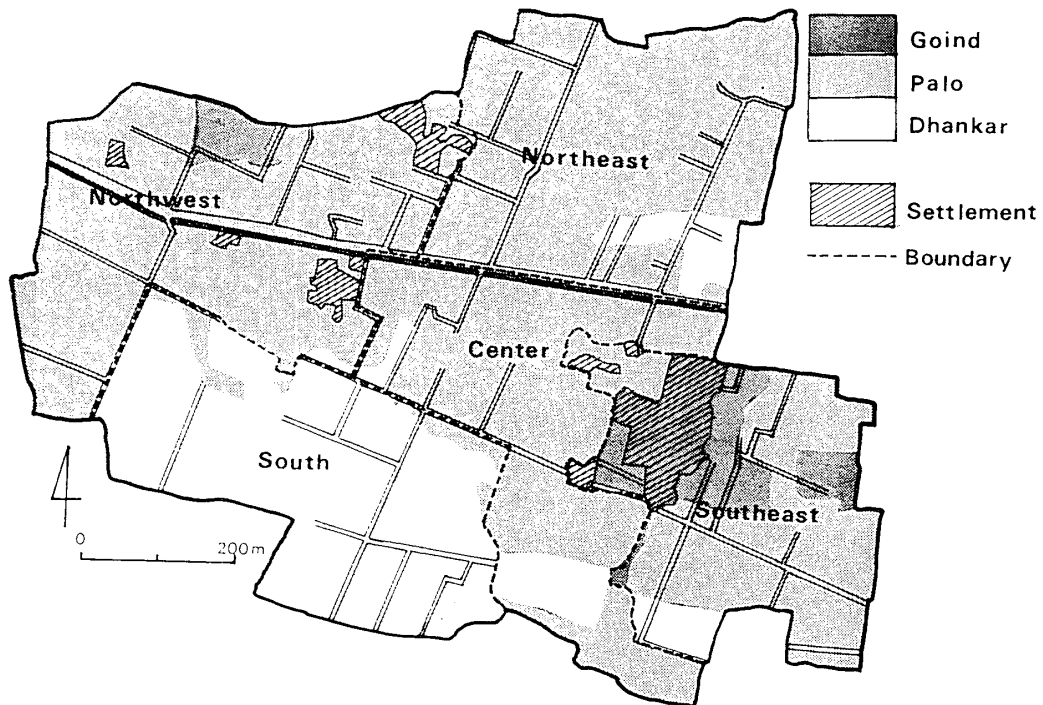


Fig.1 Land classification of Khardaha mouza.

mouza, leaves some uplands unirrigated.

In this study, the *mouza* area is tentatively divided into five subdivisions, considering the soil conditions recorded on the cadastral map (Figure 1). The main settlement is located in the southeastern part, where the land level is highest in the village. About two-thirds of the cultivated area in this part is planted to other crops than rice or wheat, probably because of its land level and convenient location for gardening. The soil around the settlement is classified as *goind*, which is evaluated as most productive.

The southern part includes much of the *dhankar* land, which lies in the depressed zone and has been utilized traditionally for rice cultivation. This area is often submerged in the wet season, and it is characterized by the relatively high percentage of single cropping fields of rice.

Palo land, or the arable land on the middle level, extends from the northwestern part to the northeastern part. More than a half of the cultivated area in the northwestern part is under double cropping of rice and wheat. In the northeastern part, single cropping fields of wheat exceed 10 percent because its land level is higher than others.

III. Cropping patterns in Khardaha

Figure 2 shows the climatic diagram of Allahabad in the eastern Uttar Pradesh, and the cropping patterns of rice and wheat in Khardaha. According to the diagram, the wet season begins in June and ends in October, followed by the cool and dry season from November to March. In April and May, the weather becomes too hot and dry for farming.

The preparation for nursery bed of rice starts in early June with the onset of the wet season. Main fields are fertilized, and plowed often with tractors two to three times before transplanting six-week-old seedlings. If the rainfall supplemented by the canal water is not sufficient, electric pumps are used to irrigate the fields. The first topdressing is applied ten days after transplanting, and weeding is practiced several times by manual labor. In August, heavy rains sometimes bring about flash floods which may cause severe damages to the crops.

At the maturing stage in September, the second topdressing is practiced just after the heads of rice come out. The rainfall in this season is important for the rice cultivation because insufficient soil moisture brings poor harvest, especially in the case of drought

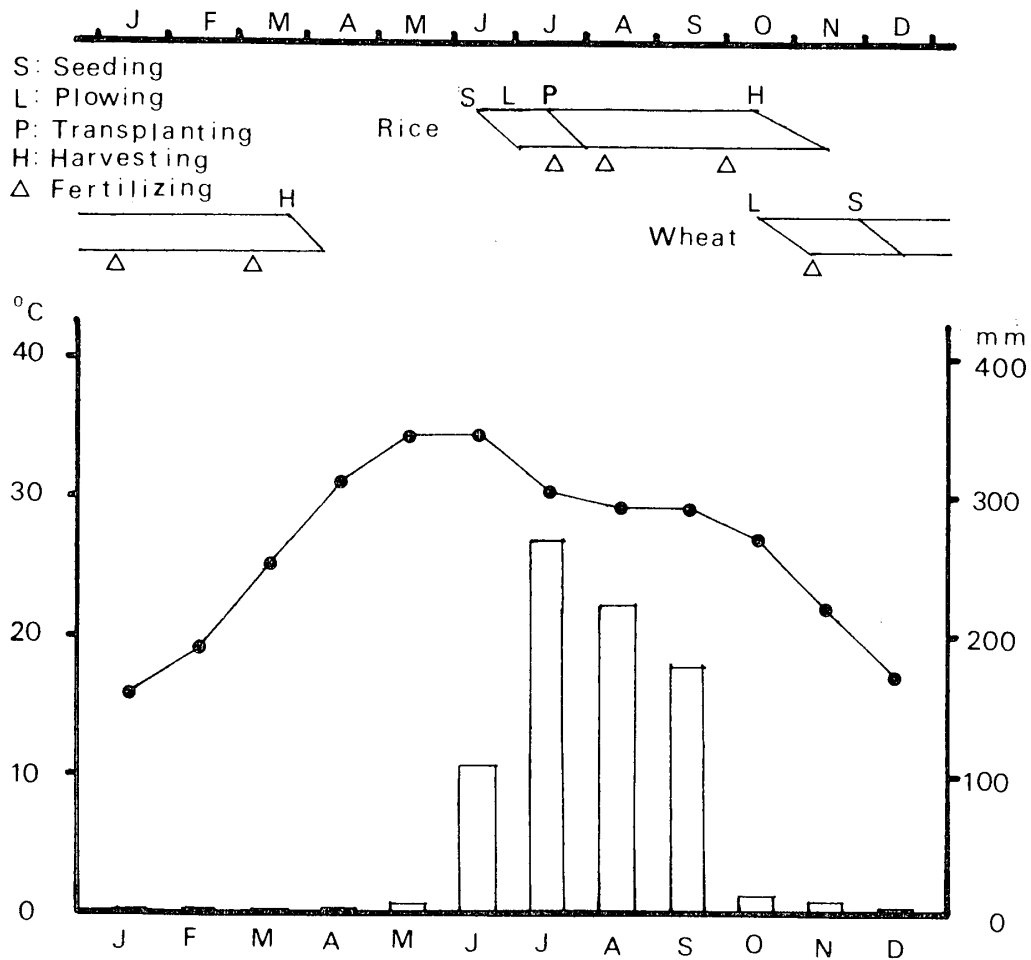


Fig.2 Climatic conditions in Allahabad and cropping patterns in Khardaha

intolerant varieties. The harvesting of rice starts in October, and the late maturing varieties are harvested by the last week of November, at latest, in order to clear the fields for the wheat cultivation.

The plowing and fertilization of wheat fields starts in mid October to early December about a half month before sowing seeds. If the surface of soil becomes too dry and hard to plow at the end of the wet season, the fields are irrigated with pumps even though the stands of rice are remaining in the fields. The seeds of wheat must be sown by the second week of December to catch the showers in time. These showers in December are so essential to the germination of wheat seeds that its timing imposes restrictions on the design of cropping patterns with respect to the selection of rice varieties.

During the growing period of wheat, only topdressing and irrigation are practiced two to three times. The harvesting of wheat continues from the end of March till mid April, and the fields are left fallow until the next cultivation starts in the wet season. In the traditional cropping patterns, drought-tolerant crops such as maize were sometimes grown as *zaid* crop, or the early wet season crop, between *rabi* and *kharif* season.

Most of the varieties of rice and wheat grown in this village are modern varieties. The seeds of rice are usually purchased from the local markets every few years, in order to avoid the decrease of yield according to some farmers. The seeds of wheat are, however, domestic. They are selected from the tall parents in the fields.

The area and the yield of principal varieties are studied through the survey of selected 25 farms (Table 4). The predominance of specific varieties is clear in the case of wheat. The average yield of rice is 3,142 kg/ha while that of wheat is 2,685 kg/ha. Wheat has greater variance of the yield than rice partly because of the difference between varieties. *RR 21* occupies more than a half of the wheat area although its yield is lower (2,177 kg/ha) than others, especially compared with the *UP* or *HD* series (4,380 kg/ha), which is said to be more responsive to fertilizer.

Masuri is the most prevalent rice variety in area. Its popularity is due to its good price despite its low yeild (2,721 kg/ha) and susceptiveness to drought damage. *Sarju 52*, the second popular one, is most productive (3,605 kg/ha), and its yield is 1.3 times as high as

Table 4 Yield of major varieties of rice and wheat in Khardaha

Crop/ Variety	Sample Plots			Yield (kg/ha)	
	(ha)	(%)	N	Mean	S.D.
Rice					
<i>Masuri</i>	7.7	(38.3)	12	2,721 ^a	659
<i>Sarju 52</i>	5.3	(26.3)	7	3,605 ^b	890
<i>Sita</i>	3.5	(17.3)	6	2,779	460
All Varieties	20.2	(100.0)	29	3,142	1,035
Wheat					
<i>RR 21</i>	10.4	(51.2)	14	2,177 ^c	592
<i>HD/UP Series</i>	5.5	(27.0)	7	4,380 ^d	929
<i>Kalyansona</i>	2.7	(13.2)	7	2,220	443
All Varieties	20.5	(100.0)	32	2,685	1,092

Note: N gives the number of sample plots.

a-b, c-d. Difference is significant at 95 % level.

Masuri. The growth duration makes another important difference between them. *Masuri* is a late maturing variety harvested in mid November, or one month behind *Sarju 52*. This leads to the differentiation of cropping patterns.

Most of the fields planted to rice are under double cropping (Table 5), although *Masuri* is disadvantageous to the double cropping with wheat because of its long growth duration. On the other hand, some of the wheat fields are left fallow in the wet season. Especially, the percentage of single cropping fields of *RR 21* is large, probably because of the poor conditions of irrigation.

The interpretation of the cropping patterns shows that the most critical season for the double cropping of rice and wheat is from late September to early December. The rainfalls in this season affect the yield of rice as well as the germination of wheat. Since the seasonal change of cultivation from rice to wheat should be completed as early as possible, the farmers tend to grow the early maturing rice. The early start of rice cultivation requires early supply of irrigation water or sufficient rainfalls at the beginning of the wet season.

To cope with the unstable start of the wet season, some farmers cultivate a local rice variety called *Karanghi* (or *Karahani*). This is a very short duration variety which is broadcast in late August and harvested in late October to early November. Although its yield cannot be expected as high as the modern varieties, it enables to avoid the shortage of water in July as well as the flash floods in early August.

Table 5 Cropping pattern of rice and wheat by variety in Khardaha

Crop/ Variety	Sample Area (ha)	Cropping Pattern (%)		
		Single Cropping	Rice & Wheat	Others
Rice				
<i>Masuri</i>	7.7	3.5	71.1	19.7
<i>Sarju 52</i>	5.3	9.2	90.0	0.5
All Varieties	20.2	4.9	81.2	13.9
Wheat				
<i>RR 21</i>	10.4	25.2	68.2	6.6
<i>HD/UP Series</i>	5.5	10.9	86.2	2.9
All Varieties	20.5	15.9	79.9	4.2

IV. Socio-economic aspects of double cropping

According to the census survey of the households in Khardaha, there are 207 households in total, of which 158 are operating land. The total operated area amounts to 173 hectares excluding orchard. It is twice as large as the cultivated area within the *mouza*, suggesting that more than a half of the villagers' fields are located outside the *mouza*. This situation has limited the effects of the land consolidation project implemented in 1977.

Compared with the result of the previous survey in 1967, the number of households is almost doubled from 94 including 77 farms, while the total operated area has been unchanged (Table 6). The percentage of the large-sized farms operating 2.50 hectares or more has decreased from 32 to 10 percent in number, and from 71 to 38 percent in area. To the contrary, the percentage of the upper-middle-sized farms operating 1.00 to 2.49 hectares has increased from 23 to 32 percent in number, and from 17 to 45 percent in area. The percentage of the small-sized farms less than 0.25 hectare has also increased from 16 to 28 percent in number. This structural change is explained mainly by the division of property and household among the large farms, as the comparison of two Lorenz curves of land distribution in 1967 and 1991 does not indicate the augmentation of disparity (Figure 3).

Table 7 shows the utilization of draft animals and farming machines by farm size. In general, small farms, especially less than 0.25 hectare, are less equipped. The number of the farms using tractors is smaller than others because about two-thirds of the farms

Table 6 Distribution of households and operated areas by farm size in Kharda, 1967 and 1991

Farm Size by Operating Area (ha)	Households				Operated Area			
	1967		1991		1967		1991	
	N	(%)	N	(%)	(ha)	(%)	(ha)	(%)
0.01–0.24	12	(16)	45	(28)	0.7	(1)	3.9	(2)
0.25–0.49	10	(13)	24	(15)	4.4	(3)	8.3	(5)
0.50–0.99	12	(16)	23	(15)	13.2	(8)	16.5	(10)
1.00–2.49	18	(23)	50	(32)	30.2	(17)	78.7	(45)
2.50+	25	(32)	16	(10)	124.3	(71)	65.6	(38)
Total	77	(100)	158	(100)	172.8	(100)	173.0	(100)

Note: N means the number of households.

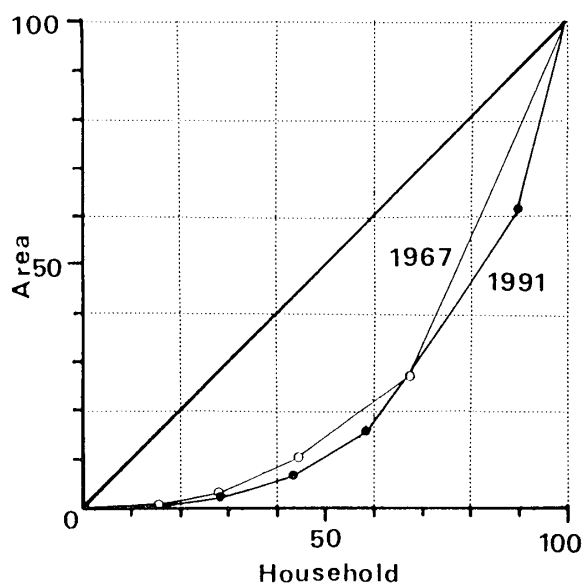


Fig.3 Distribution of operated land in Khardaha in 1967 and 1991.

Table 7 Utilization of farming equipments by farm size in Khardaha, 1991

Farm Size by Operation (ha)	Number of Farms	Draft Animal	Tractor	Thresher	Pump
0.01-0.24	45 (100)	11 (24)	19 (42)	17 (38)	15 (33)
0.25-0.99	47 (100)	38 (80)	17 (36)	36 (77)	34 (72)
1.00-2.49	50 (100)	34 (68)	30 (60)	31 (62)	36 (72)
2.50+	16 (100)	11 (68)	12 (75)	12 (75)	12 (75)
Total	158 (100)	94 (59)	78 (49)	96 (60)	97 (61)

Note: Figures in parentheses are the percentages.

Table 8 Cropped areas of rice and wheat by farm size in Khardaha, 1991

Farm size by Operating Area (ha)	Cropped Area		Mean of Percentages			Cropping Intensity
	Total (ha)	(ha/Farm)	Rice (R)	Wheat (W)	(R) + (W) (%)	
0.01-0.24	6.3 ^a	0.16	34.6	38.7	73.3	163
0.25-0.49	13.2	0.55	33.1	44.5	77.6	162
0.50-0.99	27.9	1.21	28.2	47.1	75.3	168
1.00-2.49	132.7	2.65	29.9	35.7	65.6	168
2.50+	90.1	5.63	28.9	34.4	63.3	144
Total	270.2	1.77	31.1	39.4	70.5	163

a. Excluding 5 farms whose records of cropping are not available

operating 0.25 to 0.99 hectare use draft animals instead of tractors.

Table 8 suggests the difference of cropping patterns between large and small farms in Khardaha. In general, small farms depends a great deal on the cultivation of rice or wheat. Although the percentage of wheat area is greater than that of rice at any class, the ratio of wheat area to rice varies from 1.11 at the class less than 0.25 hectare, to 1.67 at those operating 0.5 to 0.99 hectare. In other words, the farms less than 1.0 hectare depend more on the wheat cultivation than rice. The average of the cropping intensities of the 153 farms is calculated as 163, and there is no significant difference by farm size except for the case of the large-sized farms operating 2.5 hectares or more.

The crop combination at each farm is estimated by the Doi's method, selected from five groups of crops; rice, wheat, legumes, cash crops, and others. According to table 9, about two-thirds of the farms less than 1.00 hectare are specialized in the cultivation such as vegetable growing and double cropping of rice and wheat. On the other hand, a half of the farms operating 1.00 hectare or more cultivate more than three crops including legumes. This suggests that only the large farms can afford diversifying crops to conserve soil fertility although the cropping intensity may be retained.

The difference of cropping patterns by farm size is also represented by the predominant varieties of rice and wheat (Table 10). The large-sized farms operating 2.50 hectares or more allocate much area to *Masuri* rice and *HD or UP* series wheat, while the small farms less than 0.50 hectare prefer to grow *Sarju 52* and *RR-21*. This suggests that the large farms are more interested in improving the productivity of each crop than intensifying multiple cropping. This is because the large-sized farms have enough land to grow various *rabi* crops other than wheat after *Masuri* rice cultivation,

Table 9 Type of crop combination by farm size in Kardaha, 1990

Farm Size by Operating Area (ha)	Total Number of Farms	1 Crop or 2 Crops	3 Crops without Legumes	3 Crops with Legumes	4 Crops or 5 Crops
0.01–0.24	40 (100) ^a	31 (77)	5 (12)	3 (8)	1 (3)
0.25–0.99	47 (100)	34 (72)	11 (24)	-- (--)	2 (4)
1.00–2.49	50 (100)	15 (30)	9 (18)	12 (24)	14 (28)
2.50+	16 (100)	5 (31)	3 (19)	4 (25)	4 (25)
Total	153 (100)	85 (56)	27 (18)	19 (12)	21 (14)

Note: Figures in parentheses are the percentages.

a. Excluding 5 farms whose records of cropping are not available

Table 10 Cropped area by variety and farm size in Khardaha, 1990

Farm Size by Operating Area (ha)	N	Crop Area (ha)	Rice Area			Wheat Area		
			Total (ha)	<i>Masuri</i> (%)	<i>Sarju</i> (%)	Total (ha)	<i>RR-21</i> (%)	<i>HD/UP</i> (%)
0.01–0.99	11	6.2	2.8	26	42	3.4	75	0
1.00–2.49	9	29.9	9.4	31	29	9.4	49	21
2.50+	5	34.0	8.0	51	16	7.8	46	43

Note: Data of 25 sample farms. N gives the number of farms.

and also because they are fully equipped with farming machine which enable to complete operations quickly.

The production costs of rice and wheat is roughly estimated from general information orally obtained from some farmers (Table 11 and 12). The comparison between these two crops characterizes rice cultivation as labor intensive. The labor input or labor cost of rice is more than twice as large as that of wheat. On the other hand, the capital inputs of the two crops are almost at the same level. The percentage of capital costs is smaller in the rice production because rice is expected 1.5 times as profitable as wheat with respect to the gross return as well as the net surplus. The intensity of capital inputs has greater influence on the wheat cultivation than on the rice cultivation.

Considering the percentage of rent and surplus, *batai*, or a share cropping system, seems more favorable for the land owner than owner-operating with employed laborers. The income of land owner is calculated as 42 percent of the rice yield and 35 percent of the wheat yield on the condition that the material cost is equally shared with the tenant side. On the other hand, the income of tenant can hardly cover the labor cost unless the farmer saves the cost of rentals for tractors and pumps, especially in the case of rice cultivation. This explains the less frequent utilization of tractors by the small farms less than 1.0 hectare.

Compare with the share-cropping system, *bauli*, or the fixed lease system, is much favorable for the tenant side because the level of rent is at only less than 20 percent of the total returns of rice and wheat. This system is practiced, at present, only by the landholders who cannot supervise their land.

It is concluded that the development of double cropping has absorbed the local labor force, resulting in the rise of agricultural wages in Khardaha. This has promoted the

Table 11 Production cost of rice per hectare

Cost	Rupees	Description
Materials	2,040 (16%)	seed (Rs 470/78 kg), fertilizer (Rs 1,570/urea 250 kg, potash 100 kg, DAP 180 kg)
Rentals & Charges	2,360 (19%)	tractor (Rs1,180/3 times), canal (Rs 160), pump (Rs 390/twice), thresher (Rs 630/5%)
Labor	4,400 (35%)	nursery (Rs 320/16 man-days), transplant (Rs 1,560/78 man-days), crop care (Rs 1,260/63 man-days for weeding & fertilization), harvest (Rs1,260/10% for 63 man-days)
Total	8,800 (70%)	
Yield	12,560 (100%)	3,140 kg in paddy @Rs4 excluding by-product
Balance	3,760 (30%)	rent and surplus

Table 12 Production cost of wheat per hectare

Cost	Rupees	Description
Materials	2,490 (31%)	seed (Rs 630/157 kg), fertilizer (Rs 1,860/urea 310 kg, potash 120 kg, DAP 200 kg)
Rentals & Charges	2,180 (27%)	tractor (Rs 1,180/3 times), pump (Rs 590/3 times), thresher (Rs 410/5 %)
Laobr	1,200 (15%)	sowing & crop care (Rs 400/20 man-days) harvest (Rs8 00/10 % for 31 man-days)
Total	5,870 (73%)	
Yield	8,070 (100%)	2,690 kg @Rs3 excluding by-product
Balance	2,200 (27%)	rent and surplus

change of the farming system of the large land holders from share-cropping to owner-operating, which has probably encouraged the division of farms. In the case of small holders, they tend to adopt the capital saving techniques to maintain the level of wages and to maximize their labor income. This also explains their preference of wheat cultivation to which capital saving techniques are effective.