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ARTICLES

Irrigation Difference and Productivity Variations in Paddy Cultivation: Field Evidences from Udalguri District of Assam

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ABSTRACT

Using field survey data, the paper examines the seasonal variation of irrigation facilities for cultivation of paddy with special emphasis on summer paddy in Assam. Paddy is cultivated in three seasons: autumn, winter and summer. In terms of acreage and production, winter rice has traditionally been the most dominant. However, the acreage shares of winter and autumn rice in total rice area have been declining continuously over the years. On the contrary, the importance of summer rice has been increasing in terms of acreage share and yield mainly since the last few decades. This trend has opened up a debate whether the summer season, being a flood free season, can be made an important cropping season. Many farmers have adopted the risk aversion strategy of not using costly inputs like fertilisers, pesticides, improved seeds, etc. during *kharif* season for the fear that excess rainwater and floods would wash away. Field reports show that the availability/arrival of short duration new paddy varieties has enabled the farmers to adjust crop seasons and cultivate paddy in the three seasons of the year. While summer is a new emerging season for paddy cultivation, farmers face problems of scarcity of irrigation water due to scanty rainfall. Only those farmers were found cultivating summer paddy, whose plots had access to naturally flowing water ways and who can afford artificial means of irrigation through borewells and pumpsets. Therefore, the future plans on the development of irrigation potentials should give emphasis on the development of groundwater based on installation of shallow tubewells and borewells, construction of small dams on the naturally flowing water ways, harvesting of rainwater during rainy season and also on controlling of floods for water management.

Keywords: Agriculture, Cropping pattern, Groundwater, Irrigation, Summer rice.

JEL: Q100, Q150, C420

I

INTRODUCTION

Availability of irrigation facilities, whatever may be the source, still depends on seasonal rainfall in many states of India. If rainfall is plenty, rivers and waterways tend to be full and canal irrigation flows may be adequate. Likewise, groundwater is recharged if rainfall is heavy and continuous. Many farmers in India still depend on rainfall directly for crop cultivation. Instances of irrigation facilities being damaged due to excess rainfall are also not rare. Consequently, irrigation water varies across seasons even within one agricultural year, which again influences the cultivation practices of paddy and other crops. Situated in the north-eastern part of India, Assam

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is one of the states where seasonal rainfall influences irrigation water to a great extent.

The broad objective of this paper is to examine, using field survey data, the seasonal variation of irrigation facilities for cultivation of paddy with special emphasis on summer paddy in Assam. Specifically, the present paper addresses the following issues: (i) how the irrigation facilities mainly for paddy cultivation vary over three seasons of the agricultural year?, (ii) what are the possible impact of this seasonality of irrigation on the adoption/cultivation of paddy, both high-yielding varieties (HYV) and traditional varieties (TV), and their yields?, (iii) how are farmers managing irrigation for summer paddy cultivation? and (iv) what are the issues or strategies to be addressed for paddy cultivation mainly in summer?

The rest of the paper has been structured as follows: Section II provides a brief discussion on the irrigation conditions and paddy cultivation in Assam. Section III presents the profile of sample locations. Section IV describes field survey results. Section V is on the excess water during *kharif* season and consequent paddy variety choice. Section VI outlines the conclusions and policy implications.

II

IRRIGATION AND PADDY CULTIVATION IN ASSAM

As an agricultural state, Assam exhibits quite different agro-climatic conditions, particularly in terms of water resources, compared to other parts of India. The sources of water in Assam are many, such as two mighty river systems (viz., the Brahmaputra and Barak along with their tributaries and streams), rich underground water aquifer, various ponds and lakes. The heavy rainfall further adds to the vastness of water resource. Unfortunately, only a small fraction of the vast inland water resources has been utilised for gainful economic activity (Saikia, 1999; Basu, 1979; Goswami, 1993). Despite abundant water resources, the ratio of gross irrigated area (GIA) to gross cropped area (GCA) was only 12 per cent per year on an average during 1980-81 to 2004-05, compared to 36 per cent at the all India level, 93 per cent in Punjab, 40 per cent in Andhra Pradesh and 29 per cent in West Bengal during the same period (Goyari, 2008a). Hence, Assam exhibits the paradox of water scarcity inspite of water abundance (Goyari, 2008b). Although Assam receives heavy annual rainfall, the seasonal rainfall is the heaviest during *kharif* season, i.e., June-September period (see Figure 1). The rest of the agricultural year is relatively a dry period. Every year, during *kharif* season, Assam receives heavy south-west monsoon rainfall and due to excess water, floods occur. Frequent floods in the forms of excess water and soil erosion cause enormous damages to various sectors; the greatest single casualty being the agricultural sector, the mainstay of the state economy. Within agriculture, rice crop is the worst hit by floods (Goyari, 2005).

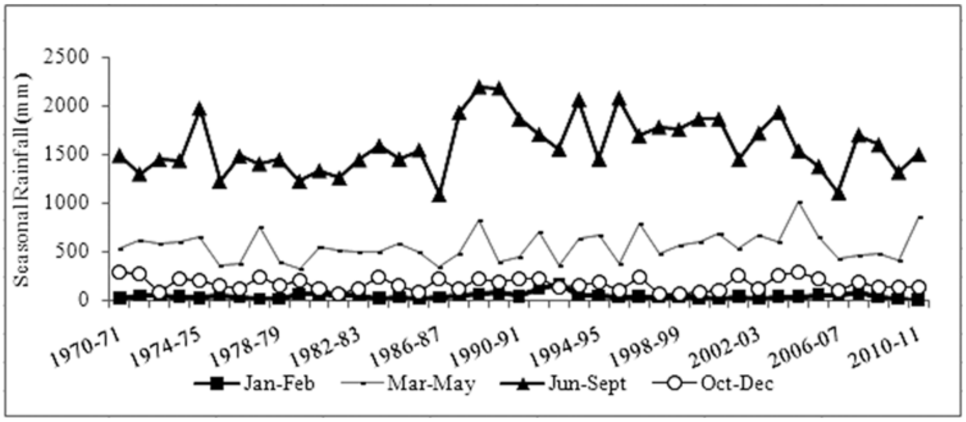

Figure 1: Actual Seasonal Rainfall in Rainfall zone "Assam and Meghalaya" during 1970-71 to 2010-11.

Source: Data are from 'Weekly Weather Reports' of Indian Meteorological Department, New Delhi, and collected from *Fertiliser Statistics* (various issues) and www.indiastat.com.

The farmers in Assam cultivate paddy in three seasons in an agricultural year: autumn, winter and summer, locally known as *ashu*, *sali* and *boro* seasons respectively.[1] In terms of acreage and production, winter rice has traditionally been the most important of the three categories. However, the acreage shares of winter and autumn rice in total rice area have been continuously declining over the years (Goyari, 2008a). On the contrary, the importance of summer rice in the total area under rice has been increasing continuously. Thus, summer season, being a flood free season, is emerging as one of the important crop seasons for paddy cultivators in the state. Several factors are responsible behind such a changing seasonal cropping pattern, irrigation being one of them. One reason for declining acreage share of winter paddy is the adoption of risk aversion strategy by many farmers of not using costly inputs like fertilisers, pesticides, HYV of seeds, etc. during *kharif* season for the fear that excess rainwater and floods would wash away. However, summer being a flood free season, many farmers like cultivating paddy during this season. But irrigation condition decides the cultivation of summer paddy. For all these reasons, a careful study on the irrigation situations in Assam assumes special importance.

It goes without saying that abundance of water either at the surface or ground level is necessary for creating irrigation facilities. As cited by Goyari (2008b), many studies (e.g., Rao and Deshpande, 1986; George and Chaukidar, 1972; Coupal and Wilson, 1990; Arabiyat *et al*., 2001) observe the water scarcity as one important reason behind slow/low adoption of modern seed varieties and hence, slow/low growth of agricultural production and productivity. Accordingly, suitable water-conserving technologies were suggested. However, as stated above, the situations in Assam are quite peculiar. In general, farmers in this state face two distinct situations:

(i) excess water from natural sources like rain and streams specially during wet *kharif* season and (ii) less water or almost zero rainwater during dry summer or *rabi* season within the same agricultural year. Thus, irrigation facilities vary from season to season. While many studies (e.g., Narayanan and Kamath, 2012; Singh, 2011; Gulati *et al.*, 2009; Agnihotri, 2004; Pereira, 2004; Shah, 2003; Parthasarathy, 2000) have examined the problems of irrigation in water scarce regions, relatively few have studied the seasonality of irrigation and agricultural development in a region, where there is excess water from natural sources like rain and streams or rivers like in Assam. The present study is an attempt in this direction.

III

LOCATION OF FIELD SURVEYS

Primary data were collected through field surveys at farm household level in seven villages spread in two distinct locations of Udalguri district in Assam. The total sample included 300 farm households, the distributions of which across sample villages and regions are shown in Table 1. Udalguri town is about 160 kms towards the northern side of Guwahati, the biggest city in the north-eastern region of India. The two sample regions were selected on the basis of differential conditions in irrigation facility and soil quality. The first region, basically is having clayey-sandy type of soil (locally known as *hasrao ha or bala sahia ha*, the clayey proportion being larger than that of sand). This region (Region 1) is better irrigated in the sense that it gets water more from naturally flowing sources. This region covers four villages closely lined up with each other and located towards the north-eastern side of Udalguri town. The second region, having more alluvial or loamy or muddy and sticky type of soils, (locally known as *hama ha*) depends more on rainwater for

TABLE 1. NUMBER OF HOUSEHOLDS AND HYV PADDY SEED ADOPTERS IN SAMPLE VILLAGES

Villages (1)	No. of Households (2)	No. of farmers cultivating paddy: Total paddy (3)	No. of farmers cultivating paddy: HYV (4)	No. of farmers cultivating paddy: Traditional (5)	Per cent of farmers cultivating paddy: HYV (6)	Per cent of farmers cultivating paddy: Traditional (7)	Total paddy area (hectares) (8)
Region 1							
Ahomakha	19	14	14	9	100.0	64.3	37
Komabari	45	28	28	16	100.0	57.1	84
Bwigriguri	46	28	28	14	100.0	50.0	87
Bandorguri	48	24	23	10	95.8	41.7	93
Sub-total 1	158	94	93	49	98.9	52.1	300
Region 2							
Dhalkata	42	28	28	6	100.0	21.4	68
Hokradoba	55	36	35	16	97.2	44.4	83
Kuptimari	45	31	31	7	100.0	22.6	63
Sub-total 2	142	95	94	29	98.9	30.5	214
Total	300	189	187	78	98.9	41.3	515

Source: Author's field surveys.
Note: Some farmers are cultivating both varieties of paddy and hence total percentages are not exactly 100.

cultivation. This region (Region 2) is less irrigated in the sense that it has less naturally flowing water ways and depends more on rainwater. The water retention capacity of *hama ha* in this region is high. Surveys were conducted in two phases using a systematic questionnaire schedule. The first survey conducted during December-2004 to June-2005 covered data on crops of *sali* and *boro* seasons. Data on *ashu* season were collected in the second survey, during September-October 2005. The data for the three seasons formed one complete cycle of agricultural year.

IV

FIELD RESULTS AND DISCUSSION

4.1 *Profiles of Sample Farmers, Land and Cropping Pattern*

The study region as a whole is agrarian in nature, nearly 91 per cent of the total workers being agricultural workers. The occupational diversification is very limited. The whole sample had 130 per cent of cropping intensity. Almost all non-rice crops are cultivated only once during one cycle of the agricultural year. So the extent of overall cropping intensity is totally dependent on rice acreage. The ownership-land holdings in the study villages were dominated by marginal farmers (owning below 1 hectare) in terms of number of holders. However, in terms of land shares, small farmers (between 1 and 3 ha) dominated other holders. In the case of the number of land operators, the marginal farmers with 42.7 per cent of households topped and small farmers dominated in terms of operated land area (with 42 per cent of operational land) among the four farm-size groups found in the combined sample. The average size of ownership and operational land holding per household were 1.46 and 1.53 hectares respectively for the combined sample. The latter figure was higher than the average figure for Assam (1.20 ha) and India (1.32 ha) in 2000-01.

Table 2 shows the season-wise crops, areas and proportions of crop areas in the sample regions. About 65 per cent of gross cropped area (GCA) in the combined sample was allocated for *kharif* (winter) season crops. The main *kharif* crop in the sample is *sali* rice. Maximum number of crops is cultivated during *rabi* (summer) season. But, land allocation in *rabi* season is the lowest (5 per cent) among the three seasons. Majority of the *rabi* crops are vegetables like cabbage, cauliflower, arhar, grams, potato etc. The perennial crops together occupy about 8 per cent of GCA. Both sample regions allocated almost similar seasonal proportions of cropped areas in spite of differences in irrigation conditions and soil quality. Cropping patterns in both sample regions are dominated by rice. The total area under rice in the sample Region 1 was 300.5 hectares, which accounted for 87 per cent of GCA. This acreage share of rice in this region is much higher than the figure of 66.19 per cent of GCA observed for Assam as a whole during the quinquennium period 2000-01 to 2004-05.

TABLE 2. SEASON-WISE CROPS AND CULTIVATED AREAS IN SAMPLE REGIONS

		Total area in hectares			As per cent to GCA		
Season	Seasonal crops	Region 1	Region 2	Total	Region 1	Region 2	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Autumn	Autumn rice, chilly, jute, ladies finger, maize, fruits and autumn vegetables	76.5	55.1	131.6	22.14	22.09	22.12
Winter	Winter rice and vegetables	224.0	160.0	384.1	64.82	64.21	64.56
Summer (including *rabi* crops)	Arhar, black gram, cabbage and cauliflower, carrot, chilly, coriander, garlic, onion, ginger, groundnut, pea, potato, pumpkin, radish, rapeseed and mustard, linseed, sesamum, tomato, turmeric, wheat, leafy vegetables and summer rice	14.8	16.3	31.1	4.28	6.54	5.23
	Perennial crops (betelnut, bamboo, fruit crops, etc.)	30.3	17.9	48.1	8.76	7.17	8.09
	GCA (in ha.)	345.6	249.3	594.9	100	100	100

Source: Author's field surveys.

4.2 *Paddy Cultivation*

Out of the total sample of 300 households, only 189 were paddy cultivators. Of the total paddy area, 88.4 per cent was allocated to HYV paddy cultivation. Only HYV paddy was cultivated during summer (Table 3). In the sample region, almost all paddy farmers are cultivating HYV seeds in the whole sample. Only two farmers

TABLE 3. SEASON AND VARIETY-WISE PADDY AREA SOWN BY SAMPLE FARMERS

	Region 1		Region 2		Total	
Crop/Variety	Area in hectares	Per cent to total paddy area	Area in hectares	Per cent to total paddy area	Area in hectares	Per cent to total paddy area
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Winter paddy	223.2	100	158.7	100	381.9	100
HYV	190.1	85	147.9	93	338.0	89
Traditional	33.1	15	10.8	7	43.8	11
Autumn paddy	72.6	100	49.8	100	122.4	100
HYV	59.6	82	46.8	94	106.4	87
Traditional	13.0	18	3.0	6	16.0	13
Summer paddy	4.7	100	5.6	100	10.3	100
HYV	4.7	100	5.6	100	10.3	100
Traditional	Nil	Nil	Nil	Nil	Nil	Nil

Source: Author's field surveys.

were found cultivating traditional varieties (TV) of paddy. However, in each sample village, many farmers (40 per cent) were found cultivating TV of paddy along with the modern varieties. Of the total paddy output in the combined sample during the survey period, about 91 per cent was contributed by HYV paddy. The adoption of HYV paddy seeds in Assam started picking up only in the middle of 1970s, compared to its first arrival during 1960s in the Indian agricultural fields. However, the information provided by sample farmers shows that adoption of HYV paddy seeds by farmers in the sample locations started only in the early 1990s, about three decades after these new varieties had appeared on the Indian agricultural scene.

It was observed that majority of the sample farmers were found adopting new paddy seeds because of the advantages of HYV seeds like shorter maturity duration, higher yield, higher net return, all-season-cultivable nature etc. compared to TV paddy seeds. A new variety can be harvested after a minimum of 100 days of planting. However, a TV paddy, on an average, requires about minimum 160 days to become ready for harvesting, taking about two months more than a new variety. Even the longest duration new variety like, aijong or ranjit, matures about one month earlier than the shortest duration TV paddy like ashu gwoja or kaowajuri. One notable feature of TV of paddy seeds reported by the sample farmers, is that they are ‘season-specific’, compared to ‘all-season cultivable’ character of HYV seeds. TV of paddy like haldharam, tiamikri, maisali maima, etc. cultivated during sali season are not suitable for ashu season. This is one of the reasons for which the sample farmers prefer more of new varieties than TV. Any new variety like mahsuri can be cultivated in any season of the year.

4.3 *Irrigation Water Sources for Cultivation: All Crops*

The sources of water for crop cultivation in both the sample regions can be broadly classified into three: (i) rainwater, (ii) the natural flow of river, streams, springs and water of small lakes and low-lying areas and (iii) groundwater. Thus, both the sample regions do not have any systematic irrigation system. Canal irrigation is nil. Table 4 shows the source wise irrigated areas under all crops in the sample

TABLE 4. SOURCE-WISE IRRIGATED AREAS IN SAMPLE REGIONS (ALL CROPS)

	Region 1		Region 2		Total	
Sources	Area	Per cent	Area	Per cent	Area	Per cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rainfed	47	13.6	165	66.4	212	35.7
Dams	298	86.2	19	7.6	317	53.3
Dugwells	1	0.1	1	0.4	1	0.2
Pumpsets	-	-	45	18.2	45	7.6
Borewells	-	-	18	7.4	18	3.1
Total or GCA	346	100.0	249	100.0	595	100.0

Source: Author's field surveys.

Notes: Source-wise classification as per the main source of water for cultivation, area in hectare and data are for all crops: perennial, annual and seasonal crops.

regions. In the combined sample, the largest crop area (about 53 per cent) is served by small dams lifted water. The farmers depend on rainwater for as high as 36 per cent of the crop areas. Borewells and pumpsets irrigation water constitute 11 per cent of the total irrigated crop area.

Groundwater is harnessed through privately owned shallow tubewells, dugwells, borewells and pumpsets. Field surveys revealed that the groundwater level is high in both sample regions compared to some other parts of Assam and the rest of the country.[2] Due to less naturally flowing water ways, the groundwater level is deeper in the Region 2 than in the Region 1 (by about 2 to 3 metres). Generally, for dugwell, it is easy to get groundwater by digging 2 to 4 meters deeper. For borewell and tubewell operations, it is necessary to put water pipe 10 to 13 meters inside the ground. But, for effective discharge of water, some farmers, who are using borewells, put water pipes to even 30 meters inside the ground. River or stream water is harnessed by means of community or collectively-owned lift irrigation system. Water is lifted usually by constructing small dams on naturally flowing water ways. Under this system, water is diverted to cultivation fields through narrow canals or distributor channels. The bounds of canals are made up of soils and, therefore, not pucca. Since water channels may be long, head reach (near dam) farmers get more water than tail end (far from dam) farmers. Water can be lifted to the fields both during the *kharif* and *rabi* seasons depending on the availability of water flow. The waterways can have continuous water flow mostly if there is rainfall. But, whenever there is heavy rainfall during *kharif* season, there may be excess water in the area.\

The use of shallow tubewells, borewells and pumpsets or other artificial irrigation methods are also not economical in the sample Region 1 because of more sandy soil. Water can stay on the surface only about two or three hours. Some plots can retain water for about one day. So, watering should be done repeatedly, especially for rice cultivation. However, the sample Region 2 has soil types most of which are sticky, muddy and yellowish. These soils are naturally more fertile than those in region 1. These sticky soils have a high water retention capacity. Since Region 2 has less streams or naturally flowing water ways, many land plots are rainfed. Once irrigated, water stays for three to four days, in some plots up to ten days. So, people are using borewells and pumpsets for irrigation purposes. They are drawing water either from the nearby low lying areas or from underground through borewells. If there is rainfall, the farmers have to use less irrigation from artificial methods.

4.4 *Irrigation Water for Paddy*

Paddy is the dominant crop in both the sample regions. For paddy cultivation, farmers in Region 1 get water only from rain and small dams. The artificial means of irrigation through borewells and pumpsets are in use only among farmers in Region 2. Data in Table 5 show some interesting features about paddy cultivation under different irrigation sources. First, water from small dams provided the highest portion of water needs in paddy cultivation in the whole sample. It accounts for 56 per cent of HYV paddy and 78 per cent of TV paddy. Second, artificial irrigation by borewells and pumpsets provided water to 14 per cent of HYV paddy areas. Compared to this figure, the sample farmers used very small portion of borewells and pumpsets irrigation (less than 2 per cent) in the cultivation of TV paddy. Third, as high as 29 per cent of the total area under paddy cultivation in the total sample region is still fully rainfed. Variety-wise, HYV paddy was cultivated more under rainfed condition than TV paddy, both in terms of absolute area and relative share. Fourth, region-wise, farmers in Region 2 are highly dependent on rainfall for paddy cultivation (in 61 per cent of paddy area) than their counterparts in Region 1. In Region 1, 93 per cent of HYV paddy area was irrigated, all of it through small dams and 7 per cent area was completely rainfed during the survey period. It must be mentioned that most waterways in the sample regions get continuous water flows if there is rainfall. Thus, small dams irrigation also depends on rainfall.

TABLE 5. SEASON-WISE NET IRRIGATED AREAS UNDER HYV AND TRADITIONAL PADDY IN SAMPLE REGIONS

Seasonal rice	Region 1 Source wise irrigated areas			Region 2 Source wise irrigated areas				Total Source wise irrigated areas			
	Rainfed	Dams	Total	Rainfed	Dams	B & P	Total	Rainfed	Dams	B & P	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sali HYV	10.4	179.7	190.1	108.1	17.1	22.8	147.9	118.5	196.7	22.8	338.0
Ashu HYV	7.3	52.3	59.6	11.4	0.7	34.7	46.8	18.7	53.0	34.7	106.4
Summer HYV	-	4.7	4.7	-	-	5.6	5.6	-	4.7	5.6	10.3
Total HYV	17.7	236.7	254.4	119.5	17.7	63.1	200.3	137.3	254.4	63.1	454.8
Per cent to total HYV	7.0	93.0	100	59.7	8.9	31.5	100	30.2	55.9	13.9	100
Sali Trad	0.7	32.4	33.1	8.5	1.3	1.0	10.8	9.2	33.7	1.0	43.8
Ashu Trad	-	13.0	13.0	3.0	0.01	-	3.0	3.0	13.0	-	16.0
Summer Trad	-	-	-	-	-	-	-	-	-	-	-
Total Trad	0.7	45.4	46.1	11.5	1.3	1.0	13.8	12.2	46.7	1.0	59.8
Per cent to total Trad	1.5	98.5	100	83.5	9.2	7.3	100	20.4	78.0	1.7	100
Total paddy	18	282	300	131	19	64	214	149	301	64	515
Per cent to total	6.1	93.9	100	61.2	8.9	29.9	100	29.0	58.5	12.4	100

Source: Author's field surveys.
Notes: Classification as per the main source of water for cultivation, B & P is borewells and pumpsets, area in hectare.

4.5 *Season-wise Irrigation*

Season-wise and variety-wise irrigated areas under both varieties of paddy, HYV and TV, are also shown in Table 5. Rainwater was not available for summer rice during the survey period. The proportion of both varieties of paddy areas getting water from small dams was higher during sali season than during ashu season in Region 1. Compared to this, the proportion of both varieties of paddy areas under rainfed condition was more during sali season than during ashu season in Region 2. Season-wise, farmers in Region 2 had to depend only on borewells and pumpsets to irrigate paddy lands in summer. Farmers in Region 2 got the largest proportion of irrigation water from rain during sali season for both HYV and TV. However, irrigation by borewells and pumpsets provided the largest share of irrigation water (74.1 per cent) to farmers in Region 2 during ashu season for the cultivation of HYV paddy followed by rainwater.

Thus, as we move from sali to ashu and summer seasons, the proportion of the use of irrigation water from borewells and pumpsets went up among HYV paddy farmers in Region 2 (i.e., from about 15 per cent in sali to 74 per cent in ashu and cent per cent in summer season). On the contrary, the proportion of the rainfed irrigation among paddy farmers increased as we move from summer to ashu and sali seasons in both sample regions. In terms of area allocation, sali season is still the dominant season for paddy growers among three seasons due to available rainwater.

Comparing the seasonal adoption patterns of HYV data with the irrigation data, it can be seen that the presence of systematic irrigation is not a crucial input for the adoption and cultivation of new varieties of paddy in the sample regions. The sample farmers were cultivating modern varieties of paddy even under rainfed condition in about one-third of the paddy area. Systematic canal irrigation facilities are yet not available in the sample regions. But, as we shall see in the next section, the yields of paddy cultivated under unsystematic irrigated conditions of sample regions are lower than yields obtained under systematic irrigated conditions elsewhere in the state and other parts of the country.

4.6 *Overall Yield of Paddy: Across Seasons*

With 2821 kg/ha, the overall yield in the summer rice was the highest among three varieties of rice in the combined sample (see Table 6). On the contrary, the yield per hectare of autumn rice was the lowest in the combined sample during our

TABLE 6. YIELD OF PADDY PER HECTARE IN SAMPLE REGIONS

	Paddy yield in kg per hectare			
	Autumn	Winter	Summer	Average
(1)	(2)	(3)	(4)	(5)
Region 1	1991	2230	2049	2169
Region 2	3135	2923	3465	2987
Total sample	2456	2518	2821	2509
HYV	2555	2604	2821	2597
Trad	1799	1870	-	1851
Yield gap	756	735	-	746
No. of plots ($n_1 + n_2$)	160	520	13	693
d.f.	158	518	-	691
t-statistic	5.115*	8.239*	-	9.455*

Source: Author's calculations from field survey data.

Notes: (i) Yield gap is calculated as absolute yield of HYV minus that of traditional variety. (ii) t-statistic is for testing difference of mean yield between HYV and traditional. Paddy assuming equal variances (*Significant at 5 per cent level).

survey period.[3] The overall paddy yield in the combined sample during our survey period 2004-05 was 2509 kg/ha, which was higher than 1467 kg/ha observed for Assam as a whole in 2005-06. In HYV category also, yield was the highest in summer paddy.

Although the yield of summer paddy was the highest, the area allocations and number of plots were the lowest among all the three seasons because many farmers are not cultivating summer paddy due to scarcity of irrigation water. Only two categories of sample farmers were cultivating summer rice – (i) farmers whose land plots have access to naturally flowing water and (ii) farmers who are having (or who can afford) artificial means of irrigation through borewells and pumpsets. Moreover, only HYV paddy was cultivated during summer.

4.7 *Yield of HYV Paddy with Chemical Fertilisers*

Yield differences were observed within the new varieties between use and non-use of chemical fertilisers (Table 7). The HYV paddy yield was 2792 kg/ha when chemical fertiliser was applied, compared to 2433 kg/ha without using that input. Between regions, the fertiliser effect on yield was observed to be substantial in HYV paddy yield in Region 2. The fertiliser effect on paddy yield in region 1 seems to be very marginal as the yield difference with fertiliser and without fertiliser was not substantial and is not statistically significant. The reasons are as follows. The intensity of overall use of chemical fertilisers was much higher in Region 2 than in Region 1. Most of the rice farmers in Region 1 were using this input in rice seed-beds only to grow rice seedlings quickly. This might be the reason behind less yield difference in Region 1.

TABLE 7. YIELD OF HYV PADDY UNDER CHEMICAL FERTILISERS IN SAMPLE REGIONS

(kg/ha)

	Chemical fertilisers		Yield difference		
	Applied	Not applied	(kg/ha)	Per cent to not applied	t-statistic (d.f.)
(1)	(2)	(2)	(3)	(4)	(5)
Region 1	2242	2217	25	1.1	1.481 (315)
Region 2	3313	3015	298	9.9	3.624* (259)
Average	2792	2433	359	14.7	8.005* (574)

Source: Author's calculations from field survey data.

Notes: (i) Yield difference is the yield with chemical fertilisers minus without chemical fertilisers. (ii) t-statistic is for testing yield difference between fertiliser applied and not applied, under the assumption of equal variances, for plot wise data (* Significant at 5 per cent level).

4.8 *Yield of Paddy under Different Irrigation Conditions*

Yields of paddy, for both varieties, in the sample were observed to vary by irrigation conditions (Table 8). The yields of both varieties of paddy were observed to be the highest under irrigation condition of borewells and pumpsets, i.e., 3305 kg/ha for HYV and 2112 kg/ha for TV paddy.[4] However, the yield of HYV paddy was significantly higher than the yield of TV paddy in all three irrigation conditions. The yield of total paddy under rainfed condition (2218 kg/ha) was the lowest among three irrigation conditions. The yield of total paddy under small dams irrigation was lower than the yield under borewells and pumpsets by 488 kg/ha but higher by 580 kg/ha under rainfed condition. This is expected as the water from equipments like borewells and pumpsets is under better human control than the other two conditions. Rainwater depends totally on the vagaries of nature and hence the yield per unit of land can be low.

TABLE 8. YIELD OF PADDY UNDER THREE IRRIGATION CONDITIONS IN TOTAL SAMPLE

(kg/ha)

Irrigation sources (1)	HYV paddy (2)	Trad paddy (3)	Yield difference (4)	Total paddy (5)
Rainfed	2284	1804	480	2218
Dams	2892	1863	1028	2798
Borewells and pumpsets	3305	2112	1193	3286

Source: Field survey data.
Notes: Yield difference is the yield of HYV minus traditional paddy.

4.9 *'HYV Seeds-Fertilisers-Irrigation' Combinations*

Studies on the combined input-use technology, like the adoption of HYV paddy seeds along with the application of chemical fertilisers and use of systematic irrigation water, have been attracting the attention of many scholars, more particularly since 1960s when green revolution technology made its appearance in India.[5] Many new varieties of paddy seeds are able to give higher yields than the traditional varieties, especially if the supply of soil nutrients can be increased. So, soils are to be supplied with additional nutrients through application of chemical fertilisers to get better results from HYV seeds. Since chemical fertilisers contain nutrients in concentrated form, they, in turn, have to be applied with adequate supply of water to enable plants to absorb the nutrients without causing damage to them. The use of chemical fertilisers with HYV seeds, thus, necessitates the use of controlled supply of water. Full utilisation of the potentialities of the new technology requires adequate application of the complementary inputs of fertilisers and irrigation with the HYV seeds (Bezbaruah, 1994, p.17).

Substantial yield differences of HYV paddy were observed under different irrigation and fertiliser use conditions in the study areas (Table 9). As already discussed above, yields of HYV paddy with chemical fertilisers were significantly higher than those without chemical fertilisers. Similarly, taken individually, paddy yields under controlled irrigation conditions, say, borewells and pumpsets, were much higher than those under natural water conditions like rainfall. In addition to this finding, data in Table 9 also reveal some interesting results. The yield of HYV paddy under borewells and pumpsets irrigation with chemical fertiliser (3347 kg/ha) was significantly higher than the yield (2955 kg/ha) when it was not applied. Similar trends were also observed in the case of yields of paddy under rainfed and dam water conditions. However, the yield difference (between chemical fertiliser applied and not applied) under borewells and pumpsets was much higher than those under rainfed and dam water conditions. The absolute yield difference was 392 kg/ha under borewells and pumpsets. Compared to this quantity, the yield difference with and without chemical fertilisers was about 213 kg/ha under dam water condition. The yield difference of HYV paddy was only 79 kg/ha under rainfed condition. So, as we move from rainfed to dam water condition and controlled water by borewells and pumpsets, HYV paddy yield increased significantly with the application of fertilisers.

TABLE 9. HYV PADDY YIELD WITH FERTILISER IN THREE IRRIGATION CONDITIONS

(kg/ha)

Irrigation sources	Yield with chemical fertilisers		Yield difference		t-statistic (d.f.)
	Applied	Not applied	(Kg/ha)	Per cent to not applied	
(1)	(2)	(3)	(4)	(4)	(5)
Rainfed	2339	2260	79	3.5	1.994* (179)
Dams	2940	2727	213	7.8	1.953* (324)
Borewell and pumpset	3347	2955	392	13.3	3.875* (71)

Source: Field survey data.

Notes: (i) Yield difference is the yield with chemical fertilisers minus without chemical fertilisers. (ii) t-statistic is for testing difference in yield between fertiliser applied and not applied, under the assumption of equal variances, for plot wise data (*Significant at 5 per cent level).

The above results indicate that new varieties of paddy can be cultivated without fertilisers (as many sample farmers were doing), but yields can be enhanced by applying this input. Secondly, new varieties of paddy can be cultivated without any assured irrigation facilities. But, yields can be much higher under controlled irrigation condition. The farmers are willing to use artificial means of irrigation but due to high cost, every farmer cannot use it.

Borewells and pumpsets irrigation has not yet been used by the sample farmers in Region 1. So, irrigation cost was found to be zero in that region. In Region 2, irrigation cost was Rs. 127/ha in HYV paddy and Rs. 34/ha in TV paddy. The total irrigation cost accounted for about 4 per cent of the total cultivation cost of paddy in that region (Table 10). The farmers need not pay any out-of-pocket expenses for utilising small dam water since it is managed by private individuals or/and village communities themselves. Whatever costs they incur are in the form of constructing small dams and maintenance of distributor channels. It forms only very negligible part of the total cultivation cost.

V

EXCESS RAINWATER DURING *KHARIF* SEASON AND PADDY VARIETY CHOICE

The common problem in both sample regions is the excess water during *kharif* (June-September) season and less water during the *rabi* season (October-March). The area gets heavy rainfall almost every year. During this period, water ways and the cultivated areas become filled with water, specially whenever there is heavy rainfall.

TABLE 10. COST OF PRODUCTION OF HYV AND TRADITIONAL PADDY IN SAMPLE REGIONS

(Rs./ha)

SL. No.	Cost Items	Region 1			Region 2			Total sample		
		HYV	Trad	Total	HYV	Trad	Total	HYV	Trad	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1.	Seed	931.6	789.9	908.7	916.8	777.8	908.0	925.0	787.3	908.4
2.	Chemical fertiliser	9.0	6.0	8.5	142.0	32.0	135.0	67.9	11.7	61.1
3.	Pesticide	7.1	2.5	3.2	14.2	12.8	12.9	8.6	7.1	7.2
4.	Irrigation	-	-	-	127.2	33.5	121.3	56.4	7.3	50.5
5.	Ploughing	14.8	7.1	13.6	38.4	3.3	36.2	25.3	6.3	23.0
6.	Planting	673.0	660.4	671.0	563.4	466.2	557.2	624.4	618.0	623.7
7.	Harvesting	1252.8	1181.0	1241.2	1344.3	817.1	1310.8	1293.4	1101.4	1270.2
8.	Threshing	40.8	34.0	39.7	55.4	11.0	52.6	47.3	29.0	45.1
9.	Land rent (LI+MI)	28.2	-	23.7	200.2	362.4	210.5	104.4	79.3	101.4
10.	Others	8.3	8.3	8.3	5.9	3.7	5.8	7.2	7.3	7.2
	Total cost	2961.0	2689.3	2917.9	3406.4	2521.2	3350.2	3158.4	2656.1	3097.8

Source: Author's calculations from field survey data.

Notes: Item No. 4, irrigation costs refer to costs involved in pumpset and borewell operations.
Item No. 5 to 8, costs are of only hired labour/machine services, own labour charges not included.
Item No.5, costs are of hired ploughing service by bullocks and tractor/ power tiller.
Item No.7, cost of hired labour services for uprooting rice seedlings are also included.
Item No.9, land rental costs are for those who leased in (LI) and mortgaged in (MI) land plots, but rent costs of MI plots in 'repay & take back land' are excluded as operators get back the money.

It is difficult to deal with this excess water problem. For farmers, there is no way to divert this excess water. It is more serious for some farmers whose cultivable plots are in low-lying areas and of cauldron-shaped plots. So, many farmers don't want to use costly chemical fertilisers even if they have resources. Moreover, many new varieties of rice plants are short. These crops stay under water whenever there is heavy rainfall and excess water. Sometimes, if submerged for many days, these crops are damaged. In contrast to excess water during *kharif* season, both regions suffer from less or almost zero rainfall during *rabi* season. So the water ways dry up and the cultivation areas do not get water for cultivation. If irrigation water is available, many farmers are willing to cultivate paddy during summer season.

TV of paddy, like haldharam, are generally taller than HYV. So, in low–lying marshy and excess water prone areas, only traditional varieties are preferred to be cultivated. Moreover, the stems of traditional varieties are stronger than HYV. So, local varieties can stand even if there is an excess water flow as well as heavy ripe fruits. Among all new rice varieties cultivated in the sample areas, mahsuri has been the most popular among sample farmers in all the three seasons, both in terms of the number of adopters as well as area allocation. This variety is taller than many other new rice varieties. The relatively taller mahsuri plants are preferred to dwarf plants of other new varieties during sali season so that they can stand high even during excess rainwater filled flooded paddy fields. Second, this variety suits to almost all types of land- sandy, sandy-muddy, alluvial etc.

The arrival of HYV seeds of paddy, with short duration of maturity and all-season cultivable character, has brought many advantages to the sample farmers. It became convenient to divide their lands between new varieties (shorter duration of 3 to 4 months) and traditional varieties (longer duration of 4 to 6 months) instead of planting only one variety. In this field survey, it was also reported that farmers used to cultivate paddy only in two seasons: *sali* and *ashu,* in an agricultural year. With the arrival of short duration new paddy varieties, summer season has also emerged as one of the crop seasons. It is now possible to cultivate paddy three times in a single plot in one agricultural year. Similar evidence was observed in other eastern states like West Bengal (Rawal and Swaminathan 1998; Saha and Swaminathan 1994). Three major rice seasons in West Bengal are *aus*, *aman* and *boro*. Like in Assam, 'the cultivation of paddy in the summer season is a relatively new phenomenon' (Rawal, 1999, p.93) in West Bengal. Rawal and Swaminathan (1998) state that 'the boro or summer crop was introduced in the 1960s and the area cultivated with boro increased rapidly thereafter'. The arrival of new varieties of seeds also enabled many farmers in North-Western states of India to have rotation of rice and wheat in a single agricultural year (Castillo 1975, Chand and Haque, 1998, Kumar *et al*., 1998, Singh *et al*., 2004). Rice-wheat rotation system is still not possible in many plots in Assam. Many rice growing land plots in the state are not suitable for wheat.

VI

CONCLUDING REMARKS

This paper examined the seasonal variation of irrigation facilities for cultivation of paddy with special emphasis on summer paddy in Assam. The main analysis is carried out using the primary field survey data which were collected from seven villages in Udalguri district of north Assam. The study found that paddy cultivation in summer season is a new emerging phenomenon (though still at a low scale), actually facilitated by new HYV technology combined with irrigation. Moreover, the paddy yield obtained under the combination of "HYV seed-chemical fertiliser-borewells and pumpsets irrigation" package was the highest among all water conditions. These findings have important implications for policy actions with respect to irrigation development and agricultural production. The state does not have adequate irrigation facilities to make the summer season as the main cropping season. All farmers who are willing to cultivate summer paddy are not able to cultivate paddy in their plots. Only those sample farmers were found to be cultivating summer paddy whose land plots have access to naturally flowing water ways and who can afford irrigation by borewells and pumpsets.

The growing importance of summer rice is good for Assam's economy to avoid crop damages by excess rainwater or floods during *kharif* season. Emphasis on summer paddy cultivation demands development of suitable agricultural infrastructural facilities in the state. The first component of infrastructure which requires attention is the development of irrigation facilities. In spite of abundant water sources, canal and other types of systematic irrigation facilities are very low in the state. Even though the irrigation potential created in the state has been increasing over the years, the irrigation potential utilisation has been declining over the years for various reasons, some of them being the flood problems and lack of efficient water management system. Still many farmers depend on rainwater and naturally flowing water ways.

Thus, for widespread summer paddy cultivation, irrigation development policies in the state should give attention to some of the following points. First, in general, Assam is still having vast potential of developing irrigation facilities based on groundwater through installation of shallow tubewells and borewells. Development of more irrigation facilities based on groundwater will really help farmers, especially to cultivate summer paddy on a larger extent. Given the hydrological conditions of Assam, groundwater-based well irrigation systems are both cheap and within the easy reach of an average farmer. Many studies (like ADR 2002, p.163) also emphasised the development of irrigation in the state through the utilisation of the abundant groundwater by installation of shallow tubewells. It is true that large scale development of groundwater-based irrigation systems may lead to new problems like depletion/lowering of water table. Many studies conducted in others parts of India and abroad have revealed this problem. Assam, as a whole, is too early to face such a problem. Added to it, the state, as a whole, generally receives heavy rainfall during *kharif* season, which acts as a replenishment of the natural water resources of the state. Second, because of the presence of available naturally flowing water ways, small streams and rivers, ponds, lakes, etc., Assam has tremendous potential for developing small and medium irrigation systems in the form of surface flow irrigation and lift irrigation through construction of small dams and distributor channels. Due to large initial investment and long gestation period involved, large scale irrigation systems based on big dams and large canals have several limitations. Moreover, due to heavy rainfall and frequent floods every year, the possibility of large scale irrigation systems being destroyed and great loss is obvious. Third, the state receives heavy rainfall during *kharif* season. But, rainwater is wasted due to lack of rainwater harvesting facilities. Therefore, government should make provisions for rainwater storage during wet season, which can be used during dry season. Fourth**,** more emphasis should be given on the fuller utilisation of the already created irrigation facilities rather than creating new and new additional irrigation potentials. Along with the irrigation development, successful summer paddy cultivation also requires available and accessible complementary inputs like short-duration improved seeds, fertilisers, pesticides, credit etc. Since *kharif* paddy is still the dominant season for crop cultivation, complete seasonal shifting in favour of summer rice is not possible. Thus, adoption of short and long-term flood control measures is also very much important.

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NOTES

1. Crops are named by autumn, winter and summer during which these are usually harvested, and not by cultivation period. Autumn (ashu) rice is sown in February-March and harvested in July-August. Winter (sali) rice is cultivated in July-August and harvested in November-December. Summer (boro) rice is generally grown in low-lying marshy lands during dry season from December to May.

2. In an article on tubewell drilling in Punjab, Agnihotri (2004) wrote 'The water level was 12 metres in Jattpur village, Balachaur Block, in 1996. It is 20 metres now. Similarly, the level was 14 metres in Takhatgarh village of the same block in 1992. It is 18 metres at present. Hassanpur village, Derabassi block, has a current static water level of 60 metres. It was 36 metres 10 years ago.' ….He quotes of one driller, 'To ensure good water discharge, we have to dig 300 to 375 metres in Derabassi block. Earlier, 120 metres of drilling used to be sufficient.' Likewise, in Rayalaseema and Telengana regions of Andhra Pradesh, a majority of the wells are of 10 to 20 metres depth in 1999-2000 (Reddy, 2003).

3. In a study in West Bengal, Rawal (1999) also found that the average yield of boro (summer) paddy was the highest among three seasons, i.e., aus (autumn), aman (winter) and boro (summer).

4. The yield (in kg/ha) of total paddy of this sample (3286) under the borewells and pumpsets irrigation condition was higher than that of all Assam average (1468) and some states like Andhra Pradesh (2939), Haryana (3051 for kharif paddy), West Bengal (2509) and even all India (2103) in 2005-06. However, it was lower than that of Punjab (3858 kg/ha for *kharif*) in that year.

5. In a study in Mexico, Burke (1979) came to the conclusion that the 'HYV-fertiliser package' was more profitable and less risky if means of developing assured and regulated water supply were provided. McGuirk and Mundlak (1991) found that adoption of HYV in Punjab was constrained by the availability of water and fertilisers. Saha and Swaminathan (1994) reported that the major contributor to increased production of aus and aman paddy in West Bengal in the 1980s was the growth in yield. They attributed this high yield increases to changes in input uses, including greater use of HYV seeds, and better farming practices.

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