Changing Land Use Pattern and Hybrid Rice production: A way to Improve Food Security in Bangladesh

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Abstract

Attaining self sufficiency in food production is considered as the topmost strategy of the government. For enhancing the level of cereal production, emphasis is given on technological advancement since the possibility of achieving higher production through horizontal expansion of area is indeed impossible. A study was undertaken to assess the possibility of gaining output through disseminating and adopting hybrid rice technology under the changed land use patterns. The study used both primary and secondary data. Applying both descriptive and inferential statistics, the study revealed that cropped acreage had a shrinking trend over the period of 1980/81 to 2006/07. Although cropping intensity at macro level had shown on increasing trend earlier it has been stagnant in the recent years. Area under single cropping decreased over the years resulting in higher cropping intensity. The growth in MV Boro acreage was the highest (10.89%) during 1981 to 1990 and decreased to 1.43% during 1999/07. Growth in total rice production was 3.35% in 1972/80 and it decreased to 2.49% in 2000/07. Growth in boro rice production was highest (8.35%) in 19981/90 and slightly decreased to 6.16% in 2000/2007. Growth in maize production was -10.36% during 1972/80 but it impressively increased to 11.64% during 2000/07. However, there has been deficit in food production and it ranged from 1.6 mmt to 0.60 mmt from 1980/81 to 1999/2000. Bangladesh has become marginally self-sufficient in food production after 1999, but the level of self sufficiency neither appears weighty nor seems sustainable. Area coverage under hybrid was 0.06% of total Boro area in 2001 and it increased to 26.73% in 2008/09.

The farm level overall yield gain from growing hybrid rice in the Boro season of 2006/07 and 2008/09 were 21% and 25%, respectively. The average yield of hybrid variety was much higher (7.75 ton/ha) than that of inbred HYV (6.02 ton/ha). Production of both varieties was profitable but investment in hybrid rice production appeared more profitable.

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1. Introduction

Rice is the dominant dietary item and will remain the staple food in Bangladesh. More than 95% of population consume rice and it alone provides 76% of calorie and 66% of total protein requirement of daily food intake (Bhuiyan *et al*, 2002). In fact, rice is the driving force of agriculture. Present population of the country is 140.60 million (BBS, 2007) and will swell progressively to 223 million by 2030 which will require 48 million tons of food grain (Alam, 2008). About 80 percent of the total arable land is devoted to rice production and it alone occupies 77% of total cropped area (Jufiquar, 2009). The share of rice the total food grain is more than 90% (BBS, 2007). Bangladesh has made remarkable progress in achieving food sufficiency through adoption of modern rice varieties (MVs) in spite of the declining trend of arable land. Rice production in Bangladesh has increased from 9.77 mmt in 19971/72 to 32.93 mmt by 2007/08 (DAE, 2008). In fact, the increase in productivity was made possible due to rapid diffusion of the modern high yielding varieties and expansion of irrigation facility. However, the level of yield of modern varieties has either reached a plateau or it has been declining. On the contrary, the country is adding two million people every year. Therefore, it can be presumed that with the present level of yield, it will be difficult to keep pace with the growing demand for rice in the future. Producing extra rice to feed them remains a formidable challenge. New rice varieties with higher yield potential (almost 7.0/ha) is needed to meet the increasing demand for food until the country achieves a stationary population (Mustafi, 2003). Due to scarcity of arable land, the possibility of horizontal expansion of the cropped area is absolutely impossible. Therefore, strategies must be taken in consideration on how to produce more rice for increasing population in the country. Rapid diffusion of hybrid rice, which promises a yield gain of about 15%-20% over the best-inbred modern varieties, can contribute substantially to maintaining the food-population balance in the country. Under such condition, adoption of hybrid rice technology could be the possible way of enhancing productivity and thus improving food security. It is necessary to evaluate the possible implication of adopting /growing hybrid and inbred modern rice varieties in relation to improving food security status. The present study was therefore, designed to: i) evaluate the level of changes in land utilization pattern in Bangladesh; ii) estimate the growth/trend in area and production of rice and other cereal crops; and iii) examine comparative profitability of inbred and hybrid rice production at the farm level.

2. Methodology

2.1 Data source

The study used both primary and secondary data. Primary data were collected through conducting field level survey. Secondary data were used from different published and unpublished sources. To conduct survey at farm level, Gazipur district was selected purposively where both inbred and hybrid rice are grown in Boro season . Sadar upazila under Gazipur district was selected considering the intensity of Boro rice cultivation. Four villages under sadar upazila were chosen purposively. From each village, 20 farmers (10 hybrid and 10 inbred growers) were selected randomly. In selecting the sample areas and farmers, necessary help was taken from the local agricultural extension agents. The number of sample was 80 (10*4 + 10*4). Structured questionnaire was used in generating the data.

2.2 Analytical technique

2.2.1 Growth estimation

In order to estimate the growth rate of area and production of rice and other crops, the following exponential growth function was employed (Gujarati, 2007).

$Y = \alpha e^{\beta x}$

Where; Y = dependent variable (Area and production of food grain)

x = independent variable/serial time (year)

β = regression coefficient, i.e. growth rate (in ratio scale)

α = intercept.

Taking logarithm in both sides, the above equation was further transformed into log linear as,

$$LnY = Ln\alpha + \beta x \quad [\text{because } Ln\ e = 1]$$

Here, β is the growth rate in ratio scale; it was multiplied by 100, so that it expresses the growth in percentage.

2.2.2 Profitability analysis

Cost and return analysis is the most common method of determining and comparing the profitability of different farm households or technologies. Profit is defined as the difference between the total revenue and total cost. The following conventional profit model was applied to examine farmers' profitability in

producing inbred and hybrid rice.

$$\Pi = P_1Q_1 + P_2Q_2 - \Sigma P_iX_i - TFC$$

Where

Π= Profit per season

P_1= Per unit price of paddy

Q_1= Quantity of output

P_2=Per unit price of by-product

Q_2 = Quantity of by-product obtained

P_{xi}= Per unit price of the ith (variable) input

X_i= Quantity of the ith (variable) input

TFC = Total fixed cost

3. Results and Discussions

3.1 Present land utilization pattern:

Bangladesh is one of the land scarce countries. Bangladesh has a very little scope of increasing agricultural production through expansion of land since the cultivated land is constant of around 8.50 million ha (Hossain, 1990). Therefore, it is argued that the agricultural production can be increased only by increasing productivity of land through technological advancement. The intensity of cropping increased very rapidly from about 130% in 1961 to 148% by 1970 and it further increased to about 175% in 2007 (BBS, 2007). Although cropping intensity increased substantially, both the total cropped area and net cropped area have been slowing down (Table 1 &2). Due to continuous population pressure and rapid urbanization in Bangladesh, the cultivable land is decreasing rapidly. Consequently, the total cropped acreage is shrinking from 35.07 million acres in 2001/02 to 33.92 million acres in 2006/07. Single cropped are was 11.4 million acres in 1980/81and it decreased to 7.02 million acres. Double cropped area remains more or less the same over the period of 2001/02 to 2004/05. But during the period of 2005/06, double cropped areas decreased to 9.48 million acres and slightly increased to 9.82 million acres during 2006/07.

3.2 Area Covered under Rice production

3.2.1 Growth in MV rice areas over the years:

The growth rates of total rice acreage and MV acreage in Bangladesh from 1981/82 to 1999/07 are presented in Table 3. It is evident from the analysis that,

Table 1 : Changes in the intensity of land use in Bangladesh, 1980-2007

Year	Single cropped		Double cropped		Triple cropped		Total cropped area	
	Area (million acres)	share of total cultivated land	Area (million acres)	share of total cultivated land	Area (million acres)	share of total cultivated land	Area (million acres)	share of total cultivated land
1980-81	11.4	53.5	8.20	38.5	1.6	7.5	32.7	153.5
1990-91	7.34	37.82	9.65	49.72	2.40	12.36	33.88	174.55
2001-02	7.09	35.77	10.20	51.46	2.52	12.71	35.07	176.94
2002-03	7.10	37.78	10.19	51.36	2.54	12.80	35.12	177.01
2003-04	7.94	40.02	10.21	51.46	2.54	12.80	35.12	177.01
2004-05	7.94	40.30	10.08	51.16	2.53	12.84	34.84	176.85
2005-06	7.04	36.51	9.48	49.17	2.40	12.44	33.94	176.03
2006-07	7.02	36.44	9.82	48.18	2.42	12.56	33.92	176.11

Source: BBS, 1980-2007

Table 2 : Projected land availability for crop production in Bangladesh, 1999-2020

Year	Net sown area (mha)	Net cultivable area (mha)	Cropping intensity (%)	Per capita net cultivable area (ha)
1999	7.99	8.42	174.7	0.066
2000	7.96	8.35	174.8	0.066
2005	7.90	8.29	176.3	0.064
2010	7.82	8.17	177.6	0.060
2015	7.77	8.05	178.9	0.055
2020	7.71	7.94	180.2	0.052

Note: The base year is 1999 for projection

Sources: Ministry of Agriculture, GOB, (2004) and Bhuiyan *et al* (2002).

the average growth of total rice acreage during the period from 1981/90 through 1999 to 2007 was only 1.39% (BBS, 2007). During the period of 1981/82 to 1989/90, the trend in area growth was higher for Boro (7.21%). The growth in MV Boro acreage was also the highest (10.89%) during the period from 1981 to 1990 and this higher growth rate has accelerated the overall growth of area devoted rice in this period.

This substantial increase in MV rice acreage has contributed to the total increase in the country's overall rice production during these two decades. However, within the rice sector, acreage under MV Boro and MV Aman has increased during 1980s and 1990s, but there has been a substantial declining trend for MV Aus during the period of 1981-1990 (Table 3).

It is important to note that the expansion of cropped area (through increase in rice cropping intensity and replacement of land from non-rice crops) which was an important source of production growth till mid 1980s has already dried up (Hossain, 1996). This indirectly or directly indicates that Bangladesh has reached the limit of extensive margin of bringing additional land under crop cultivation.

Table 3 : Growth of total rice and MV rice areas in different seasons in Bangladesh, 1981-2007

Growth factor	Growth rate(% per annum)		
	1981-1990	1991-1998	1999-2007
Total rice areas			
Aus	-0.90	-4.23	-2.04
Aman	1.92	-1.60	0.69
Boro	7.31	2.10	2.74
All	2.10	-0.04	0.18
MV rice areas			
Aus	-2.30	2.10	-1.10
Aman	6.83	2.50	3.92
Boro	10.89	4.14	1.43
All	7.21	3.64	-4.92

Source: Calculation made using data collected from BBS (various issues)

3.3 Present food production and future requirement

Data on domestic food grain production and requirement is summarized in Table 4. It appears from the available data that from 1980-81 to 1999-2000 there has been deficit in food production and the deficit ranged from 1.6 mmt to 0.60 mmt (Table 4). Although Bangladesh becam marginally self-sufficient in food (rice)

production after 1999, the level of self sufficiency neither appeared weighty nor seemed sustainable. As such government had to continue importing food from abroad to maintain smooth food supply.

However, in order to keep pace with the increasing demand for food grain, the productivity level must be uplifted. Since the way of increasing area under modern technology is impossible, the only way open is to enhance the level of productivity through adopting frontier technology in the production process.Ministry of food and department of agricultural extension projected that,

Table 4 : Food availability (production) and requirement scenario over the years, 1971/72 to 2004/05 and 2010 to 2020

Year	Mid-Year Population (Million)	Food grain Requirement	**Production (thousand metric tones)**				Net Total Production	Import /Donation (Rice+Wheat)
			Rice	Wheat	Maize	Total		
1971-72	72.60	12020	9774	113	2	9889	8744	-
1974-75	78.00	12914	11109	115	2	11226	9926	2293
1980-81	89.91	14886	13883	1092	1	14976	13242	1076
1984-85	98.00	16242	14622	1483	3	16108	14243	2593
1990-91	111.0	18377	17785	1004	3.0	18792	16616	1577.0
1994-95	119.0	19703	16833	1245	29	18107	16010	2566.0
1999-00	129.8	21490	23067	1840	121	25028	22130	2104.0
2000-01	131.5	21771	25085	1673	149	26907	23791	1554.0
2001-02	133.5	22094	24300	1606	172	26078	23059	1799.0
2004-05	138.0	22856	25156	976	356	26488	23421	3375.0
Projected population, food grain requirements and production								
2010	148.1	24520	29150	1600	450	31200	27587.04	-
2015	156.7	25943	31550	1600	550	33700	29797.54	-
2020	166.9	27632	32800	01600	600	35000	30947.00	-

Source: BBS and DAE, 1971/72 to 2007/08

Note: Food grain requirement is calculated @ 453.66 gram/cap/day.

Net total production is calculated by deducting 11.58% of total production for seed, feed and wastage.

in order to remain self-sufficient, Bangladesh will need to produce 42.86 million tons of paddy (27.63 million tons of rice) by the year 2020.

However, the Agricultural research strategy document made by the Bangladesh Agricultural Research Council projected the required paddy production by 2020 at 52 million tons food grain (34.7 million tons of rice) which would require a production growth rate of 2.2% per year. Although cropping intensity is rapidly increasing, per capita cultivable land is decreasing. To achieve required food grain, Bangladesh will have to target the yield growth at a higher rate to release some land from rice cultivation for supporting crop diversification and meeting the growing demand for land for housing, industrialization and also for the infrastructure development. Thus, rapid technological advancement is the only key to maintaining the food-population balance in the country. Hybrid rice technology could offer considerable opportunity for increasing food grain production in Bangladesh.

3.4 Changes in growth of rice and other cereal crops production

Production of rice in Bangladesh has increased substantially in the last three decades (1972 -2007). The introduction of modern rice technology and adoption of high yielding varieties (HYVs) has contributed to increase food production and also changed cropping patterns.

The trends in growth of different cereal crops are available in Table 5. It appears from the analysis that growth rate of total rice production during the period of 1972-80 was 3.35% and in the second period (1981-1990) it moderately declined to 2.75%. But the growth rate further increased to some extent (3.25%) during 1991-99 and then it again declined in the period of 2000-07. The growth rate in Boro paddy production over the first period of 1972-80 was 3.12% and it significantly increased to 8.53% in period 1981-90). However, there has been a decrease in growth rate in case of T. Aus and T. Aman over the period of 1972-2007. Therefore, the contribution of boro to total rice production is considerably higher than that of aus and aman. There has been a decreasing trend in the growth rate of wheat but in case of maize, a different picture appeared over the period of 1980 toward 2007. The results also showed an increasing trend of maize production with a accelerated growth of 11.6% during the period of 2000-07. The trend of growth of total cereal crop production was almost similar to that of total rice production. Although the growth rate of total cereal crops showed a declining during the period of 1981-90, the trend over the longer period of 1980-2007 has been consistently increasing. In fact, this increasing growth of boro production

contributed much to the grain availability in the country. It was due to higher expansion and adoption of high yielding varieties during this season.

3.5 Hybrid Rice Production

Present scenario of hybrid rice production: In achieving food grain security, increase in Boro rice production is really considered as an important factor. For this reason government took different special program in motivating the farmers

Table 5 : Growth rate (%) in the production of cereal food grain in Bangladesh: 1972-2007

Crops	Estimated growth rate (%)			
	1972-1980	1981-90	1991-1999	2000-2007
Rice	3.35	2.75	3.25	2.49
Aus	2.73	-3.73	-0.76	-3.57
Aman	2.86	1.82	1.62	1.53
Boro	3.12	8.53	7.89	6.16
Wheat	3.03	-2.66	5.28	-14.37
Maize	-10.36	6.38	6.66	11.64
Total cereal food (rice+wheat+maize)	6.50	-4.41	4.25	2.94

Source: Calculation based on data collected from BBS

to adopt hybrid rice that could give about 15-20% higher yield than that of HYV. DAE also extended substantial efforts in persuading farmers to devote more land under hybrid rice production. Area under hybrid rice cultivation is increasing substantially by year and year. Acreage under hybrid rice shared only 0.06% of the total Boro area in 2001 and very surprisingly it increased to 26.73% in 2007/08. The farm level overall yield gain from growing hybrid rice in the Boro season of 2006/07 and 2008/09 were 21 and 25% respectively (DAE, 2009). Rice farmers in many areas are really convinced to grow hybrid rice varieties extensively especially in the Boro season in order to achieve higher productivity.

Yield performance of hybrid rice and HYVs by farm size is shown in Table 6. The yield performance of hybrid rice was much better than that of inbred rice irrespective of farm size categories.

Analysis in table 8 indicates that the yield performance of Sonar Bangla was impressive on both sample farms, research farms and on farm trials. The performance of Alok-6201 did not out yield significantly HYVs of rice on farms. The yield rate of Alok-6201 ranged from 5.22 t/ha in BADC farms to 7.29 t/ha in

DAE farms. However, the yield of Alok-6201 is quite impressive in DAE on-farm trials. The yield rates of HYVs varied from 4.78 t/ha on BADC farm to 6.26 t/ha under AAS on-farm trials.

Table 6 : Area covered and yield of HYV and hybrid rice in Boro season 2001-09

Year	Area under Boro ('000' ha)	Share of HYV area in Boro season (%)	Hybrid ('000' ha)	Share of hybrid area in boro season	Yield (t/ha)		Yield increase by hybrid over HYV
					Inbred HYV	Hybrid	
2001-02	3771	94.63	2.51	0.06	3.20	-	-
2002-03	3845	95.37	21.05	0.55	3.24	-	-
2003-04	3944	94.71	202.43	5.13	3.33	-	-
2004-05	4064	95.37	128.00	3.15	3.47	-	-
2005-06	4066	95.71	244.00	6.00	3.50	-	-
2006-07	4367	77.97	800.00	18.31	3.74	4.55	21.2
2007-08	4675	75.70	1011.00	21.61	3.85	4.75	20.7
2008-09	4675	70.58	1250	26.73	3.92	4.88	25

Source: BBS and DAE, 2001-09

Table 7 : Yield gains from hybrid over inbred HYV rice achieved by different farms size groups

Farm size	Yield (t/ha)		Yield difference (%)	t-ration
	Hybrids	Inbred HYVs		
Functionally landless	5.91	4.96	19.16***	3.86
Small	6.39	5.85	9.23**	2.32
Medium	6.35	5.74	10.63*	1.94
Large	6.45	5.53	16.64**	2.41
All sizes	6.45	5.63	14.74***	5.24

Source: Adopted from Hossain *et al*, 2002

***, **, * indicates significant at 1%, 5%, 10% level respectively.

Table 8 : Yield of hybrid and HYV rice in sample farms, research farms and on farm trials

Variety	Sample farms	Research farms BRRI	On farm trials		
			BADC	DAE	AAS
Hybrid (Alok-6201)	5.81 (3.2)	5.27 (3.2)	5.22 (18.6)	7.29 (18.6)	6.06 (-3.2)
Hybrid (Sonar Bangla)	7.48 (32.9)	6.72 (25.7)	5.47 (24.3)	-	7.55 (20.6)
HYV	5.63	5.11	4.78	-	6.26

Source: Adopted from Hossain et al, 2002

Note: Figures in parentheses are % yield gains of hybrid over the HYVs.

It is interesting to note that the yields recorded in BRRI research plots and BADC seed farms were lower than the yield obtained on farmers' fields. The performance of AAS on-farm trials was even better than BRRI and BADC yield figures.

4.1 Comparative profitability structure of hybrid and inbred HYVs

The costs of production of the two types of varieties grown in the study areas are presented in Table 9. Analysis revealed that total human labour cost (Tk.2,4375/ha) was higher for hybrid rice compared to that of inbred HYVs. The land preparation cost was more or less same for both types of varieties. Although the amount of seed needed for production of hybrid rice was lower than that of inbred, the cost of hybrid rice seed was 2.07 times higher compared to that of inbred because the market price of hybrid rice seed was higher. On the contrary, the cost of fertilizer for hybrid rice was lower compared to that for inbred because the sample farmers grew hybrid rice in single cropped and low land in the study areas and that needed lower amount of fertilizer. The cost of insecticides and herbicides were also higher in case of hybrid rice compared to that of inbred HYV. Irrigation cost is one of important cost item of growing boro rice. This was found slightly higher than that for inbred HYV. Eventually the total cost of production for hybrid rice was Tk. 66756 per hectare, which is about 11 higher than that of inbred HYV. Results further show that unit cost of production (Tk/kg) for Hybrid rice was Tk.8.61 leading to a higher benefit while it was almost Tk. 10 for inbred.

The average yield of hybrid variety was much higher (7.75 ton/ha) than that of inbred HYV (6.02 ton/ha). Taking into account of the value of by product per hectare net return of hybrid (Tk.55677) was also higher than that of inbred (Tk.43795). The empirical result also indicates that, production of both varieties was profitable but investment in hybrid rice production is more profitable (Table 10& Fig1).

5. Conclusions and Recommendations

The present analysis revealed that, both the total cropped area and net cropped area have been declining over the years probably due to continuous population pressure and rapid urbanization in Bangladesh. Although cropping intensity increased substantially in some early years, it remains almost steady in the recent period. The growth in MV Boro acreage was the highest (10.89%) during the period from 1981 to 1990 and the accelerated growth in area devotion to Boro rice has helped increase the overall growth in rice acreage. The substantial increase in MV rice acreage has contributed to the total increase in the country's overall rice production during the last two decades. Bangladesh since 1999 has become

Table 9 : Per hectare costs of inbred and hybrid rice production

Items of cost	Inbred farms		Hybrid farms	
	Cost Tk./ha)	Share of total cost (%)	Cost (Tk./ha)	Share of total Cost (%)
A. Variable cost				
Human labour	23,310	38.70	2,4375	36.51
Power tiller	4,630	7.69	4,970	7.44
Seed	1525	2.53	3162.5	4.73
Fertilizer	6700	12.29	5905	8.84
Insecticides	895	1.49	1375	2.06
Herbicides	185	0.31	303	0.45
Irrigation	9,000	14.95	11,599	17.37
B. Fixed cost (TFC)				
Land use cost	12959	21.52	13972	20..93
Interest on operating capital @ 10% for 5 months	987	1.63	1094	1.65
Total cost (A+B)	60,218	100	66756	100

Source: Field survey 2008

Table 10 : Costs and returns of producing inbred and hybrid rice varieties in the study areas; Boro, 2008

Items	Inbred farms	Hybrid farms
Paddy (kg/ha)	6027	7757
By-product (Tk/ha)	7581	6078
Gross return (Tk/ha)	104,013	122,433
Total variable cost (Tk/ha)	46,245	51,693
Total cost (Tk/ha)	60,218	66,756
Gross margin (Tk/ha)	57,768	70,739
Net return (Tk/ha)	43,795	55,677
BCR	1.72	1.83

Source: Field Survey 2008

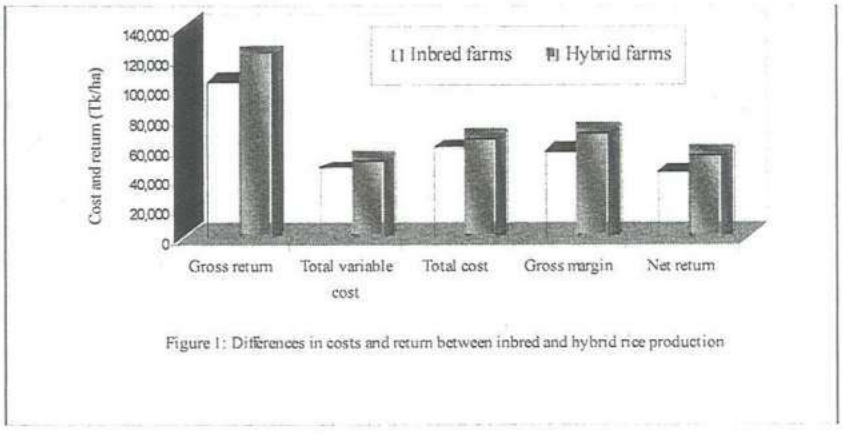

Figure 1: Differences in costs and return between inbred and hybrid rice production

marginally self-sufficient in food production, but the level of self sufficiency neither appeared weighty nor seems sustainable. Area under hybrid rice cultivation is increasing substantially by year and year. It was 0.06% of total Boro area in 2001 and it increased to 26.73% in 2007/08. The yield performance of hybrid rice was much better than inbred HYV at the farm level. The total cost of production for hybrid rice was about 11% higher than that of inbred HYV. It was also observed that, the unit cost of production for hybrid rice was relatively lower than that of inbred HYV. It was due to higher yield gained from hybrid rice. The production of both hybrid and inbred HYV is profitable but investment in hybrid rice production is comparatively more profitable. Adoption of hybrid rice should be increased to greater extent to enhance the food grain production in Bangladesh. Necessary support (such as training and inputs) should be provided for farmers. Research on hybrid rice at public sector and coordination between public and private sector should be strengthened.

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