Tracking of Improved Varieties in South Asia

Bhutan Report on Rice

Estimating adoption rate of modern rice varieties in Bhutan

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Acronyms

AEZ	Agro-EcologIcal Zone
CARD	Centre for Agricultural Research and Development
CoRRB	Council for Renewable Natural Resources of Bhutan
DoA	Department of Agriculture
DST	Dry Subtropical
FTE	Full-Time Equivalent
HST	Humid Subtropical
HYV	High Yielding Varieties
IRRI	International Rice Research Institute IRRI
NPPC	National Plant Protection Centre
RNR RDC	Renewable Natural Resources Research and Development Center
TRIVSA	Tracking Improved Varieties in South Asia (TRIVSA
WST	Wet Subtropical
WT	Warm Temperate

Introduction

Bhutan has an area of 38,394 km^2 and a population of approximately 700,000. It is a landlocked country situated on the south-eastern slope of the Himalayas. Over 72% of the country is under forest cover. The cultivated area is only about 3%, including wetland, dryland for horticulture crops and fallow rotation. Rice is indispensable in the Bhutanese culture, tradition, religion and farmers' livelihoods. More than 69% of the population is engaged in farming with rice and maize as the main crops. Although rice is not the largest produced cereal in the country, it is the most widely consumed cereal. The per capita consumption of rice is computed at 172 kg milled rice per year. Rice is grown in about 23,444 ha (DoA, 2009) with a total production of about 65,763 MT of rough rice. The national average rice yield stands at 2.81 t/ha. Domestic production of rice has not been able to meet the demand due to low productivity. The domestic production of rice meets only about 50% of the total requirement. The deficit is met from rice imports amounting to over 50,000 MT per annum from India. The insufficiency in rice stems from a number of factors such as limited wetland, use of low yielding traditional cultivars, low use of plant nutrients from inorganic fertilizers (9-11 kg of plant nutrients per ha), weeds, diseases and insect pests, and limited irrigation water supply. The majority of rice farmers produce rice for their household needs alone; marketing constraints limit the incentives to produce beyond their needs. A study in 2007 showed that less than 15% of the rice produced is marketed locally (Ghimiray et al, 2007), although the demand for locally produced rice exists.

The main objectives of this paper are to update the available information on the spread and adoption of modern rice varieties in Bhutan and to quantify the resources being invested in rice research and development. Bhutan is a collaborator in Tracking Improved Varieties in South Asia (TRIVSA) project with the International Rice Research Institute (IRRI) that aims to attain a wider understanding of key aspects of the performance of food crops genetic improvement and to gain a deeper understanding about the adoption and diffusion of new varieties in selected major food crops in the region. The objectives of TRIVSA are relevant to Bhutan to update the existing information and documentation on the adoption and spread of improved rice varieties in the country. This paper builds on the results obtained so far from the project activities.

Rice production systems and productivity growth

Rice is grown from tropical lowlands (200 m) in the south up to elevations as high as 2700 m in the north. Because of Bhutan's rugged topography, rice fields are generally terraced. Rice environments are broadly grouped into three altitude zones which also reflect temperature regimes. The high altitude zone, also referred to as warm temperate zone, covers rice areas from 1,600 m and above. Low temperature at early vegetative stage of the rice crop characterizes this environment. Around 20% of the rice areas fall under this zone. The mid altitude zone which accounts for 45% of the rice areas has an elevation of 700 m to 1500 m. Its sub-ecologies are the dry and humid sub-tropical environments, the latter receiving more rainfall than the former (Javier, 2007). The remaining 35% is the low altitude zone (200 m – 600 m) concentrated in the southern part of Bhutan and also referred to as the wet sub-tropical zone. Rice agro-ecological zones are described briefly below.

Warm Temperate (high altitude) zone

The warm-temperate high altitude zone includes mainly the valleys of Paro and Thimphu, higher altitude areas of Punakha and Wangdue valley, and parts of other districts. Approximately 20% of the total rice area falls in this zone. The highest altitude where rice is grown is about 2700 m above sea level in Bumthang. The climatic conditions allow only one crop of rice in a year. Rice is sown in March-April, transplanted in May-June and harvested in October-November. Rainfall in this zone is rather low (650-850 mm per year) and hence rice is grown as irrigated crop. Small springs and the main rivers are the sources of irrigation. Rice blast is a major problem.

Dry Sub-Tropical (medium altitude) zone

The dry sub-tropical zone includes broad valleys of Wangdiphodrang and Punakha, hill slopes and narrow valleys of Trongsa, Tashigang, Mongar, Lhuentse. This is a mid altitude zone with a lower rainfall (850-1200 mm). In the lower valley bottoms upto an elevation of 1500, low temperature is not a major problem for a single crop of rice. Rice is sown in March-April, transplanted in June and harvested in October-November (Ghimiray et al, 2008). Two crops of rice could also be grown. The first crop, transplanted in March by using seedlings raised in a poly-tunnel nursery, can be harvested in July and immediately an early maturing second crop can be planted which is harvested in October. Insect-pests and diseases are not a major problem. This environment has a higher yield potential because of high solar radiation, and long ripening phase.

Humid Sub-Tropical (mid altitude) zone

The humid sub-tropical (mid altitude) zone includes hills of Tsirang, Samtse, Gelephu, Tashigang, Zhemgang, Pemagatshel, and Chukha. This is a distinct humid hilly environment with substantially high rainfall (1200-1500 mm). Almost all rice is grown under irrigated condition. The rice terraces are carved in hill slopes. The dry and humid subtropical zones account for about 45% of the total rice area. Low temperature is not a major problem during early crop growth stage. However humid conditions favour disease development. At the higher elevations, cold spells during anthesis cause spikelet sterility.

Wet Sub-Tropical (low altitude) zone

The wet sub-tropical low altitude zone includes mainly the districts of Samtse, Gelephu, and Samdrupjongkhar and account for about 35% of the national rice acreage. It is a high rainfall environment with higher temperatures. Diseases and insect-pests are more common. Soil conditions are poor (low N and K) compared to other zones. Rice is grown mainly as a rainfed crop due to lack of assured irrigation infrastructures. Rice cultivation is dependent on monsoonal rains and yields are generally low compared to other zones. Moisture stress flowering and post flowering stages considerably reduces yield. Local varieties are long duration and lack drought tolerance. The climatic conditions permit two crops of rice in a year though it is not practiced for varied reasons.

Production growth trend/pattern

The RNR Statistics of the Ministry of Agriculture are the official data source on rice area, production and productivity. However, lack of consistency in data collection approach and methods over the years is acknowledged as a source of error affecting data quality and efforts to improve the methodology are currently underway. Hence the data should be considered with some caution.

Table 1. Rice acreage, production and yield in Bhutan, 1989-2009.

Year	Area (ha)	Rough Rice Production (MT)	Yield (t/ha)
1989	26010	39790	1.53

1990	26304	59449	2.26
1996	23777	65576	2.76
1997	23679	63065	2.66
1999	19374	44686	2.30
2000	18683	37868	2.03
2002	18432	37867	2.03
2003	19480	45805	2.35
2004	18634	54325	2.92
2005	24983	67606	2.71
2006	27026	74380	2.75
2007	27024	74438	2.76
2008	19124	77314	4.04
2009	23443	65763	2.81

Table 1 summarizes data on rice area, production and productivity from 1989 to 2009. The area figures represent the actual area grown to rice in a given year, and not the total rice acreage in the country. It is estimated that 5-10% of the rice area is left fallow each year for reasons ranging from lack of farm labor, water shortage and predation by wild animals (wild boars, elephants, monkeys).

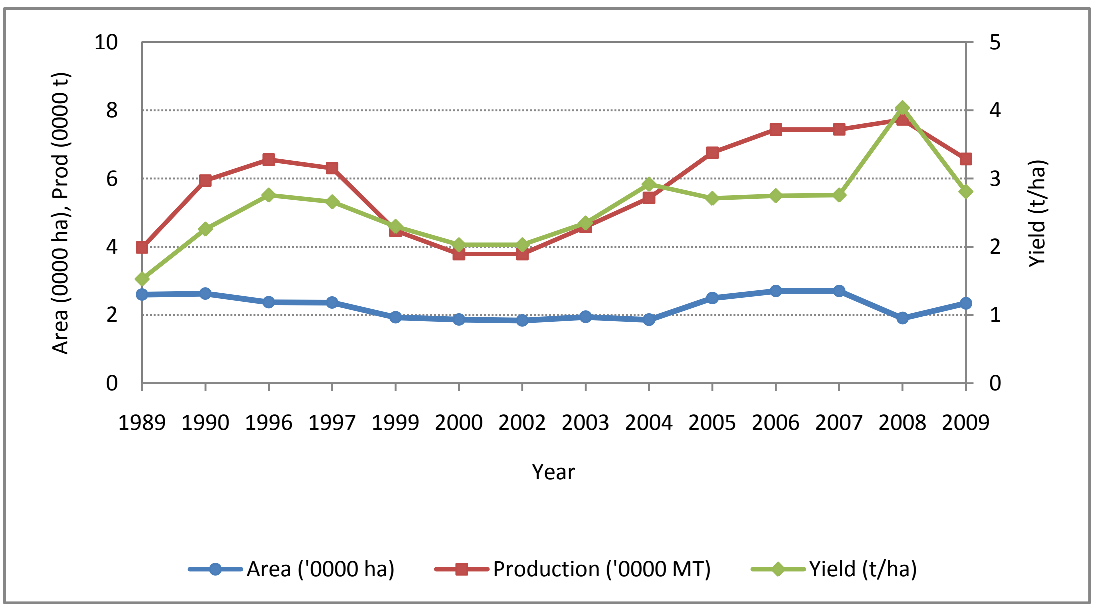

Figure 1. Area, production and yield of rough rice.

Overall, area cultivated to rice has decreased over the years. The sharpest decline of 29% was recorded in 2002 (Fig 1). The latest data available for 2009 shows a decline of 10%. The total rice production in the country however has been on the rise, except in 2000 and 2002, and the production gain has been impressive ranging from 12-94%. Research and development on rice is attributed to this increased production, with improved rice technologies leading to an increase in national rice output by 5000 to 10000 tons per year (Shrestha, 2004). The national average yield has risen from 1.53 t/ha in 1989 to 2.81 t/ha in 2009. Except for 2008 when unusually high yield of 4.04 t/ha was recorded, the productivity gain has been more or less consistent between 33-91%. The main factors contributing to the gain in productivity are the improvement in crop management such as better land preparation, weed control and fertility management, and the use of high yielding varieties (HYV) that out-yield traditional varieties by at least 27% under similar rice growing conditions (Shrestha, 2004).

Organization of rice research

Under the Ministry of Agriculture and Forests fall two important agencies for agricultural development, the Department of Agriculture (DoA) and the Council for Renewable Natural Resources of Bhutan (CoRRB). CoRRB is a policy making-body that coordinates the national renewable natural resources research programs of agriculture, horticulture, forestry and livestock enterprises. The DoA is mandated to plan, coordinate, administer, supervise and monitor the overall agriculture programs and RNR infrastructure growth to expand agricultural development in the country. Under the DoA, research programs are implemented through four integrated Renewable Natural Resources Research and Development Centers (RNR RDCs) located at Bajo (Wangdue), Bhur (Sarpang) and Wengkhar (Mongar). Each center has a national mandate for coordinating research in one of the four major sectors and a regional mandate to conduct research in sectors relevant to the assigned districts in its domain.

The RNR RDC-Bajo has the national mandate for field crops research program, of which rice is a major component. The national rice research program is geared towards the development of rice-based technologies and related information to overcome production constraints to raise farm productivity for the benefits of rice farmers and consumers (Javier, 2007). The RNR RDC-Bajo is the primary center for formulating the national strategic objectives and planning, managing and implementing the rice research program. To achieve these, it is supported by the other centers for region-specific concerns. The rice research program has three agro-ecological zone oriented sub-programs, namely: mid, low and high altitude subprograms. Each research center has one or two sub-centers in targeted environments to ensure the relevance of the research outputs. Major discipline based research components include:

- varietal improvement – germplasm conservation, varietal development, varietal testing, and seed production
- crop management – crop establishment, water management, nutrient management, pest management (weeds, insect pests, diseases, and post harvest management)
- socio-economic and policy research (impact assessment and economics of rice production).

The DoA's extension system is district-based. Technologies generated in researcher-managed trials are validated in farmers' fields involving their own resources and management practices. The on-farm trials serve not only as the first step in technology dissemination but also as the vehicle for in-depth collaboration among researchers, extension officers and farmers. There are 20 District Agricultural Officers looking after the activities of around 200 extension staff assigned in various blocks of the country. An annual review and planning meeting is held to ensure effective partnership between research and extension officers in generating and disseminating improved technologies.

In terms of financial resources allocated to rice research, such data or information are not available at present. The national budgeting and accounting system follows an 'object code' or 'line item' system that does not disaggregate fund flows for specific crops or commodities. Moreover, funds are released to institutions, for instance RNR RDC Bajo with an annual budget of about Nu 20 million (1 USD = Nu 48), which deal with a number of research programs such as cereals, oilcrops, grain legumes, fruits, vegetables, pasture and community forests and it becomes difficult to separate allocation for a specific commodity like rice.

Varietal release patterns

In line with the Royal Government's policy of self-sufficiency in food production, the introduction of modern rice varieties was begun in 1982 following the establishment of then the Centre for Agricultural Research and Development (CARD), now renamed as RNR Research and Development Centre at Bajo. Varieties and breeding lines from regional and international germplasm evaluation programs are tested for their adaptability and suitability to the Bhutanese agro-climatic conditions. Such an effort has resulted in the identification and release of 15 improved rice varieties for various recommendation domains (Table 2).

Due to its uniqueness and specificity of growing conditions, rice varieties introduced from elsewhere often fail especially in the high and mid altitude zones. To overcome this problem and also to assimilate desired genes in Bhutanese local varieties for blast tolerance and high yields, a cross breeding program was started in 1995 with IRRI. The program has been highly successful and so far 8 rice varieties which combine genes for blast resistance, high yields and culinary traits (red color, medium amylose) have been released (Table 3).

Improved varieties together account for about 35% of the national rice area (Shrestha, 2004) and under similar management conditions produce about 1000 kg additional grains from a hectare in comparison to the local varieties. This has significantly improved the self-sufficiency level, both at the household and national levels. Unlike in the uniform tropical environments, modern varieties do not completely replace traditional cultivars but simply add to the mosaic of extant diversity.

Table 2. Introduced and released rice varieties.

Designation	Local names	Year of release	Recommended Altitude zone (m)
IR 64	IR 64	1988	600-1600
Milyang 54	Milyang 54	1989	600-1600
IR 20913	IR 20913	1989	600-1600
			Below 600
No 11	No 11	1989	Above 1600
			600-1600
BR 153	BR 153	1989	Below 600
BW 293	BW 293	1990	Below 600
Barkat	Barkat	1992	600-1600
Chummrong	Khangma Maap	1999	Above 1600
Khumal 2	Wengkhar Rey Kaap 2	2002	600-1600
Khumal 6	Wengkhar Rey Kaap 6	2006	600-1600
Paro China	Jakar Rey Naab	2006	Above 2600
APO	Bhur Kambja 1	2010	Below 600
IR 70181-5-PM1-1-2-B-1	Bhur Kambja 2	2010	Below 600
IR 72102-3-115-1-3-2	Bhur Raykaap-1	2010	Below 600
Karjat 3	Bhur Raykaap 2	2010	Below 600
OR 367-SP11	Wengkhar Reykaap 1	2010	Below 600

Table 3. Locally bred and released rice varieties.

Parents Crossed	Local names	Year of release	Recommended Altitude zone (m)
Local Maap x IR64	Bajo Maap 1	1999	600-1600
Local Maap x IR64	Bajo Maap 2	1999	600-1600
Paro Maap x IR41996-118-2-1-3	Bajo Kaap 1	1999	600-1600
Bja Naab x IR41996-118-2-1-3	Bajo Kaap 2	1999	600-1600
YR3825-11-3-2-1//YR3825-11-3-2-1/Barkat	Yusi Rey Kaap1	2002	Above 1600
Suweon 359//IR41996-118-2-13/Thimphu Maap	Yusi Rey Maap1	2002	Above 1600
Akiyutaka / Nam	Yusi Rey Kaap2	2010	Above 1600
Akiyutaka / Rey Maap	Yusi Rey Maap2	2010	Above 1600

The first modern rice variety to be officially released in Bhutan was IR 64 in 1988. This variety is still popular among farmers in the mid-elevation (600-1600 m) areas for its high grain yield and cooking quality (medium amylose content) although a gradual breakdown of resistance to leaf and panicle blast has been recorded in recent years. In 1999, four varieties were released of which only one (BR 153) was intended for the low altitude zone. It may be noted that the mid altitude zone was the focus of rice research and development in the 1980s and beginning of 1990s primarily because agricultural research started in this zone when CARD was created by the Ministry of Agriculture. In 1990, one more rice variety (BW 293) was released for the low altitude zone, however, this variety did not gain any popularity due to its short plant stature. It was subsequently denotified by the Variety Release Committee.

Rice double cropping in the mid altitude zone was introduced in the late 1980s and Barkat was released as a first crop variety in rice-rice sequence. After 1992, a long hiatus was observed in national releases until 1999 when five varieties were released. Of those five varieties, only one (Khangma Maap) was an introduction and the rest were all products of cross breeding using Bhutanese local varieties as parents for the first time in rice research history. It marked a new era in national rice research capability in the country. Two more locally bred varieties (Yusirey Kaap1 and Yusirey Maap 1) which incorporated blast resistance genes in the native varieties were developed and released in 2002.

The long gap between 2002 and 2010 was used to promote and popularize the already released varieties. However, the cultivation domain of the released varieties excluded the low altitude zone, where essentially a single variety (BR 153) was available for farmers. A large area (>60%) in the low altitude zone is rainfed, hence drought tolerance is an essential trait. To fulfil this need, two drought tolerant varieties (Bhur Kambja 1 and 2) were released in 2010 for the first time in the country. Three more varieties for the irrigated ecosystem were also released in addition to two more blast resistant varieties (Yusirey Kaap 2 and Maap 2) for the high altitudes.

In a span of 22 years, a total of 23 rice varieties have been released in Bhutan. Given the small research system and limited trained manpower, it is quite an achievement. Released rice varieties have good yield potential and diverse genetic background (Javier, 2007).

NARES investment in rice germplasm improvement research

The history of agricultural research in Bhutan is relatively young with the institutionalized research having begun only in 1982. Rice research began in earnest two years later in 1984 when collaboration with IRRI was forged. No separate institute exists for rice research alone, but it is amalgated within the four main RNR Research and Development Centres which are mandated to conduct integrative research on field crops (cereals, oilcrops, pulses) and horticultural crops (temperate to subtropical fruits and vegetables). Within the field crops program, rice research receives a higher priority in terms of research resources.

The national rice research program, however, is small with only five scientists allocating 30-60% of their time for actual research (Table 4). The data in Tables 4 and 5 were obtained based on questionnaire survey of the researchers implemented in the project. These scientists are spread across different institutes that are located in different agro-ecological zones (AEZ) and rice ecosystems. The education level of scientists ranges from MSc (4) to PhD (1) and disciplines include plant breeding (2), agronomy (2) and crop protection (1). In the Bhutanese context, agronomy also encompasses soil science and on-farm water management although research work is limited at present.

Table 4: Scientists involved in rice research in Bhutan, 2011.

Scientist	Organi-zation	Educa-tion	Discipline	Time allocation by Theme		Time allocation by Ecology	
				Theme	%Time allocated	Ecology	%Time allocated
Thinlay	NPPC	PhD	Crop protection	Pest mgt	30	HST, irrig, mid alt	10
				Technology transfer	30	WT, irrig, high alt	15
						WST, irrig and rainfed, low alt	5

Mahesh Ghimiray	RDC Bajo	MSc	Plant breeding	Breeding for higher yield	60	DST, irrig, mid alt	36
				Germplasm conservation	60	HST, irrig, mid alt	6
						WT, irrig, high alt	12
TB Katwal	RDC Wengkhar	MSc	Agronomy	Varietal selection	40	DST, irrig, mid alt	15
				Expt trials	40	WST, irrig, rainfed, low alt	6
						High alt upland	10
Wangda Dukpa	RDC Bhur	MSc	Agronomy	Expt trials	40	WST, irrig, rainfed, low alt	20
				Drought tolerance	20	-	-
Mumta Chhetri	RDC Yusipang	MSC	Plant breeding	Breeding for higher yld and disease resistance	60	DST, irrig, mid alt	10
				Germplasm cons'n and establishment methods	60	HST, irrig, mid alt	5
						WT, irrig, high alt	40
						WST, irrig, rainfed, low	5

HST = humid subtropical zone (mid altitude), WT = warm temperate(high altitude), DST = dry subtropical (mid altitude), WST = wet subtropical (low altitude)
NPPC = National Plant Protection Centre

Within plant breeding, focus is geared towards breeding varieties for higher yields, disease resistance (rice blast in particular) and drought tolerance. Conservation of germplasm is another important activity. As part of agronomic research, conduct of experimental trials on sowing and transplanting times, spacing, varieties and plant nutrient management is the major activity. In crop protection, IPM and technology transfer are emphasized.

Table 5 summarizes allocation of rice research resources across AEZs and ecosystems in full-time equivalent of scientists' involvement and percentage share in each AEZ. The Warm Temperate (WT) zone has the maximum FTE (0.77) which is equivalent to 39% share among the AEZs. This is also the only zone where upland rice research (0.10 FTE) occurs apart from research on normal irrigated ecosystem. At the national level, upland ecosystem constitutes an insignificant 1-2% of the total rice area, nonetheless it can be important for farmers who have majority dry land holdings. The Dry Subtropical zone (DST) has 0.61 FTE (31%) followed by Wet Subtropical (WST) with 0.36 FTE (19%). The Humid Subtropical (HST) zone is neglected with only 11% of the national resources allocated to it. Categorized by altitude regimes, the mid altitude region comprising of DST and HST receives the highest (41%) allocation of resources, followed by high altitude (39%) and low altitude (19%) zones.

Table 5: Allocation of rice research resources across ecosystems and agro-ecological zones (AEZ).

Ecosystem	Actual FTE person-year				
	WT	DST	HST	WST	Total
Irrigated	0.67	0.61	0.21	0.18	1.67
Rainfed					
Lowland	-	-	-	0.18	0.18
Upland	0.10	-	-	-	0.10
Total					1.95
% share of each AEZ	39	31	11	19	

Note: No disaggregated data available for irrigated and rainfed lowland in the WST, hence assumed as 50% each.
HST = humid subtropical zone (mid altitude), WT = warm temperate(high altitude), DST = dry subtropical (mid altitude), WST = wet subtropical (low altitude)

Javier (2007) in a review of research allocation noted that the mid altitude zone received the highest allocation of resources, with DST getting more attention than the HST. The low altitude zone research has the least amount of resource allocation, particularly the unfavorable rainfed lowland environment which represents a considerable area in the region. This anomaly needs to be corrected. It is also important to emphasize that the overall investment in research is very low, both in terms of manpower and budgetary resources. While the Ministry of Agriculture stresses on increasing food production and self sufficiency, it has not lived upto its commitment by increasing investment in research and development. Varietal improvement research has been a priority area among the disciplines as improved varieties serve as the base from which other research components are built upon.

Results and discussion

Expert panel estimates of cultivar-specific adoption

An expert panel to elicit the spread and adoption of modern rice varieties in Bhutan was organized in July 2011. Expert panel estimation is a quick and easy way for varietal adoption and diffusion. This approach is particularly relevant in a small system with limited resources such as in Bhutan. A total 12 local experts participated in the meeting. They comprised of rice breeders (6) from different research centers, extension staff (3) of the Department of Agriculture, agronomist (1), seed expert (1) from the national Seeds Centre and one farmer representative. The meeting was facilitated by an expert from IRRI. Two sets of forms were used to gather information. The first form collected information on the percentage area grown to 10 top rice varieties and summarized the overall adoption rate of HYVs versus traditional varieties. The other form elicited information by rice agro-ecologies: high altitude (>1800 m), mid altitude (800-1800 m) and low altitude (<800 m) as commonly accepted altitudinal categorization in the country. Within an altitude zone, most popular varieties were also enlisted with their percentage area. So, the type of information synthesized included the overall area covered by modern varieties in the country, most popular varieties and their share of area covered in different agro-ecologies.

Table 6. Expert panel estimate of area under high yielding varieties (HYV) by altitude zones.

Zone	% Share in total rice area	Expert estimate of area under HYV in 2010 (%)	Area under HYV based on a previous study (Shrestha 2004) (%)
High	20	80	66
Mid	45	40	38
Low	35	55	17
All	100	53	35

Overall, results of the expert elicitation showed that MV adoption at the national level is 53% (Table 6). When compared with the findings of the study conducted by Shrestha (2004), adoption increased by 18 percentage-points from 35% relative to 2002. The major expansion has taken place in the low-altitude southern belt where improved varieties are being actively promoted by the government. New varieties suited to this region have been developed and there is some diffusion of improved varieties from the border regions of India. The lowest level of expansion is in the mid-altitude zone. The 2002 study also indicated that MVs are already widely adopted in the high-altitude zone and there have been further increases in the adoption of MV in this zone.

Estimates of cultivar-specific adoption level derived from expert panel are presented in Table 7. We clearly observe a delineation of varieties grown in the different domain. Experts were able to identify the popular varieties grown in the different zones.

Table 7: Cultivar-specific adoption (%Area) by altitude zones.

Varieties	Expert estimates		
	High	Mid	Low
Khangma Maap	50	0	0
Yusi Rey Maap	23	0	0
Yusi Rey Kaap	13	0	0
No 11	3	0	0
Jakar Rey Naab	3	0	0
IR 64	0	50	0
Wengkhar Rey Kaap	0	20	0
Bajo Maap	0	10	0
BR 153	0	0	70
Bhur Rey Kaap	0	0	10
Bhur Kamja	0	0	6
Other MVs	8	20	14

The varieties recommended by the Department of Agriculture and cultivated by farmers are specific to a given altitudinal zone. In the high altitude zone, Khangma Maap is the pre-dominant variety covering 50% area. This is followed by Yusi Rey Maap (23%) and Yusi Rey Kaap (13%). Other modern varieties grown are No 11 and Jakar Rey Naab. Khangma Maap is a red grained variety introduced from Nepal and is known for its resistance to blast and cold tolerance. In the mid altitude zone, IR 64 is the most popular variety with 50% area coverage. Other varieties include Wengkhar Rey Kaap (20%) and Bajo Maap (10%). The low altitude area is dominated by BR 153 (an old variety from BRRI, Bangladesh) covering 70% area. A recent release for the low altitude belt, Bhur Rey Kaap (10%) and a rainfed variety Bhur Kambja (6%) are gaining popularity. Due to porous border with India, many HYVs (14%) from across the border are also grown by farmers. Overall, the most popular rice varieties are Khangma Maap, IR 64 and BR 153 in the high, mid and low altitude zones respectively.

Household survey to validate the expert panel estimate

A household survey was conducted to validate results of the expert panel estimates of varietal adoption. Eight main rice producing districts across altitudinal agro-ecologies were identified for the field work. This included Thimphu and Paro in the high altitude zone, Wangdue, Punakha, Trashigang and Monggar in the mid altitudes and Sarpang and Samtse in the low altitude region. According to RNR Stats 2009, the coverage of rice districts from where the samples were drawn added to 59% of the total rice area. Of the districts sampled, coverage in the high, mid and low altitude zones was 15%, 51% and 34% respectively. A multistage random sampling method was used, with 4 blocks (a group of villages) from each district, 3 villages from each block and 3 households from each village. This gave a total sample size of 288 households. A standard questionnaire was developed and used. Data entry, validation and analysis were done at jointly by RDC Bajo and IRRI. The data collected from the survey included: general information on the interviewee (gender, education level, land holding size etc), cultivation of improved varieties (name of the varieties, seed source, area grown), traits of the improved varieties, pest resistance), inputs used (fertilizers, herbicide) and some aspects of rice marketing.

A comparison of the results as shown in Table 8 indicates that the experts' perception of area grown to modern varieties matches well for the high and low altitude zones but not for the mid-altitude zone. The greater discrepancy for the mid-altitude zone probably is the result of expert panel composition which had inadequate representation of experts from this zone. This highlights the importance of ensuring that the expert panel includes people knowledgeable about specific zone as a way of reducing possible biases. There may, however, be some problems with the household survey also as the adoption rate obtained from the survey for 2010 is less than that estimated in an earlier study for 2002. It is unlikely that adoption rate of improved varieties decreases over time.

Table 8: Comparison of expert estimates and household survey results (%).

Zone	% Share in rice area	Expert estimate	Household survey
High	20	80	83
Mid	45	40	19
Low	35	55	46
All	100	53	42

A comparison of cultivar-specific adoption estimated through expert panel and through household survey is insightful (Table 9). We clearly observe a delineation of varieties grown in the different domain. Except for Wengkhar Rey Kaap and Sorbang in the mid-altitude zone, and IR 8 in the low-altitude zone, estimates of the adoption are close to the estimates obtained in the household survey.

Table 9: Cultivar-specific adoption (%Area).

	Expert estimates			Household survey			
	High	Mid	Low	High	Mid	Low	All
Khangma Maap	50			39	8		15
Yusi Rey Maap	23			28			10
Yusi Rey Kaap	13			2			1
No 11	3			19	8		8
Jakar Rey Naab	3			9			3
China 7				2			1
Janaam				2			1
IR 64		50			49		8
Wengkhar Rey Kaap		20			2	2	1
Bajo Maap		10			13		2
Sorbang					14		2
Zhung Bara					4		1
Bajo Kaap					2		
Tsepo Bara					1		
BR 153			70		2	57	28
Bhur Rey Kaap			10			13	6
Bhur Kamja			6			4	2
IR 8						13	6
IR 72102						5	2

Jaya						2	1
Pussa						2	1
IR 20913					1	1	
Mansara						1	
Radha						1	1
Other MVs	8	20	14				

Overall, there was a good match between the expert estimates (53%) and the results of the household survey (42%) on the adoption of modern rice varieties. One problem that emerged was the low (19%) adoption rate from the household survey in the mid elevations compared to 40% estimate by panel experts. The mid altitude zone has the largest share (45%) of the rice area and the sampled area may not have been adequate. A relook at the sample size and the data collected will be useful.

Within varieties, the estimation from the household survey for Wengkhar Rey Kaap was low (2%) as against experts' view of 20%. This variety is confined to the eastern region of the country where only two districts were sampled and this may not have captured the entire spread of the variety. In the low altitude belt, the household survey captured many more modern varieties (IR 8, Jaya, Pusa, Mansara) than the experts thought of. There is a varietal inflow from across the Indian border and it is common to find farmers adopting such varieties even if they are not officially released in the country.

During the expert panel discussion, it was strongly felt the expert panel did not represent experts from all areas. So the results may have been biased. This means that supplementary panel for those locations where the data may be less representative need to be conducted. Scientists' estimates of adoption may be biased towards a higher side. Again, the strategy to reduce this type of bias is to include more experts from the local areas. There was a lot of discussion on the estimates for the mid-altitude. It was agreed that it would be better to sub-divide the mid-altitude domain into humid and dry zone. For the humid zone, the improved varieties available are currently very limited – so the adoption rate is likely to be very low. In the dry zone, the adoption rate is expected to be much higher. Conducting an expert panel separately for the dry and wet zone for the mid-altitude might provide better estimates. Experts from the eastern region of the country could not participate in the discussion, but they had provided some estimates in written form. Given the discussion and some limitations identified, it was agreed that such shortcomings needed to be addressed for future panel estimations.

Concluding remarks

Like any other Asian countries, rice is an important food crop in Bhutan. However, the domestic production meets only about half of the national requirement and the Ministry of Agriculture, Royal Government of Bhutan wishes to raise the level of rice self-sufficiency in the country. One of the ways to increase production has been to use high yielding modern varieties. Rice research and development started in 1982 with modest resources. IRRI has been providing technical backstopping since 1984. Rice research is carried out by four main RDCs across the country under the supervision of the DoA. The national rice research program is geared towards developing new rice varieties concomitant with better crop management practices.

So far, a total of 23 rice varieties have been developed and released by DoA. Of the 23 varieties, 15 varieties are introductions and 8 have been developed locally. The varieties cover the entire cultivation domain ranging from high, mid to low altitudinal zones. The country has a relatively short history of institutionalized research program and the research system remains small. The overall investment in research, both in terms of manpower and funds, also remains small and largely inadequate to meet the aspiration of the government in enhancing food production and food self sufficiency in the country. The national rice research program has only five scientists allocating 30-60% of their research time. The scientists are spread across different agro-ecologies and rice ecosystems ranging from irrigated, rainfed to upland. Main disciplines covered are rice breeding, agronomy and crop protection. Among altitude zones, the mid altitude zone currently has the highest allocation of resources, followed by high and low altitude zones. It may be noted here that the resource allocation for low altitude zone is not commensurate with the large rice area it occupies. Due to overall low investment in research, resource allocation amongst rice ecosystems does not seem to make any difference in development.

An adoption study done in 2004 showed that improved rice varieties covered 35% of the total area. To update the data on varietal spread, two more studies were commissioned in 2010. An expert panel estimation was organized as part of the TRIVSA project with IRRI. Results of the expert elicitation showed that modern variety adoption at the national level was 53%, an increase of 18% from 2002. A household survey was concurrently conducted to validate the results of the expert estimation. The survey results showed an overall adoption rate of 42%, slightly lower than the expert estimate. Although the overall match between the results of the two methods was good, a few discrepancies emerged. For instance, the household survey revealed a much lower adoption rate (19%) compared to the expert estimation of 40% for the mid elevation zone. Notwithstanding some shortcomings in the household survey, such a mismatch needs to be understood in more detail. The expert panel discussion was organized for the first time in the country and it was felt that it lacked adequate representation from all rice ecosystems and stakeholders. In general, the estimates derived from expert panel were higher than what the household survey showed. The reason for the discrepancy could be errors in expert panel or household surveys or both. One way to correct possible biases in expert panel-based estimates may be to have a larger number of local experts representing all rice ecosystems and disciplinary areas. Consultation with all relevant stakeholders including non-government organizations and farmers will also be useful.

The concept and methodology of expert estimation is fairly simple, easy to use and saves a lot of time and resources. This method also seems to provide a consensus estimate when experts have the time to discuss and resolve differences in their estimates. This method needs to be further developed and used more often while attempting to minimize the potential errors.

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