RAINFED LOWLAND RICE CULTIVATION IN BHUTAN

A Survey Report

by

Karma
(Asstt. Research Officer)
Mahesh Ghimiray
(Program Officer)

Survey team
Neelam Pradhan (RC Bajo)
Wangda Dukpa (RC Jakar)
Kalpana Rai (RC Bajo)
DB Rana (RC Yusipang)

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Acronyms

AEZ	Agro-ecological zone
C/mari	Changmari geog, Samtse Dzongkhag
DAOs	District agriculture Officers
FYM	farmyard manure
G/ney	Ghumauney geog, Samtse dzongkhag
G/phu	Gelephu geog, Sarpang Dzongkhag
IMVs	Improved Modern varieties
J/cling	Jigmecholing geog, Sarpang dzongkhag
MVs	Modern varieties
Nu.	Ngultrum
TMVs	Traditional Modern varieties
TVs	Traditional varieties
S/soo	Sibsoo geog, Samtse dzongkhag
U/ling	Umling geog, Sarpang dzongkhag
WST	Wet-Sub tropical

Abstract

This study reports on the rice cultivation practices under rainfed environment in Bhutan. In addition, some information on trend and constraints in rice production under the system is also briefly captured to identify possible research and extension intervention for the development of a better breeding strategy and devise an appropriate approach to increase rice production. The report findings are entirely based on a rapid farm survey conducted in two major rainfed lowland rice growing dzongkhags in November- December 2003.

Rainfed lowland rice system, under Wet Subtropical zone, accounts for major portion of rice growing area but contributes least in terms of total production. Improvement in productivity of rice in this zone will increase rice production at the national level and enhance the income at the household level, and thereby improve food security.

Survey region, WST zone, receives four months of rainfall, starting from early June and lasts till early September. The region receives a mean of 13 ± 4 days of rainfall per month with the highest of 20± 4 days of rainfall during the month of July.

Rainfed rice accounts for 40% of total rice area in the kingdom, roughly an area of 2.61 ± 0.91 acres of land per house hold under cultivation.

The production system has broadly three cropping seasons; monsoon, winter and summer season. Single crop of rice is practiced in low rainfall areas and rice-maize, rice-wheat is practiced in areas where the rainfall is adequate. Maize is the predominant crop under upland conditions, followed by mustard, barley and vegetables.

About 33 traditional or introduced local varieties are cultivated by the farmers of the survey region. Traditional varieties are characteristically all white pericarp generally preferred for their good taste and some for scents but are prone to lodging and susceptible to diseases. Due to introduction of different IMVs and TMVS, about 17 local varieties are lost and or more are on threat of being lost forever.

An overall mean yield of rough rice is estimated at 680 kg/acre. The low productivity of rice in the region is due to low yield and low adoption of MVs. Despite significant yield advantage of MVs over local varieties (i.e. 153 kg/acre)

and the rate of adoption of 44% of household, the extent of cultivation in terms of acreage within the household is very small.

Use of chemical fertilizers is limited to 13.2% of total respondents and tethering is the common practice of cow-dung application in the field. Similarly, adoption of improved management technologies such as use of herbcides and pesticides are also very low.

Sowing of rainfed rice commences from late May and extends till late June. Transplanting operation begins by early June and staggers till mid July. Crops are harvested in late November -December.

Sowing and transplanting operations are constrained by lack of assured irrigation. Generally, the source of irrigation in the study region is rainfall dependent and seasonal interflows are the principle source of supply.

Weed, diseases and pest are also major problem in rainfed rice ecosystem and estimated to reduce 2-50% of total grain yield. Adoption of chemical control measures like use of herbicides and pesticides is very low (12% and 16% respectively). Vertebrate pest, especially elephant, is a nuisance in rice crop, often destroying the crop completely. Storage losses due to rodents, weevils and grain moth are estimated at 2-50% of total production.

Approximately, 97 men-days of labor is required to carry out various cultural operations. An additional labor of 60 men-days per season is spent in guarding the crop against vertebrate pest. The existing rate of payment for labor ranged from Nu. 35- 100/- per day and Nu.150-300/- for a pair of bullock. Farmers owning machineries is as low as 3%.

Surplus production of rice is reported in 9.2% of respondents and rest reported just sufficient or shortage of rice for household consumption.

Introduction

Rice is a major crop of the Wet Subtropical zone, which accounts for about 40% of the total rice area in Bhutan. But from the productivity point of view, it is the least productive of all AEZ with an average yield of less than 2t/ha. The low yield is primarily attributed to the poor soil conditions, high disease and pest incidences, and above all, unreliable irrigation supply (9th FYP Strategy Document). The above inverse relation of area and productivity offers an opportunity to raise the production in WST even with slight increase in the current yield level. The WST zone is characterized by long but erratic rainy season where drought frequently occurs in mid season. Hence, the rice crop in this AEZ is grown partially or completely under rainfed conditions.

The rice research attempts in the past have focused on improvements of rice under favourable conditions, i.e. irrigated environments, of high and mid altitudes. Several high yielding varieties and appropriate technology packages have been released for different agro-ecological zones. Despite much progress in rice research and development, rainfed rice received very limited attention till date. No conscious efforts were made in improving production of rice of the unfavorable condition. Even the varieties released for similar altitudes could make little difference in productivity because the breeding attempts were targeted on irrigated environments and were constrained by the lack of clear understanding of rainfed environment. Thus, it was decided during the 5th National Field Crops Co-ordination Workshop in 2002, to carry out a study to capture the production system of rice under lowland rainfed conditions in Bhutan. The RC Bajo has the national responsibility for coordinating this activity in collaboration with RC Yusipang, RC Jakar and dzongkhag Agriculture of Sarpang and Samtse.

Objectives of the study

Briefly, the main objectives of this survey are:

- To understand cultivation/farming practices of lowland rainfed rice
- To study production trend and future potentials of rainfed rice
- To identify production constraints and needs for research interventions
- To develop a breeding strategy to improve rice production in rainfed environments

Rainfed Rice Environments

A precise definition in scientific terms for the rainfed rice environment in Bhutan is yet to be developed. However, for the purpose of this study the rainfed rice environment is defined as "*a target population of environment where rice fields are naturally flooded and there is limited control over irrigation water. Rice is often direct seeded or transplanted when rain intensifies and the soil surface may be flooded during part of crop cycle*".

By definition, the proposed rainfed environment under study is devoid of any controlled water supply and the crop is dominantly controlled by seasonal rainfall. Rainfed ecosystem in this context covers both *upland* and *lowland* unfavorable conditions (IRRI 1984 & *Machill et al* 1996). Upland suggests that the rice is grown in dry fields that are not flooded whereas lowlands are terraced and flooded. The main difference between lowland and upland rainfed rice is that the lowland type is grown in bunded terraces where water is colleted and impounded, whereas upland rice is grown in dryland without rice terraces/bunds just like maize or other non-irrigated crops.

In our context lowland rainfed rice is similar to irrigated rice, the main difference being the source of irrigation water; rainfed rice depends completely on the amount of rainfall received in the crop season and does not have perennial round-the-year source of irrigation water. Thus this study was focused on areas where irrigation control was absent, or where there was no assured source of irrigation and rice cultivation depends completely on rainfall or monsoon.

Methodology

1. Sampling Method and Sample Size

The proposed sites for sampling were Sarpang and Samtse, two potential rainfed lowland rice growing dzongkhag in Bhutan. From each dzonkhag three representative sample geogs, identified as potential rainfed lowland rice growing areas were selected through consultation with the concerned DAOs. Potential pockets/villages of the study were then selected with the help of DAOs and extension staff. Stratified random samplings of households were done from each village in order to cover all possible altitude range of the sample geog. The attempt was to select at least 10 households per geog and obtain substantially comfortable sample size.

2. Sampled house hold category distribution by geogs and altitude ranges

A total of 76 farming households were surveyed from two selected dzongkhags. Of the total, 46.1 % of households (n=35) were from Sarpang and 53.9 % house holds (n=41) from Samtse dzongkhag, which exhibits a good proportion of sample distribution on either sites.

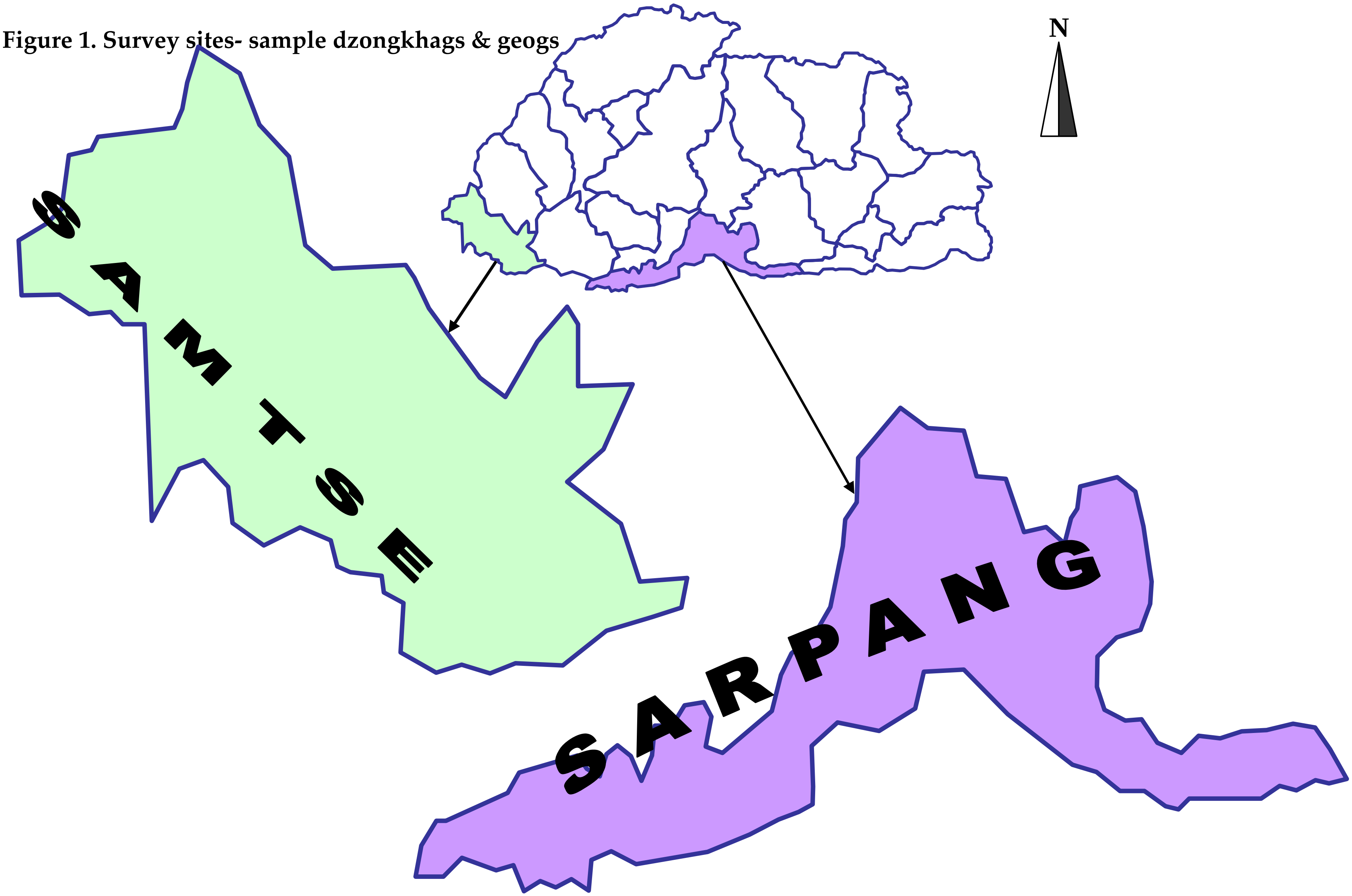
Table 1 Distribution of households and altitude range within geogs

	Geogs						
	G/phu	**J/cling**	**U/ling**	**G/ney**	**S/soo**	**C/mari**	**Total**
No. of selected household	10	15	10	15	13	13	76
Altitude (masl)	300-350	1260- 1450	350- 400	500-570	500-890	400-1800	300-1800

3. Data processing and analysis

Informal question and answer were done with individual farmer with the pre-set questionnaire. Data obtained were crossed checked in the field itself. MS excel was used for database and crossed checked which than was transferred to SPSS software (version11.0) for analysis. Tools such as cross tabulations, frequency and ANOVA were used for analysis and interpretation of the results.

Figure 1. Survey sites- sample dzongkhags & geogs



Results

Bio-physical environment

Rainfall

The rainy season starts by early June and ends by early September (Table 2), with an average rainfall duration of four months across the study sites. On an average, the region receives 13 ± 4 days of rainfall/month through out the rainy season (range of 10-23 days rainfall/month). The highest rainfall is received during mid July-mid August, with an average of 20 ± 4 days of rainfall per month (Table 3).

Due to unavailability of meteorological data during the survey, detailed reports on patterns, frequency distribution and quantity of rainfall cannot be established for this study.

Table 2. Percent of respondents for the start and end of rainy season by geog

Geog	Start		End	
	June	Late June	August	Early Sept
Gelephu	3.9	9.2	2	8
Jigmecholing	6.6	13.2	10	5
Umling	10.5	2.6	0	10
Ghumauney	9.2	10.5	8	7
Sibsoo	13.2	3.9	10	3
Changmari	9.2	7.9	9	4
Nos. of respondents	**40**	**36**	**39**	**37**
Total	**76**		**76**	

Table 3. Mean of average (days) monthly rainfall and peak rainfall (days) by geogs

Geog	Average days of monthly rainfall	Days of rainfall during peak month
Gelephu	13.7 ± 1.3	20.7 ± 1.4
Jigmecholing	12.4 ±1.1	18.8 ± 0.9
Umling	10.8 ± 0.5	18.5 ± 0.7
Ghumauney	14.5 ± 1.1	20.7 ± 0.9
Sibsoo	14.9 ± 1.3	21.1 ± 0.9

Changmari	13.3 ± 0.7	20.3 ± 1.1
Total	**13.0 ± 0.4**	**20.0 ± 0.4**

Landscape and topography

The type of landscape is from gently undulating to steep for the rainfed rice field. A total of 59.2 % of the respondents cultivated rice in plain or gentle slopes and, 23.7 % of respondents in gently undulating areas. Few cases of rice fields with steep topography (>30^0) were observed.

Table 4. Percent of respondents for topography/slope of their rice field by geogs

	Geogs						
Topography	**G/phu**	**J/choling**	**Umling**	**G/ney**	**Sibsoo**	**C/mari**	**Total**
Gently slope (<10^0)	10.5	3.9	5.3	18.4	11.8	9.2	**59.2**
Gently undulating (10-15^0)	2.6	1.3	6.6	1.3	5.3	6.6	**23.7**
Undulating (15-20^0)	0	6.6	1.3	0	0	0	**7.9**
Steep (20-30^0)	0	7.9	0	0	0	1.3	**9.2**
Total	13.2	19.7	13.2	19.7	17.1	17.1	**100**

Soil

From the results of Table below, the percent of response (data based on response from farmers and visual observation by interviewer) for the type of rainfed rice soil are 39.4 % fine clay, 32.4 % sandy loam, 25.4% clay loam and 2.8 % of coarse sandy soil. Of all, brown- reddish clay soils dominate the rice pedology in the region followed by grayish-black sandy loam soils.

Table 5. Percent of respondents for type of soil in the rice field by geogs

	Geog						
Soil type	**G/phu**	**J/choling**	**Umling**	**G/ney**	**S/soo**	**C/mari**	**Total**
Fine clay	-	11.3	8.5	8.5	4.2	7.0	39.4
Clay loam	4.2	4.2	-	8.5	2.8	5.6	25.4
Sandy loam	8.5	5.6	1.4	4.2	7.0	5.6	32.4
Coarse sandy	1.4	-	-	-	1.4	-	2.8

Nos. of respondent	10	15	7	15	11	13	71

Area and land use pattern

The exact acreage under rainfed rice area cannot be stated as no such work has been done in the past due to lack of clear cut delineation between irrigated and rainfed rice systems. However, the major portion of the WST rice zone comprises of rainfed lowland rice, which accounts for 40% of the total rice area. Based on the estimates from the collected data, rice environment ranged from 300 to 1800 masl.

On an average, an area of 5.08 ± 0.48 acres/household is under cultivation from which rainfed rice cultivation accounts for **58.2 ± 27.4** % of the total, i.e, approximately an average of **2.61 ± 0.19** acres per household. Rice cultivation under assured irrigation as low as **0.44 ± 0.13** acres/household. Considering the large acreage of rice cultivation under the system, rainfed lowland rice warrants more attention in terms of resource reallocation in research and development.

Table 6. Mean area (acres) of land use pattern with in the geog.

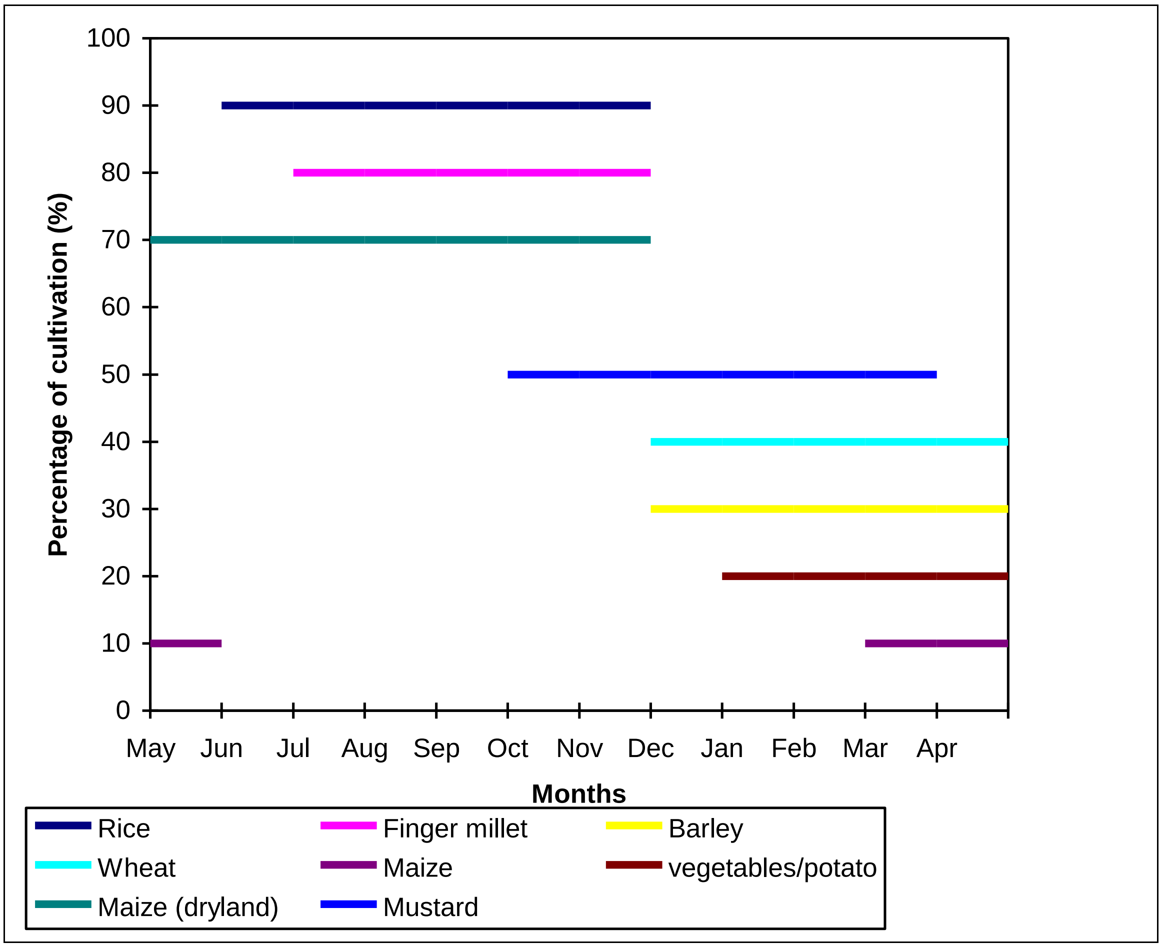
Geog	Total land holding	Total cultivated land	Total rice area	Rainfed rice area	Rice under assured irrigation
Gelephu	5.30 ± 0.34	4.34 ± 0.12	2.93 ± 0.27	2.58 ± 0.43	.33 ± 0.33
Jigmecholing	8.63 ± 1.75	6.77 ± 1.30	3.45 ± 0.39	3.65 ± 0.48	.70 ± 0.37
Umling	5.00 ± 0.00	3.60 ± 0.40	2.67 ± 0.26	2.21 ± 0.33	.15 ± 0.15
Ghumauney	5.80 ± 0.85	4.15 ± 0.65	2.58 ± 0.48	2.50 ± 0.51	.07 ± 0.06
Sibsoo	5.88 ± 0.57	4.49 ± 0.84	2.77 ± 0.37	2.55 ± 0.39	.62 ± 0.38
Changmari	7.89 ± 1.69	5.37 ± 1.54	2.62 ± 0.34	2.01 ± 0.41	.70 ± 0.40
Total	**6.52 ± 0.50**	**5.08 ± 0.48**	**2.87 ± 0.15**	**2.61 ± 0.19**	**.44 ± 0.13**
No. of respondents	**66**	**58**	**70**	**61**	**76**

Cropping Pattern

Depending on the rainfall distribution, the crop year is divided broadly into three growing seasons; monsoon season (June-July to November December), winter season (November-December to March April) and the summer season (March- June). In the lowland conditions, the land is mostly left fallow after the single rice crop. However, in areas where there is adequate monsoon rain, rice-maize and rice wheat are the predominant cropping patterns. Rice is planted in early June-July and harvested in late October-November. To take advantage of the residual moisture from the soil, farmers sow maize or wheat or potato immediately after harvesting rice in November. Some farmers also practice finger millet-finger millet and relay cropping of finger millet-maize in the lowland areas where transplanted finger millet replaces rice.

In the uplands, mustard, barley, buckwheat and vegetables (radish, turnip and spinach) are planted in December and harvested in March-April. Some practices of second maize crop during the month of March to June are also prevalent in some pockets.

Figure 2. Major cropping patterns under rainfed eco-system



Cultivated local varieties

A total of 33 local varieties are reported being cultivated presently, fourteen of which are exclusively cultivated in Samtse dzongkhag and two varieties, Attey and Choti Masino, cut across Sarpang dzongkhag also. A total of nine varieties are presently cultivated at Sarpang dzongkhag.

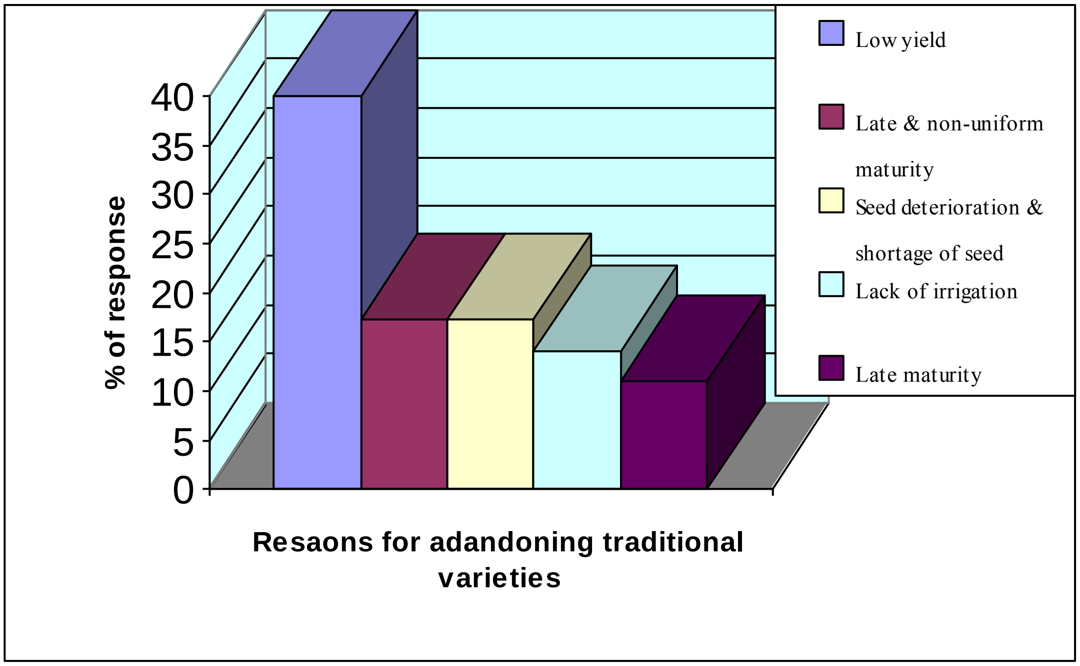
Choti Masino, Jasuwa, Babu Jasuwa, Kalo Noonia, Chotakati and Mansara (Rato & Chettri) are major varieties cultivated by the farmers of Samtse dzongkhag. In Sarpang, Choti Masino, Mama and Mauli are some of the widely cultivated varieties in the dzongkhag (Appendix 1).

Cultivated locals are almost all white pericarp varieties, generally of good taste and some scented. Most varieties are easy to thresh, some even reporting shattering loss in the field in case of 'very easy' to thresh cultivars. Most landraces of this environment are prone to lodging, and susceptible to diseases and pests.

Genetic loss

Over the last decade or two, farmers reported to have cultivated many varieties in addition to the existing ones. Today, about 17 landraces are either lost or are on threat of being lost forever (Appendix 2). Various reasons were given for discontinuing a particular variety, of which the low yield characteristics, stands out to be the major factor. Seed quality deterioration and late and non-uniform maturity are next important reasons, both contributing equally to the genetic loss/erosion.

Figure 3. Percent of response for different reasons for discontinuing cultivation of local varieties



Modern Varieties

BR 153 commonly cultivated improved modern variety, accounting for 69.7 % of the total cultivated improved modern varieties (IMVs) in the region, and is more widely cultivated in Sarpang dzongkhag. In Samtse dzongkhag, both IR 8 and BR 153 are commonly cultivated IMVs,adopted in equal proportion. Other IMVs like Bajo Kaap, IR64, Pusa 33 and TMVs (traditional modern varieties), Bikashi are also being cultivated by some farmers (Table 7).

Table 7. Percent of respondent cultivating different modern varieties by geogs

	Geog					
Modern variety	**G/phu**	**U/ling**	**G/ney**	**S/soo**	**C/mari**	Total
BR 153	24.2	30.3	-	9.1	6.1	**69.7**
IR64	-	-	3.0	-	-	**3.0**
Bajo Kaaps	-	-	6.1	-	-	**6.1**
Bikashi	-	-	-	3.0	-	**3.0**
IR 8	-	-	-	6.1	9.1	**15.2**
Pusa 33	-	-	-	-	3.0	**3.0**
Nos. of respondents (n)	**8**	**10**	**3**	**6**	**6**	**100 n=33**

Yield gap between modern and traditional rice varieties in the rainfed lowland eco-system

Table 8. shows the average yield gap between modern and traditional rice varieties in Sarpang and Samtse dzongkhags. The average yield of MVs in Sarpang is 690 kg/acre, whereas the average yield of TVs is reported to be 537 kg/acre. In Samtse dzongkhag, the average yield of MVs is 823 kg/acre and that of TVs is 668 kg/acre. Generally, traditional varieties are lower yielding than cultivated modern varieties across the rainfed environment with an average yield gap of 153 kg/acre.

Table 8. Average yield (kg/acre) of traditional and modern varieties in Sarpang and Samtse Dzongkhags

Dzongkhag	Av. yield of traditional varieties	Av. yield of modern varieties	Yield gap
Sarpang	537	690	153.3
Samtse	668	823	154.5
Average	**603**	**756.5**	**153.5**
Overall average yield	**680**		

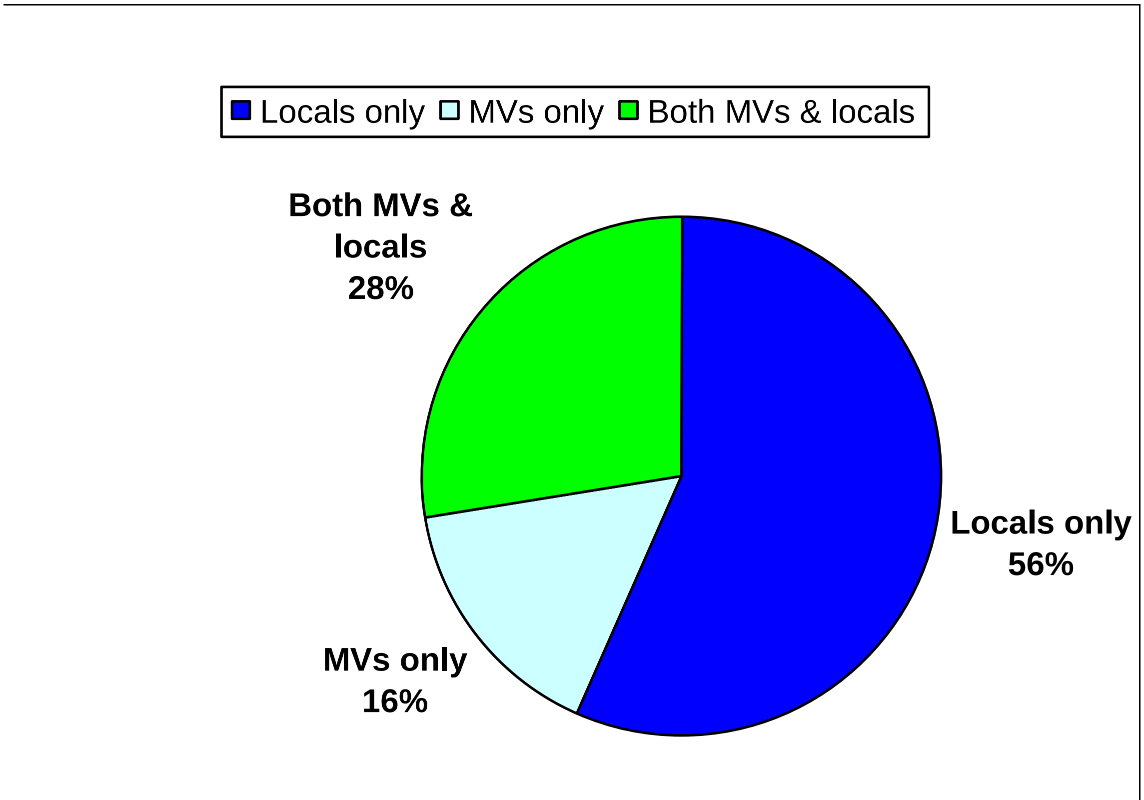
Constraints to adoption of modern varieties and their component technologies

Adoption of modern varieties

Approximately 44% of the households have registered the adoption of MVs in Sarpang and Samtse dzongkhag from which 15.6 % cultivates solely modern varieties. However, major chunk of the households (56%) in the survey region have not adopted the modern varieties, which could be the main reason for the lower productivity of rice in the area. Even among the adopters, the acreage of modern varieties cultivated in a household is lower than that of local varieties.

Low adoption rate of IMVs could be attributed to the varietal characteristics of modern varieties and its preferences by farmers. Besides BR 153, cultivated modern varieties like IR 8 and IR 64 were those targeted for the favourable irrigated conditions, which however have been adopted by some farmers due to the proximity of targeted environment where the varieties were easily available through extension crop promotion programs.

Figure 4. Percent of rate of adoption of rice varieties



These varieties yield low under low input conditions like fertilizers and irrigation and yield is generally unstable under drought conditions. Certain negative traits of MVs, like poor taste,, difficulty in threshing, etc. (Table 9), are also perceived by farmers as factors affecting for its poor adoption. Understanding the farmers' preferences and conducting on-farm studies with regards to varieties and selection of promising materials would be the imminent strategy to improve production.

Table 9. Summary of positive and negative traits of modern varieties by farmers

Varieties	Positive traits	Negative traits
BR 153	Moderate yield under high input/irrigated condition, Stable yield Early maturity Resistant to pest and diseases	Poor taste Bit hard to thresh Low milling recovery with more 'brokens'

IR 64	Resistant to lodging Resistant to pest and diseases	Low yield
Bajo Kaap 1 & 2	Resistant to lodging Resistant to pest and diseases	Unstable yield Low yield Poor taste
Bikashi	Moderately resistance to drought	Poor taste Hard to thresh
IR 8	Good yield in high input condition	Susceptible to diseases & pest Unstable yield Succumbs to drought
Pusa 33	Resistant to lodging	Low yield

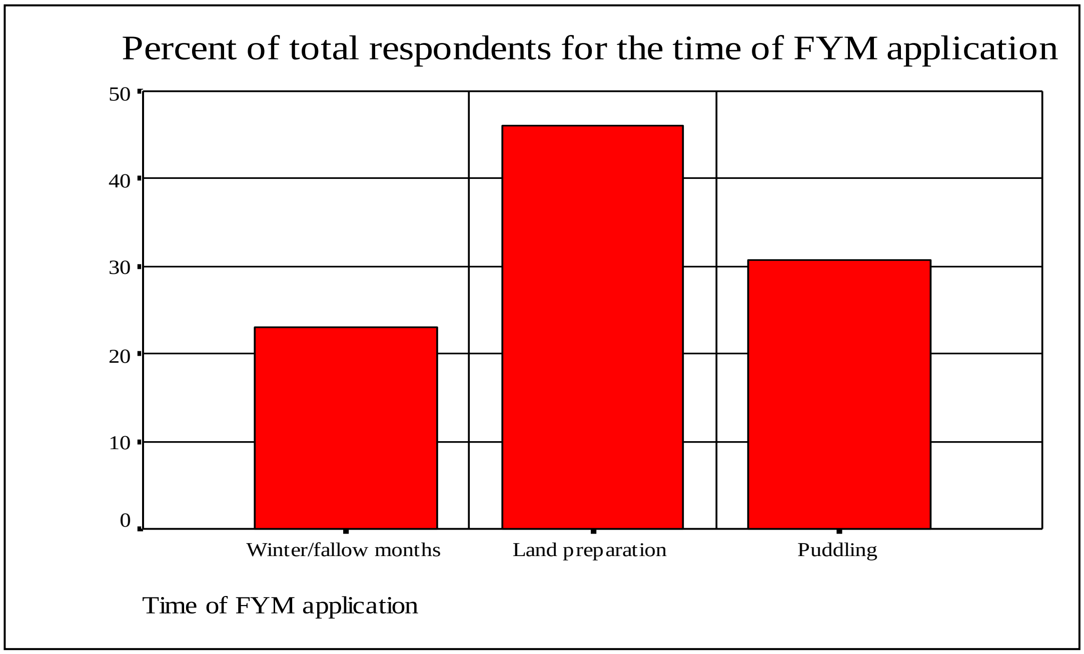
Adoption of chemical fertilizers

Cow dung compost or FYM is usually applied, by carrying it in the basket, in the field few weeks prior to land preparation. FYM application by carrying is limited to 23 % of the total observation, whereas in-situ application by tethering is the principle practice followed through out the surveyed region. Tethering is usually done during fallow months, where second crop after rice is usually not cultivated.

Table 10. Percent of respondents for FYM/cowdung compost application across geogs

Response	**Geog**						
	Changmari	**Sibsoo**	**Ghumauney**	**Umling**	**Jigmecholing**	**Gelephu**	**Total**
Apply by carrying in baskets	30.8	23.1	33.3	0	20	25	**23.0**
Do not apply at all	23.1	23.1	46.7	100	20	12	**36.5**
Tethering	46.2	53.8	20.0	0	60	62	**40.5**

Figure 5. Percent of respondents for the time of application of FYM



The use of synthetic fertilizer is very low. Only 13.2% of the total respondent reported the use of synthetic fertilizers whereas 86.8% still do not use chemical fertilizers. Urea and suphala are the common chemical fertilizers used by few farmers. The non-availability of chemical fertilizers or non-availability on time has emerged as the most important constraints to its adoption by farmers. Besides, farmers responded that high cost of fertilizers make their application unprofitable in the rainfed lowland ecosystem where the dependence on monsoon and inefficient water management techniques reduce the efficiency of chemical fertilizers. Besides, given the subsistence farming system of rainfed environment farmers do not afford to buy 'high-cost' fertilizers.

Table 11. Percent of respondents for use of synthetic fertilizers in rice crop

	Geog						
Chemical fertilizer use	**G/phu**	**J/cling**	**U/ling**	**G/ney**	**S/soo**	**C/mari**	**Total**
Yes	7.9	2.6	1.3	1.3	-	-	13.2
No	5.3	17.1	11.8	18.4	17.1	17.1	86.8
Nos. of response	**10**	**15**	**10**	**15**	**13**	**13**	**76**

Cultural operations

Sowing

Sowing of rice in the survey region commences from late May and sometimes extends till late June when the monsoon rains are late. Sowing is either done with the first shower of rain or in dry fields. Seed is broadcasted evenly in the field and covered by light planking or by hand.

On an average, the quantity of seed rate used is **26.5 ± 1.6** kg/acre, with significant differences with in geogs.

Table 12. Mean of seed rate (kg) used across geogs

	Geog						
	Gelephu	**J/choling**	**Umling**	**Ghumauney**	**Sibsoo**	**Changmari**	**Total**
Mean	33.3	26.5	35	26.7	19.6	28.0	**26.5±1.6**
Nos. of response	6	7	1	15	11	13	53

Transplanting

Transplanting is the principle crop establishment method employed in the rainfed system (97.4%). Direct seeding of rainfed is observed in only 2.6% of the total sample household, which is typical to Umling and Ghumauney geogs. Transplanting starts by early July and last till first week of August. The major source of water during this time is from the rainfall activated streams, springs and interflows. In many areas the volume of water is not adequate, since major transplanting coincides with the beginning of rainfall where the frequency is low and of less intense.

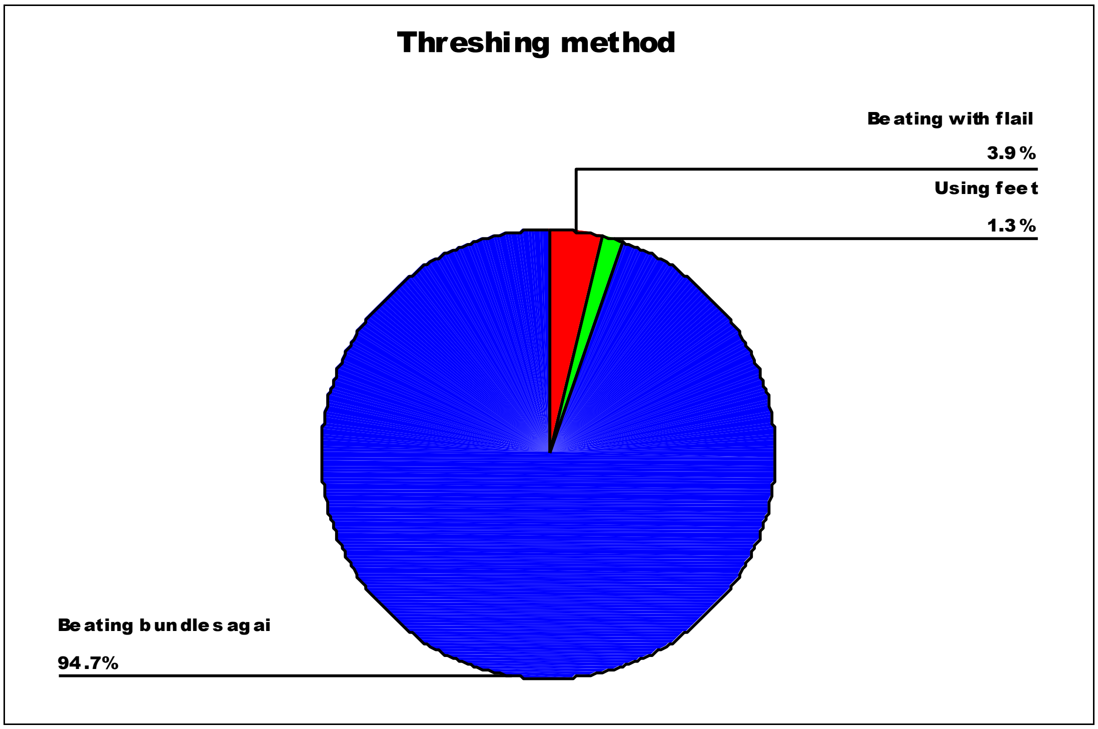
Table 13. Percent responses for methods of crop establishment employed

Crop establishment method	**Geogs**						
	Gelephu	**J/choling**	**Umling**	**G/ney**	**Sibsoo**	**C/mari**	**Total**
Transplanting	13.2	19.7	11.8	18.4	17.1	17.1	**97.4**
Direct seeding	-	-	1.3	1.3	-	-	**2.6**
Nos. of respondents	**10**	**15**	**10**	**15**	**13**	**13**	**100 (n=76)**

Harvesting and threshing

Harvesting is usually done by sickle after which the harvested bunch is left in the field to dry for few days (3-7 days). Threshing is often done in the field itself wherein dried bundles are threshed against stones or wood (95%) or the bundles are threshed by beating with flail (4%).

Figure 6. Percent of different methods of threshing of rice



Production Constraints

Constraints in Irrigation

About 22.8 % of the total sample household has an assured irrigation through perennial source, wherein the conducting systems are either concrete or traditional mud canals. Approximately, 54.3% water sources are seasonal interflows and rainfall activated springs and roughly 22.9% of farmers depend directly on rainfall for transplanting.

Table 14. Percent respondents for source of irrigation by geogs

Source	Geog						
	Gelephu	J/choling	Umling	G/ney	Sibsoo	C/mari	Total
Perennial canals	4.3	1.4		2.9	1.4	1.4	**11.4**
Perennial rivers/ streams/ springs	1.4	4.3		1.4	1.4	2.9	**11.4**
Rainfall activated sources/interflows	7.1	14.3	4.3	8.6	8.6	11.4	**54.3**
Direct rainfall	1.4	1.4	4.3	7.1	5.7	2.9	**22.9**
Total	14.3	21.4	8.6	20.0	17.1	18.6	**100**

Major problem of the existing discharge system of water in the study area is that the source is rainfall dependent, irregular and unreliable. Discharge rate is often low and discontinuous during the time of transplanting. In addition, heavy showers during peak season leads to frequent landslides, floods and wash-aways disrupting the continuity of water, both in seasonal and perennial irrigation system (Table 15), especially in traditional system.

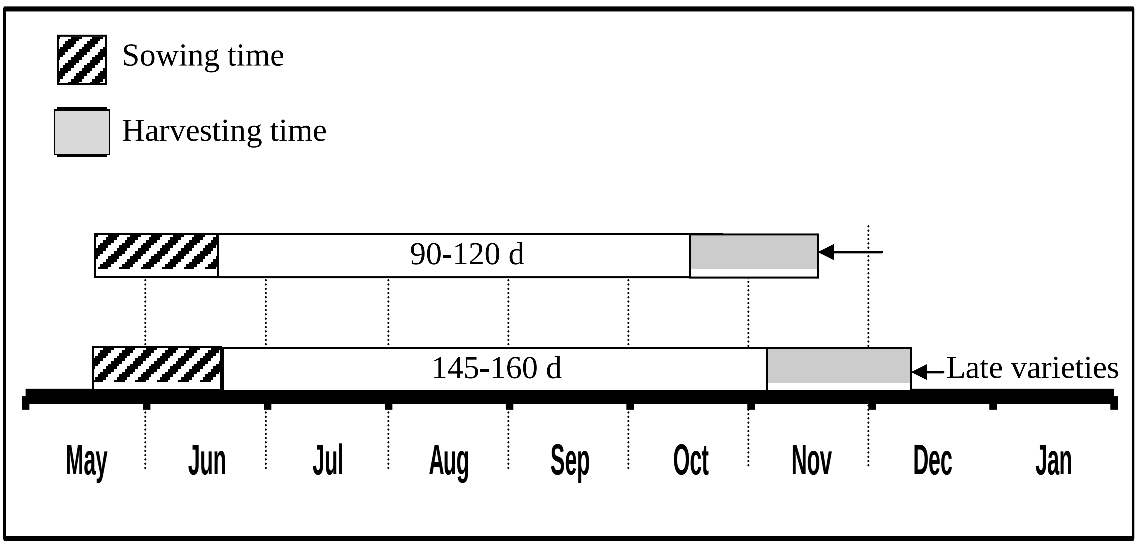
Table 15. Percent respondent for major constraints in irrigation system by dzongkhag

Dzongkhag			
Problems in irrigation system	Sarpang	Samtse	Total
Less water volume & low discharge rate during transplanting	10.2	18.4	28.6
Damage of canals by landslides/sinking area/erosion	18.4%	4.1	22.4
Irregular & erratic supply	16.3	32.7	49.0
Total	**44.9**	**55.1**	**100**

Drought Stress

Drought has long been considered as the primary constraints to rainfed rice production. Similarly, the survey region is characterized by erratic rainfall pattern, often exposing the crop to drought during the critical stages, thereby adversely affecting the crop yield. Figure 7, shows the major rice growing seasons of rainfed lowland in Bhutan. The sowing season begins by late May when there is little or no rainfall due to which the sowing operation is hampered. Farmers have to stagger sowing operation till mid June while waiting for rain. This in turn delays the transplanting operation as a whole.

Figure 7. Rice Seasonal calendar



Rainfall season begins only by June, where as the sowing has to be carried out in late May, to synchronize transplanting with the probable monsoon rain in July. Hence, sowing is done either by dry bed or wet bed method.

As per farmers, the area often experiences dry weather extended for weeks, right after transplanting, resulting in hardening of puddled soil, exposing young plants to drought stress. Besides, drought condition also hits plants during critical stages such as tillering and flowering stage which is often manifested as low tiller numbers and too many empty panicles. A reliable and adequate metereological data over the years, which could not be obtained during the survey, will be invaluable in future for proper understanding and analysis of the system. Developing drought escaping technologies and drought tolerant varieties will be an effective approach to address the drought stress.

Constraints in Weed Management

Weed is one of the major problems of rainfed rice system whereby the climatic condition favours vigorous weed growth. Of the total, 90% of respondents reported problems due to severe weed infestation in their rice field.

Table 16. Percent of respondents expressing weed infestation problem in rice by geogs

Response to weed problems	Geog						
	G/phu	J/cling	U/ling	G/ney	S/soo	C/mari	Total
Yes	13.2	15.8	10.5	17.1	17.1	15.8	89.5
No	-	3.9	2.6	2.6	-	1.3	10.5
Nos. of respondents	**10**	**15**	**10**	**15**	**13**	**13**	**76**

Hand weeding is the major weed control measures employed and use of chemical herbicides, Butachlor, as a control means is limited to as low as 11.8% (Table 17). Non-availability and non-availability on time is the main reasons cited by farmers for limited use of chemical herbicide. Usually one to two hand weeding is carried out within two to three weeks after transplanting. The mean rate of application of Butachlor across two dzongkhags was 6.44 ± 4.2 kg/acre and rate of application widely differed from farmer to farmers. Approximately, 2-50% yield is reported to be reduced due to weed infestation, depending on the severity of infestation.

Table 17. Percent of respondents for weed control measures by geogs

Weed control measures	Geog						
	G/phu	J/cling	U/ling	G/ney	S/soo	C/mari	Total
Hand weeding	70	66.7	100	100	92.3	100	88.2
Both hand weeding & herbicide	30	33.3	-	-	7.7	-	11.8

Diseases

Of the total respondents, 75% reported problems related to diseases in rice crop. Definite diagnosis of diseases and symptoms is beyond the scope of this study and it will require in-dept study of diseases at field level by a specialist in future to adequately tackle the problems of diseases.

Table 18. Percent of response for disease problems in rainfed rice crop

	Geog						
Disease problems	**Gelephu**	**Jigmecholing**	**Umling**	**Ghumauney**	**Sibsoo**	**Changmari**	**Total**
Yes	5.3	3.9	3.9	2.6	6.6	2.6	**25.0**
No	7.9	15.8	9.2	17.1	10.5	14.5	**75.0**
Total	13.2	19.7	13.2	19.7	17.1	17.1	**100 n=76**

However, through the interviews, some basic information was obtained with regards to disease problem in the survey area. Panicle sterility, wherein panicles turn whitish and fail to form grains, accounts for 46.7% of the total incidences. Yellowing and drying of whole plants in patches, which is common under drought condition in early stages of the crop, accounts for 20% of the total incidences. However, the cause for the above two problems are not ascertained whether it is due to pathogens or manifestation of drought stress. Incidences of node-blast, base rot and leaf spots are also reported in the system.

Table 19. Percent of respondents for disease by stage of maximum occurrence

Stage of crop attacked					
Disease	**Seedling stage**	**Tillering stage**	**Panicle initiation**	**Maturity**	**Total**
Empty & whitish panicles	-	-	46.6	-	**46.6**
Yellowing & drying of whole plants in patches	6.7	13.3	-	-	**20.0**
Base-rot	6.7	13.3	-	-	**20.0**
Leaf-spots	-	6.7	-	-	**6.7**
Node blast	-	-	6.7	-	**6.7**
Total	13.4	33.3	53.3	-	**100**

The practice of chemical spraying is practiced by as low as 17.6% of farmers. Traditional practice of draining out water from the field is practiced by some farmers to reduce crop damage during severe disease outbreak but effectiveness of the method is not known. It is estimated that the diseases accounts for 1-50% reduction in rice grain yield, depending upon the nature and severity of out-break.

Table 20. Percent of respondents for disease control measures employed

Control Measures	Valid Percent
Spraying fungicides by Agri. Extn	**17.6**
No control	**76.5**
Drain out water from field	**5.9**
Total (n=76)	**100**

Insect pest

About 79% of the respondents reported insect pest problem in their rice field of which the major ones are shoot borer and case worms reporting 37% and 35% of the total incidences, respectively (Appendix 4).

Table 21. Percent of respondent for problems of insect pest across geog

Response	Geog						
	G/phu	**J/cling**	**U/ling**	**G/ney**	**S/soo**	**C/mari**	**Total**
Yes	10.5	13.2	10.5	13.2	17.1	14.5	**78.9**
No	2.6	6.6	2.6	6.6	-	2.6	**21.1**
Total	13.2	19.7	13.2	19.7	17.1	17.1	**100 n=76**

Control measure is not practiced or known by as much as 48.2% of the total households. Insecticide spraying with the help of extension agents is done by as few as 28.6% of the sampled farmers and other measures, like flooding and controlled irrigation, is practices by some farmers having assured and adequate irrigation. Insect pest is estimated to cause 22% of reduction in yield (Appendix 3).

Table 22. Percent of respondents for different insect pest control measures

Insect pest control measures	Dzongkhag		
	Sarpang	Samtse	Total
Application of insecticide	16.1	12.5	28.6
Controlled irrigation and draining out water	14.3	7.1	21.5
No control	12.5	35.7	48.2
Flooding	-	1.8	1.8

Vertebrate pest

Vertebrate pest is the major problem in rice crop in the region. All the respondents expressed serious concern to the damage of standing crop by elephants (42%), monkeys (26%), wild boar and rodents.

An approximately, damage due to vertebrate is responsible for 47% reduction in production from the field (Table 23). Under severe cases of attack, especially by elephants, 80-100% of the standing crop is reported to be damaged and the farmers are left with nothing to harvest.

Table 23. Percent of estimated yield loss by vertebrate pest across geogs

	Geog						
	G/phu	J/cling	U/ling	G/ney	S/soo	C/mari	Total
Mean	69.50	30.63	70.50	18.75	39.90	32.78	47.33

Guarding is the only control means employed, which often accounts for maximum labor and time spent by farmers in the rice production in the rainfed environment, which is often ineffective against animals like elephant, leading to complete destruction of the crop.

Constraints due to storage pests

Drying of plants in the field is common practice through out the survey region. A slight shower after the harvest adversely affect the quality of grains and milling recovery and sometimes rainfall extended for weeks leads to complete loss of the harvest.

Grains are usually stored in wooden boxes (54%), gunny bags (35.5%) and closely knitted bamboo or cane baskets.

Table 24. Percent of respondents for type of storage containers used

Container type	Frequency	Percent
Gunny bags	27	35.5
Wooden boxes	41	53.9
Bamboo/cane baskets	8	10.5
Total	76	100.0

Grain-moth is major pest (55%) that damages the stored rice, followed by weevil (31%). Rodents cause damage but to a limited amount. Storage pest is estimated to cause reduction 13% of total produce while storing.

Table 25. Percent of respondents for different storage pest incidences

	Dzongkhag		
Storage problems	**Sarpang**	**Samtse**	**Total**
Weevil	16.4	14.9	**31.3**
Grain moths	22.4	32.8	**55.2**
Rats	7.5	4.5	**11.9**
Others	1.5	-	**1.5**
Total	47.8	52.2	**100 n=76**

Labour use and mechanization

By virtue of rice cultivation being an intensive farming, shortage of labour is always a serious concern. Cent percent of respondents reported shortage of labour as a constraint for rice cultivation, wherein the family labour is not enough for rice cultivation. The household meet their labour requirement either by hiring external labour or by exchange of labour within the community. The rate of payment for labour ranged from Nu.50-100/- per day, deferring from village to village. The hire charge for a pair of bullock for a day ranged from Nu. 150/- to Nu. 180/-.

Table 26. Rate (Nu.) of payment for labour and a pair of bullock across geogs

	Geog					
	G/phu	**J/cling**	**U/ling**	**G/ney**	**S/soo**	**C/mari**
Men	50	100	50	40	50	50
Bullock	130	180	150	150	150	150

Overall, to cultivate an acre of land, approximately 97 men-days of labour is required and an addition of 60 men days for guarding the crop against vertebrate pest. In a season, 20 pairs of bullock/day is required for cultivating an acre of rice crop under the rainfed lowland environment

Table 27. Mean of labour and bullock requirement for different rice cultural operations

Sl. No.	Operations	Labour (men-days/acre)	B.ullock (pair-day/acre)
1.	**Land preparation**	22	12
1.	**Sowing**	2	1
2.	**Nursery management**	3	-
3.	**Transplanting**	19	7
4.	**Irrigation management**	13	-
5.	**Weeding**	18	-
6.	**Crop guarding**	60	-
7.	**Harvesting**	12	-
8.	**Threshing & cleaning**	9	-
	Total	**157**	**20**

The level of farm mechanization is very minimal, i.e. 4% of the total households. Exploring the possibilities of mechanization and equipping farmers with efficient labour saving devices will make rice cultivation attractive and save labour and time, which in turn will improve income generation of the household.

Table 28. Agriculture Machinery owned

Owning farm machines	Frequency	Percent
Yes	3	3.9
No	73	96.1
Total	76	100

Production status

The production of rainfed rice is far from being self-sufficient. The rice produced is often not adequate for consumption. Surplus production is reported in as low as 9.2% of the surveyed household, the rest reported shortage (46.1%) or just sufficient (44.7%) for consumption even when supplemented with other cereals like maize, millet and wheat.

Table 29. Percent of respondents for production status of rainfed rice by geogs

	Geog						
	G/phu	**J/ling**	**U/ling**	**G/ney**	**S/soo**	**C/mari**	**Total**
Shortage	2.6	9.2	6.6	14.5	6.6	6.6	**46.1**
Just enough	9.2	6.6	6.6	3.9	7.9	10.5	**44.7**
Surplus	1.3	3.9	-	1.3	2.6	-	**9.2**
Nos. of respondents	10	15	10	15	13	13	**100** **N=76**

Farmers with insufficient production meet their requirement by purchasing rice from the nearest market or from neighboring farmers. Acute shortage of rice is reported during the month of July (transplanting time) - September (prior to new harvest of paddy), for a duration of 3 months.

Table 30. Mean of quantity of rice purchased/household in a year

Dzongkhag	Sarpang	Samtse	Total
Quantity (kg) of rice purchased	206 ± 52	362 ± 62	299 ± 44

Conclusions and recommendations

The Wet Subtropical rice growing zone consists of 40% of total rice area in the country but contributes only 29% of the total production. At the household-level, rice shortage is reported in 46% of the total household and estimated at 4 months. Despite much improvement in rice research and development the low contribution of WST to the total rice production indicates that it did not fare well. The households of mid-altitudes benefited the most from the research efforts in the past because most efforts were concentrated in generating technologies for the favourable irrigated conditions of mid altitude. The production system of rainfed rice was not understood in the past and hence no conscious effort could be made to improve production in this environment. Thus this study was conducted to throw light upon the nature of growing environment and gain a better insight to the production system of WST.

The WST largely represented rainfed lowland rice system with slight transition of irrigated system, wherever the source of irrigation is assured. Typically, the rice environment is constrained by assured source of irrigation and crops are often exposed to drought stress during critical stages. During the rainfall season, landslides and erosion is common which a serious concern to all farmers of the region, often damaging water conducting system and disrupting the continuity of discharge of water.

The production status of the rice in the given environment is far from sufficient where 45% of farmers reporting shortage and have to depend on other cereals and purchase rice from the market to sustain the household. To increase production of rice in the given environment will require multiple interventions from agricultural research, extension and policy support for agriculture development. However, the details and manners of necessary multiple interventions are beyond the scope of this study. Nevertheless, following suggestions specifically related to rice research and development under the rainfed environment are made on the basis of findings of the survey.

- Primarily, lack of assured irrigation is the limiting factor in rainfed lowland rice area. Only few percentages of households (26%) have assured water supply for rice cultivation, which is often wrought with problems of limited volume during transplanting. Irregular and erratic rainfall causes a major damage to canals by landslides, wash-aways and erosions. Repairing and stabilizing the old traditional conducting channels with improved concrete materials, especially in case of perennial sources, will significantly reduce the problems of water deficiency. A thorough study and analysis is suggested to assess the need of allocating resources in the development of irrigation facilities in the rainfed eco-system.

- Uncertain rainfall and lack of assured source of water often exposes rice crop to drought stress, which especially during critical stages adversely affects the productivity. With suitable management technologies, such as staggering operations to escape drought can substantially improve the performance of existing rice varieties. Long term knowledge on climatic condition of a locality will be essential in developing suitable varieties that will outperform existing varieties in a given environment. Hence, the proposed change in effort is the shift from broadly adapted plant type to developing plants for target environment for sharper and precision increment in productivity through thorough on-farm testing of promising materials in as many locations as possible. On other hand, development of drought tolerant varieties with stable yield, across locations and seasons can also contribute to enhance production and maintain food security.

- The overall mean yield of rice varieties in the survey region is low (680 kg/acre). The low productivity of rice in the region is due to low yield and low adoption of MVs. Despite significant yield advantage of MVs over local varieties (i.e. 153 kg/acre) and the rate of adoption of 44% of household, the extent of cultivation in terms of acreage within the household is very small. The low adoption rate of MVs is due to farmers' preference for varietal traits of locals such as good taste, stable yield and easy threshability. Developing suitable high yielding varieties through cross breeding but at the same time retaining the preferred traits of locals will substantially increase production. Besides, improving the yield of existing MVs, will also bring a quantum increase in production.

- The low use of synthetic fertilizer and herbicides is also a factor behind low rice productivity. Unavailability or poor access to chemical fertilizers and herbicides is the main reason cited for its low use. Improvement of farmers' access to such inputs through better extension services could bring improvement in rice production. Similarly, developing appropriate technologies in nutrient, weed and pest and disease management seem desirable to improve the productivity. Hence, multiple interventions of specialists in soil and nutrient management and plant protection is necessary to clearly understand and develop appropriate technologies to address problems of soil, and biotic stresses (weed, pest and diseases).

- Rice cultivation is labour intensive operation which is estimated to require 157 men-days/acre per season, including the labour requirement for guarding the crop against vertebrate pest. Topographically, the survey region offers a great opportunity for mechanization but the use of farm machineries is relatively very low (4%) compared to that of irrigated environment. Hence, there is a need to explore the possibilities of providing support in terms of labour saving devices and reduce the drudgery of rice farming.

- Detailed and in-depth understanding of rainfed system with regards to parameters like rainfall patterns and subsoil hydrology in addition to the existing knowledge of surface irrigation is lacking. Integrated approach is necessary for characterizing the rainfed lowland agro-ecosystem both for use in technology extrapolations and recommendation domains and as a tool for diagnostics of technology generated.

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4. An Economic Impact Assessment of Rice Research Program in Bhutan- Shrestra et al, 2003

Appendices

Appendix 1. General traits of cultivated landraces of rainfed environment

Varieties	Yield stability	Taste/ scent	Pericarp colour	Maturity days	DP	Threshability
Attey	Stable	Good	White	90-120	-	Very easy
Khatkiri	Stable	Poor	White	100-130	-	Easy
Kalo Noonia	Stable	Good and scented	White	145-160	s	Hard
Choti Masino	Us	Good	White	90-120	s	Easy
Mauli	Us	Good	White	145-160	s	Very easy
Timburay	Stable	Medium	White	150-170	-	Easy
Malsira	Stable	Good	White + red	100-120	-	Easy
Mama	Stable	Good	White	110-120	-	Very easy
Chotakati	-	Good	White	-	-	Easy
Babu Jasuwa	Stable	-	White	-	-	Easy
Achamay	-	Poor	White	145-160	s	Easy
Aumusli/ Musli	-	-	White	100-120	s	Easy
Bayarni Dhan	-	Good	White	145-160	-	Hard
Pakha Dhan	-	Good	White	-	-	-
Ranigajal	-	Good & scented	White	145-160	s	-
Jadu	-	Poor	White	145-160	-	Easy
Jasuwa	Stable	-	White	-	-	Easy
Morangay	Us	Medium	White	-	-	Easy
Malinginy	-	-	White	-	-	Easy
Chettri Mansara	Stable	Medium	White	145-160	-	Very easy
Rato Mansara	Stable	Poor	White	-	-	Hard
Bakhri-kotay	Us	Good	White	-	-	-
Balingpa	US	Good	Red		s	-
Katiksali	US	Medium	White	150-160	R	-
Juwadhan	US	Medium	White	-	-	-
Krishna Bhog	US	Good & scented	White	-	s	Hard
Baudhan	US	Good	White	-	-	Easy
Japaki	US	-	White	-	s	-
Tsirangzam	-	-	White	-	-	Easy
Wangdakam	-	-	White	-	-	Easy
Gauria	-	Good	White	-	s	-
Dutkalam	-	Good	White	-	-	-
Champa-suri	S	Good	White	-	-	Easy

Legend: US- Unstable, w- White, r- Red, s- Susceptible, R- Resistant, **DP**- Disease & pest resistance

Appendix 2. Some varieties listed by farmers as lost

Varieties	Geog previously found	Place found now
Anadey	Ghumauney	Not found anymore
Kumtedhan	Sibsoo	Not found anymore
Panisali	Changmari	Not found anymore
Ram Bhog	Umling, Ghumauney	-
Ram Bhota	Ghumauney, Changmari	Not found anymore
Awanpakhay	Changmari	Not found anymore
Katusay	Changmari	Not found anymore
Bhukul	Ghumauney	Not found anymore
Bagay Tulasi	Sibsoo	Other geogs
Tegmaru	Jigmecholing	Not found anymore
Ram Tulasi/ Tulasi	Sibsoo	Nearby Geogs
Choti Noonia	Sibsoo	Not found anymore
Bhachi	Ghumauney, Sibsoo	Other geogs
Lajum	Gelephu	Not found anymore
Muwadhan	Changmari	Not found anymore
Bhurku	Ghumauney	Not found anymore
Dewpaney	Sibsoo	Not found anymore

Appendix 3. Mean of estimated yield loss due to different insect pest (%)

Major insect pest	Mean
Shoot bore/stem-borer	28.33
Case worm	25.28
Caterpiller/ leaf-miner	19.00
Cutworms	15.40
Hoppers/aphids/locust/bugs	16.00
Average	23.58%