NARP RICE PROGRAMME

AND

THE NATURAL RESOURCES INSTITUTE

AN ASSESSMENT OF POST PRODUCTION LOSSES OF RICE IN NORTHERN GHANA

BY

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CONTENTS

SUMMARY

This study is a component of the project "improving the competitiveness and marketability of locally produced rice in Ghana *vis-a-vis* imports of the commodity into the country" implemented by the NARP Rice Programme in co-operation with the Natural Resources Institute of the U.K. The study assessed physical and qualitative losses in the post-production system of rice, especially during harvesting, threshing, drying and storage, focussing on the Northern, Upper East and Upper West Regions.

The study involved informal interviews of individual farmers, farmer groups and women involved in parboiling using a semi-structured questionnaire and direct observation of harvesting, threshing, cleaning, drying, storage and parboiling.

The study showed that qualitative losses were more important than quantitative losses. Important qualitative losses occurred during threshing, drying and parboiling. It is concluded that reducing the qualitative losses that occur during threshing, drying and parboiling will make locally produced rice more competitive *vis-a-vis* imported rice.

1. INTRODUCTION

1.1. Background

1.1.1 The Natural Resources Institute (NRI) in cooperation with some Ghanaian research institutes (i.e. Food Research Institute, Crops Research Institute, Savannah Agricultural Research Institute) implemented the project "Improving the competitiveness and marketability of locally produced rice in Ghana *vis-a-vis* imports of the commodity into the country." The main thrust of the project was an assessment of small-scale rice production, processing and marketing as a forerunner to possible innovations to reduce the current dependence on imported rice. For example, in 1996, rice imports into the country were estimated at about 170,000 tonnes representing about 60% of marketed supply of rice (Day et al. 1997).

1.1.2. It is generally acknowledged that, in Ghana, there is a lack of information on the effects of post-production operations such as harvesting, threshing, cleaning, drying, storage, parboiling and milling on rice quality and the opportunities available for improving the various operations (Manful and Andah, 1989; Day et al. 1997). The project, therefore, consisted of various components which sought to provide the needed information. The post-harvest practices component was expected to generate some information on qualitative loss, especially during parboiling and milling. Another component, post-production loss assessment, which is subject of this report, addressed both physical and qualitative losses in the rice post-production system, especially during harvesting, threshing, drying and storage. The loss assessment component study was closely related to the study of post-harvest practices and results from both components were expected to complement each other.

1.2 Study objectives

1.2.1. The broad objective of the study was to examine the extent and causes of quantitative and qualitative post-production loss of paddy/rice and the constraints faced by the various actors (farmers, processors etc.) at the different stages of the post-production system.

1.2.2. Specifically, the study aimed to (a) describe the methods of paddy/rice handling/processing at different stages of the post-production system and identify the major actors involved at each stage;

(b) identify, using rapid assessment methods, the causes and extent of loss for each post-production operation;

(c) describe the methods used or steps taken by the various actors to minimise losses; and

(d) identify ways in which the operations might be improved so as to reduce or further minimise losses.

1.3. Study methods

1.3.1. The study was conducted in Northern, Upper East and Upper West Regions of Ghana during two seven-day visits between December 1997 and January 1998. It involved (i) informal interviews of individual farmers, farmer groups and women involved in parboiling using a semi-structured questionnaire, (Annex 1), (ii) direct observation of post-production operations, (iii) measurement of post-production losses (Annex 2) and (iv) liaison with other researchers conducting complementary studies on rice post-harvest practices in Ghana.

1.3.2. All interviews were conducted in farmers' fields or at parboiling sites. Farmer selection was not random. Due to the time allocated to this study, only farmers who were present at the time of the study team's visit to a village or farmers who could be reached on their farms within a 45-minute brisk walk from the village were interviewed. Rice growing villages in a region were identified by front line staff of the Ministry of Agriculture. Villages to be visited were then selected at random.

2. RICE PRODUCTION SYSTEM

2.1.1. The main rice varieties cultivated in the Northern, Upper East and Upper West Regions and the production systems used by farmers have been described by Day et al., 1997. Briefly, both local (*Oryza glaberrima*) and introduced varieties (*Oryza sativa*) are cultivated. Two main production systems are used; irrigated system which can produce two rice crops in a year and inland valley system which is rainfed but water is retained on the field during the growing period. A third system, upland rice which is also rainfed is not practised in any of the three regions. Some of the important aspects of rice production in the three regions are shown in Table 1. Rice farms in the Northern Region are generally larger than those in the Upper East and Upper West Regions. However yields of paddy are higher in Upper East and Upper West than in the Northern Region (Table 1).

Table 1. Some aspects of rice production in Northern, Upper East and Upper West Regions of Ghana

Region	Production system % farmers (%area)		Frequency distribution of farm sizes %				Main varieties grown % farmers			Yield/ha (tonne)
	Inland valley	Irrigated	<1 ha	1-2 ha	>2-4 ha	>4 ha	Afife	Local	Other *	1997 (1996)
Northern	91% (98%)	9% (2%)	46	9	27	18	45	9	45	1.0 (1.7)
Upper East	71% (18%)	29% (82%)	71	14	14	-	-	-	100	2.5 (3.2)
Upper West	100% (100%)	0%	75	17	8	-	-	100	-	1.5 (2.1)

* Other varieties include Mandee, IR5, IR8, GR18, GR19, Tux, Rock 3, Thailand, Dekuku and Abidjan

Source: Survey data

3. RICE POST-PRODUCTION SYSTEM

3.1. Introduction

3.1.1. The post-production system in all the three regions included harvesting, threshing, cleaning, drying, storage, parboiling and milling. However, drying of raw paddy (not parboiled) is not common in the Northern Region; none of the farmers interviewed dried raw paddy prior to storage.

3.1.2. The role of men and women at the various stages of the rice post-production system is shown in Figure 1. Generally, men were the main operators at the harvesting, threshing and storage stages. Cleaning (winnowing) and parboiling were carried out by women. Milling of small quantities of parboiled paddy for home consumption was by women. The paddy was pounded manually in a deep wooden mortar with a stick and then winnowed. Larger quantities of paddy are milled at small-capacity rice mills. These mills are operated by men. There were, however, minor inter-regional differences. For example, in the Northern Region, men were the main operators at harvesting (82%) while in Upper West women were more important (67%). In Upper West, threshing was carried out by men (100%) while in Northern and Upper East Regions only 35% and 14% respectively of operators were men.

3.2. Harvesting

3.2.1. Both manual and mechanical harvesting were observed, though manual harvesting using sickle or knife was more common.

3.2.2. Slight differences were observed in the tools used for harvesting and length of straw left attached to panicles during manual harvesting in the three regions (Table 2). In the Northern Region, a sickle is used to cut the rice plant close to the ground leaving a long straw attached to the panicles. In Upper West where farms are usually small (< 2ha) and harvesting is carried out mainly by women, cutting of individual panicles with knives was more common. Both sickle and knife are used in the Upper East Region. However the plant is cut at mid-section leaving a short straw attached to the panicles.

Table 2. Methods and tools for rice harvesting by farmers in Northern, Upper East and Upper West Regions.

Region	Combine	Manual harvesting		
		Sickle	Knife	Knife/sickle
		Long straw	panicles only	Short Straw
	%	%	%	%
Northern	27.3	72.7	-	-
Upper East	-	-		100
Upper West	-	-	66.7	33.3

3.2.3. Mechanical harvesting in the Northern Region is by self-propelled combine harvesters which combine harvesting, threshing and cleaning in a single operation. In clean fields, harvesting with a combine produces clean paddy. However, if the field is weedy, the paddy is mixed with weed seeds and other foreign matter and cleaning by winnowing (Sec. 3.4) becomes necessary.

3.3. Threshing

3.3.1. Threshing is carried out mainly on the farm. In the Upper West Region where only panicles were harvested panicles were usually carried to the house and threshed.

3.3.2 Three methods of threshing were mentioned by farmers; hand threshing, animal treading and tractor threshing. Threshing by animal treading and tractor threshing did not appear to be common. Tractor threshing was observed on only one farm in the Northern Region and only two farmers in the same region were familiar with threshing with oxen. The most important method of threshing was hand threshing.

3.3.3 Tractor threshing involved driving a tractor in circles over stalks piled on the ground to separate the paddy from the straw (Figure 2). Threshing by animal treading is similar to tractor threshing except that oxen are used instead of a tractor.

3.3.4 In hand threshing, rice stalks are piled on bare ground and beaten with sticks until the paddy separates from the straw (Figure 3). In Upper East and Upper West where only panicles or panicles on short straw are threshed, threshing sticks were usually smaller and shorter than in the Northern Region.

3.4. Cleaning

3.4.1. Cleaning is usually carried out soon after threshing by winnowing. Threshed paddy with broken pieces of straw and other impurities is made to fall freely from an inclined container. As the paddy falls, the broken pieces of straw and other impurities lighter than paddy are blown off by wind (Figure 4). Winnowing, however, does not remove heavier impurities such as stones or small lumps of soil picked from the threshing floor.

3.5. Drying

3.5.1. With the exception of farmers at the Bontanga irrigation scheme who occasionally dry paddy after threshing, drying of paddy is not common in the Northern Region; paddy is usually very dry at harvest (<12%). There are two possible reasons for the low moisture content at harvest. First, harvesting of paddy occurs during the harmattan when relative humidities are very low. Second, due to shortage of labour or cash to hire labour (Section 4.3.3), harvesting is usually delayed and the paddy is left in the field to over dry.

3.5.2. The majority of farmers (>70%) in Upper East and Upper West sun-dried paddy after threshing and cleaning. The paddy is spread out on the flat roofs typical of the two regions, or on the floors of inside compound yards and stirred periodically until dry. It was not possible to determine the moisture content of paddy at harvest in the Upper East and Upper West Regions during the survey of the two regions in January; harvesting was completed in November/December.

3.5.3. However, the need to dry the paddy before storage indicates that the moisture content of paddy at the time of harvest is higher than paddy in the Northern Region. Though relative humidities in the two regions are generally lower than those in the Northern Region, the crop is not left in the field to over dry.

3.5.4. Paddy fields and fields planted to other staples are small so harvesting of all crops is completed within a relatively short time.

3.6. Storage

3.6.1. Paddy is stored in sacks placed in rooms in all the three regions. Only a few farmers (about 3%) stored paddy in a pile in a room or in traditional storage structures such as *kuntchun* or mud silo. It appears most farmers prefer to store paddy in sacks placed in rooms because of security. These rooms, unlike traditional storage structures can be locked up to prevent access by unauthorized persons. Storage in sacks also enables the farmer estimate his income at any time since paddy is usually sold by the sackful. However, three farmers in the Upper East Region mentioned lack of protection by 'spirits' as the main reason for not storing in traditional storage structures.

Case study: Why paddy is not stored in traditional storage structures.

Mr. Daniel Apuri Achazenga's rice farm is located in Zone F (Lateral 14) at the Tono Irrigation Project near Navrongo, Upper East Region. He does not store paddy in a mud silo for reasons of security. While nobody will dare steal, say guinea corn stored in a mud silo for fear of being punished by the 'spirits of the land', paddy may be stolen. This is because paddy, not being an indigenous crop like guinea corn, is not protected in store by the spirits of the land.

3.6.2. Storage periods varied slightly from region to region (Figure 5). Only about 10% of farmers in each of the three regions stored for less than two months. Over 60% of farmers in Northern and Upper West Regions stored up to the beginning of the next planting season when paddy was usually scarce and prices were high (5-6 months).

About 40% of farmers in the Upper East Region stored paddy until they were sure of the next rice harvest (>6 months). All farmers occasionally sold a sack or two of paddy when they needed cash.

3.6.3. The main storage pests of paddy mentioned by farmers in all three regions were rodents, weevils and moths, and termites in decreasing order of importance. No infested paddy was observed during the survey but from past observations, the weevils are mainly *Sitophilus* spp. and *Rhyzopertha dominica*. The moths observed by farmers may be mainly *Corcyra cephalonica* and *Ephestia cautella*. *Sitotroga cereallela* is also an important pests but it is usually not observed by most farmers because of its size, especially when at rest.

3.6.4. Methods of rodent control used by farmers included keeping of cats, baiting with rodenticides and regular burning of pieces of discarded lorry tyres. While the efficacy of the first two methods is not in doubt, the efficacy of the last method needs to be assessed. About 30% of all farmers (n=41) did not use any control measures against rodents. Only about 5% of all farmers used insecticides. Most farmers did not consider insect infestation important to warrant control with insecticides.

3.7. Parboiling

3.7.1. Paddy is parboiled before milling in all three regions. Parboiling involves soaking of paddy in warm water for some time (usually overnight), steaming and drying before milling. Parboiling gelatinizes paddy and seals cracks thus reducing the proportion of broken grains in the milled grain.

3.7.2. Slight variations in the process and quantity of paddy parboiled were observed in the three regions. In all regions, paddy is soaked overnight in water, steamed in the morning and then sun-dried. Sun-drying of paddy in the Northern Region is a one-stage process. The paddy is exposed to sunlight all day. In the other two regions, sun-drying is a two-stage process. Paddy is exposed to sunlight up to about mid-day. The paddy is piled up and covered. After about two or three hours, the paddy is spread out again to dry till sunset.

In all three regions, the dried paddy is kept overnight and milled the following day. Batch size for parboiling in the Northern Region ranged between two and five (80 kg) sacks. Batch sizes in the other two regions were generally smaller; ranging between one-tenth to 3 sacks of paddy.

4. POST-PRODUCTION LOSSES

4.1. Introduction

4.1.1. The survey of post-production losses was carried out to determine the extent of both qualitative and quantitative losses at the various stages of the post-production system with the end objective of helping farmers to reduce losses. In this regard, individual farmers and two farmer-groups were interviewed, using a semi-structured questionnaire, to identify farmers' opinion of level of losses, causes of loss or problems at the various stages of the post-production system and methods used by farmers to reduce losses (Annex 1).

4.1.2. The information gathered was supplemented with observations and assessment of quantitative and qualitative loss during harvesting, threshing and drying. Quantitative loss of paddy during harvesting was based on an estimation of paddy lost per hectare as a percentage of actual yield (Boxall, 1986). Qualitative loss during threshing and drying was based on an assessment of the extent of contamination of paddy with stones, sand and animal droppings. Details of the two methods are given in Annex 2. A separate study (Manful, 1998) deals in more detail with qualitative loss and its effect on the quality of rice resulting from the existing rice post-production system.

4.2. Post-production system

4.2.1. Farmers' estimation of extent of losses at some of the important stages of the post-production system are shown in Figure 6. Most farmers considered that physical loss of paddy during threshing, cleaning, drying and storage were low. There were, however, slight regional variations in farmer estimation of harvesting loss.

While over 70% of farmers in Upper East and Upper West considered that harvesting loss was low, about 30% and about 20% of farmers in the Northern Region estimated harvesting losses as high and medium respectively (see Annexe 2 for definitions of high, medium and low).

4.2.2. These variations in farmers' estimation of harvesting losses may be due to differences in timeliness of harvesting, harvesting methods and tools used in the different regions. Harvesting of paddy and other food crops is more timely in Upper East and Upper West than in the Northern Region; crops have to be harvested early to avoid bush fires which start earlier in the two regions than the Northern Region. Also harvesting of panicles or panicles with only short straw attached with a knife as practised in the Upper East and Upper West Regions would seem to cause little or no shattering even if the crop is over dry while harvesting with a combine or sickle, especially if the edge of the sickle is blunt, could cause relatively more shattering.

4.2.3. Farmers' appreciation of qualitative loss in paddy was very low. Within limits, quality of paddy does not affect the price of paddy; farm-gate price is the same, whatever the quality (Day et al., 1997). Quality, therefore, appeared to be of little importance to farmers. Observations during this survey, however indicated that qualitative loss occurred, especially during threshing, drying, parboiling and milling.

4.3. Harvesting

4.3.1. Results of assessment of harvesting losses carried out during the survey in the Northern Region using the quadrat sampling system (Annex 2) are indicated in Table 3. Harvesting losses were generally low. For example weight losses above 10% occurred about once in every five measurements. About 60% of samples showed losses in the range 1- 5% (Table 3). It should be noted, however, that under certain conditions, losses could be high. For example harvesting loss for the variety *Mandee* was higher (15%) than for other introduced varieties (*Afife*-3%; *Dekuku*-7%; *Rock3*-7%). Only two of the 10 fields sampled were combined. The combine used on one farm was old while the other was new. Mean harvesting loss with the new combine was 2.7% (mean for sickle - 3.9%). Mean loss with the old combine was 14.6%.

Table 3. Frequency distribution of harvesting losses in Northern Region measured during the survey

% Wt loss	Loss class	% samples (N = 50)
<1%	Very low	2
1 - 5%	Low	58
6 - 10%	Medium	22
11 - 15%	High	10
> 15%	Very high	8

4.3.2. Part of the grain lost at harvest, especially panicles are usually gleaned by women. It was observed that usually between two and four bowls could be gleaned by a woman in a day from one or two rice fields. In one isolated case, a woman and her daughter of about 10 years gleaned about 16 bowls of paddy in a day from two acres of irrigated plot at Bontanga in the Northern Region. The farmer harvested 20 sacks (80kg/sack). The woman and her daughter thus recovered about 2% of the obtained yield. Under normal circumstances gleaning may recover between 0.5% and 1% of the obtained yield. While harvesting loss is obviously a loss to the individual farmer, gleaning of scattered grains and panicles reduces the impact of harvesting loss at the regional level.

4.3.3. The direct causes of harvesting loss observed during the survey were shattering and incomplete harvesting of panicles. Among the factors influencing shattering are harvesting methods, rice variety and timeliness of harvesting (Anthony & Arboleda, 1987). Farmers' opinion of causes of harvesting loss are presented in Table 4. Most farmers in Upper East and Upper West Regions identified shattering as a major cause of loss. Other farmers who did not mention shattering directly identified factors such as shortage of harvesters and lack of money to hire harvesters which delayed harvesting and thus increased shattering (Table 4) as causes of loss.

Table 4. Farmers' opinion of main factors responsible for harvesting losses in Northern, Upper East and Upper West Regions

Factor	% farmers ranking factor the most important		
	Northern (n=22)	**U/East** (n=7)	**U/West** (n=12)
Shattering	27	86	58
Shortage of harvesters	20	14	-
Lack of money to hire harvesters	23	-	-
Non-availability of efficient combine harvesters	14	-	-
Rodents and birds	9	-	-
Poor harvesting by hired labour	-	-	8
Fire	6	-	-
None	-	-	33

4.3.4. Incomplete harvesting of panicles due in part to carelessness of harvesters, or panicles that are not seen because they are covered by weeds and lodged plants that cannot be picked by a combine, was also seen as an important factor causing loss.

4.3.5. Over 80% of farmers suggested that timely harvest could reduce harvesting loss to a very low level. Farmers thought timely harvesting could be achieved through the acquisition of more combines and granting of loans to farmers to hire harvesters.

4.4. Threshing

4.4.1. Loss during threshing is both quantitative and qualitative. Quantitative loss consists mainly of scattered grains, grains irretrievably mixed with the soil of the threshing floor and unseparated grains still attached to the straw. Qualitative loss results mainly from contamination of paddy with soil and stones.

4.4.2. Qualitative loss was observed to be more important than quantitative loss. A lot of the scattered grains and grains left on the straw are usually recovered by women who invade threshing floors as soon as threshing is completed. However stones and sand particles picked from the poorly prepared threshing floors remain in the paddy. It seems probable that a lot of the small stones and sand particles in local rice originate from the threshing floor. In a study by Aderibgbe (1996) in Nigeria, absence of stones was the second most preferred quality criteria in rice. Day et al. (1997) also found that consumers in Ghana preferred imported rice to local rice because imported rice was usually stone-free. It would seem, therefore, that if local rice is to compete favourably with imported rice, then greater attention should be paid to quality control at threshing.

4.4.3. As observed by Day et al. (1997), it appears there is little incentive for farmers to improve post-production practices in order to produce good quality paddy. Therefore, though over 80% of farmers interviewed were aware that by threshing on mats, tarpaulin or well prepared floors stones in paddy could be reduced, they complained that they did not have money to buy mats or tarpaulin. However it seems the real reason for not threshing on mats or tarpaulins is the present lack of a clear incentive for producing quality paddy. Apart from a few threshing floors observed at two irrigation sites in Upper East Region, very little was being done to improve threshing.

4.5. Cleaning

4.5.1. Cleaning of paddy by winnowing removes pieces of straw, unfilled grains and all other impurities lighter than paddy. Cleaning, therefore, improves the quality of threshed paddy, but to a limited extent only. Winnowing cannot remove impurities such as stones and lumps of soil picked from the threshing floor which are heavier than paddy.

4.5.2. Quantitative loss during cleaning consisting of small and partially filled grains blown off with the chaff is usually low. The social cost of this loss is usually reduced when women re-winnow the chaff to recover the grains lost to the farmer.

4.6. Drying

4.6.1. Quantitative and qualitative losses occur during drying of raw paddy in Upper East and Upper West and parboiled paddy in all three regions. Quantitative loss results from consumption by domestic animals and through spillage. Most drying floors, especially floors in the compound of houses are pitted so spilled grains can not be recovered easily. Qualitative loss is due to contamination of the paddy with soil, tones and droppings of domestic animals. Qualitative loss was observed to be more important than physical loss of paddy.

4.6.2. Almost all farmers and processors interviewed agreed that drying on a smooth clean floor, mats or tarpaulin could reduce both quantitative and qualitative loss. However, they complained that they had no money to invest in the required improvements.

4.7. Storage

4.7.1. It was not possible to assess damage and loss during storage because paddy had been in store for only one or two months at the time of the survey. However, farmers assessment of loss during the previous two seasons indicated that losses in storage were generally low even in Upper East Region where paddy was sometimes stored for six months or more.

4.7.2. About 90% of farmers identified rodent attack as the main storage problem, though the damage caused was low. Obviously the farmers were focussing only on physical loss of paddy. Quantitative loss due to contamination of stored paddy with rodent hair, droppings and urine is a potential problem that could become a real problem in future.

4.7.3. The remaining 10% of farmers said they had no problem in storage. Insect infestation did not appear to be a storage problem for the farmers. When paddy was stored on the head, losses due to infestation by *Sitotroga cereallela* and *Sitophilus oryzae* could be high (Forsyth, 1962). Since paddy is now threshed and stored at low moisture content (< 12%) in sacks, infestation by the two insects could be expected to be low. Field studies will have to be conducted to see if insect infestation of paddy is really not a storage problem.

4.8. Parboiling

4.8.1. The study by Manful (1998) looks at parboiling in more detail. Only a few observations will be made here. Loss during parboiling is mainly qualitative though some quantitative loss resulting from paddy left on drying floors or consumed by domestic animals also occurs. The difference between the quality of the darkish parboiled rice of the Northern Region and the relatively white parboiled rice of Upper East and Upper West gives an indication of the extent of qualitative loss.

4.8.2. It was observed during this study that methods of steeping, steaming and drying differed from region to region. Among the factors affecting the quality of parboiled rice are the quality and temperature of the steeping water, length of steeping, method of steeping and drying of the parboiled paddy (Gariboldi, 1974). The difference in the quality of parboiled rice from Northern and Upper East or Upper West Regions may be due to some or all of these factors.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Post-production system losses

5.1.1. Farmers' estimation of post-production losses and estimation of losses during the present study indicated that physical losses of paddy within the post-production system were generally low. Gleaning of rice fields and recovery of grains left on threshing floors by women gleaners further reduced the quantity of paddy actually lost.

5.1.2. Field observations during this study indicated that quantitative losses occurred during harvesting, threshing, drying and storage of paddy. However, qualitative losses due to contamination with stones and sand particles and poor parboiling methods were more important. Extensive qualitative losses occurred during threshing, drying and parboiling. Unfortunately farmer perception of loss in quality was very low. This may be due to the fact that there is very little incentive for producing quality paddy. Admittedly, there is some incentive for producing high quality parboiled rice.

5.1.3. It is recommended that frontline staff of the Ministry of Agriculture (MOFA) are trained to help increase awareness among farmers, processors and traders of the importance of quality and its effect on prices. Awareness of the importance of quality will facilitate the adoption of recommendations aimed at improving operations at the various stages of the post-production system by farmers. Traders may also be willing to offer higher prices for good quality rice. As far as possible, recommendations for improvement should not be expensive to adopt or require major changes in current procedures.

5.2. Harvesting

5.2.1. Reduction of physical loss of paddy during harvesting should aim at enhancing timeliness of harvesting to prevent over drying leading to extensive shattering during harvesting.

5.2.2. About 50% of farmers in the Northern Region and about 15% of those in Upper East identified shortage of labourers for harvesting and lack of money to hire labourers or combines as factors that delayed harvesting. A closer look at the problem indicated that rice harvesting usually coincides with harvesting of staples such as maize, millet, sorghum or yam (Figure 7). Since harvesting with a sickle or knife is a slow and tedious operation that usually takes a lot of time, paddy is usually the last crop to be harvested.

5.2.3. It is recommended that in addition to MOFA assisting individual farmers and farmer groups to obtain loans to buy combine harvesters, small capacity (1 - 2 hectare per day) push-type reapers (e.g. Caams-IRRI 1.0m reaper) be introduced to the Ghanaian market. District Assemblies and Rural Banks could then assist farmers with loans to buy them to use on their own farms or hire them out to other farmers. These two bodies are now expected to help develop agriculture in their districts or areas of operation.

Figure 7. Harvesting periods of some crops in the Northern, Upper East and Upper West Regions of Ghana.

CROP	MONTH							
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize				<---------->			NR	
				<---------->			UER	
				<---------->			UWR	
Paddy						<---------->		NR
					<---------->			UER
						<---------->		UWR
Sorghum						<---------->		NR
					<---------->			UER
					<---------->			UWR
Yam			<---------->					NR
				<---->			<---->	UWR

Source: Nicol et al,. (1997)

5.3. Threshing and cleaning

5.3.1. The main cause of quality loss at the threshing stage of the post-production system is contamination of paddy with stones, sand and small lumps of soil. Because these contaminants are much heavier than paddy, they are not removed during cleaning by winnowing. The objective of quality improvement should, therefore, be the prevention or reduction in the extent of contamination with stones and sand. Threshing on a cemented floor, tarpaulin or at least on a well beaten and compacted earth floor instead of a rough bare floor can eliminate or reduce the contamination. In the absence of the heavier contaminants, cleaning by winnowing will be more effective since only chaff and other impurities lighter than paddy will need to be removed.

5.3.2. It is recommended that farmers be encouraged to thresh on locally woven mats or tarpaulins. At permanent production sites (e.g. Bontanga, Vea and Tono irrigation sites), more permanent threshing floors (e.g. cemented floors) should be constructed. Farmers could then be charged a small fee for threshing on these floors.

5.4. Drying

5.4.1. Raw or parboiled paddy may be contaminated with stones, sand and droppings during drying. Where the drying floor is pitted, paddy lodging in small depressions are usually left in the pits after drying resulting in physical loss. Improvement in drying should, therefore, aim at reducing contamination and loss of grains.

5.4.2. It is recommended that farmers and processors are advised to dry paddy on mats, pvc sheets or tarpaulin. Where there is a drying floor, it should always be in good repair and should be swept clean of sand particles, small stones, etc. before paddy is spread out on it to dry.

5.5. Storage

5.5.1. The majority of farmers store paddy in sacks placed in rooms not built purposely for grain storage. The main pests are rodents, and to a very limited extent, insects. Presently losses due to insects and rodents are estimated by farmers to be very low. However, losses may increase if production levels and storage periods increase.

5.5.2. Even with the present low loss levels, some farmers are using insect and rodent control methods that are hazardous (eg mixing paddy with any insecticide a farmer lays hands on, baiting with phosphine tablets, burning discarded lorry tyres in confined areas to repel rodents, etc).

5.5.3. It is recommended that farmers be encouraged to adopt recommend insect and rodent control methods that are safe, effective and sustainable (eg. keeping of cats, making stores less accessible to rodents, use of only recommended insecticides etc).

5.6. Parboiling

5.6.1. A great deal of quality loss occurs during parboiling. Each processor has her own 'recipe' for producing high quality parboiled rice (eg. parboiler studied by Day et al. 1997). While some parboilers are able to produce relatively good quality rice most of the time with their 'recipes' (Bolga and Navrongo), others produce low quality parboiled rice most of the time. There is, therefore, the need to examine all the operations involved in parboiling with a view to producing an appropriate 'recipe' that produces high quality parboiled rice at all times. For example, a 'recipe' for steeping involves steeping paddy for not more than five hours in water with temperature between 50^{o} and 70^{o}C and pH around 5.0 (Gariboldi, 1974).

5.6.2. It is recommended that the suggestions for improving parboiling (Manful, 1998) should be studied and adopted immediately.

5.7. Social implications of change

5.7.1. The above recommendations seek to improve the rice post-production system without displacing labour, especially hired female labour. The recommendations will also not require major changes in existing procedures.

5.7.2 Easy access to combines and the introduction of small capacity harvesters will release more labour to harvest staple food crops and to make yam mounds. Suggested changes in threshing, drying and parboiling are meant to make the main operators of these stages more efficient.

5.7.3. Rice post-production in the three regions is a source of employment for many rural women. **It is, therefore, recommended that the social implications of the introduction of labour saving equipment such as threshers and cleaners should be studied before they are introduced**. In a study in Indonesia, Eyben (1984) warned that rapid high-efficiency mechanization of rice production could cause "considerable human suffering, especially in those places where off-farm rural employment opportunities are rare".

5.8. Further field studies

5.8.1. During the field trips of this study, farmers gave the impression that they were willing to improve their operations if they were assisted to do so. But will farmers carry mats, pvc sheets or tarpaulins to the field to thresh paddy on?. Will parboilers discard their traditional 'recipes' for improved parboiling procedures?. There will be the need to hold participatory meetings with farmers, processors etc to discuss all recommendations, adapt them where necessary and field test all agreed recommendations with the various actors involved at the different stages of the rice post-production system.

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ANNEX 1

ESTIMATION OF POST-PRODUCTION LOSSES

1. Farmer estimation of quantitative loss

Farmers were asked to state the number of bags (or bowls) they took home and what they estimated was left in the field after harvesting or on the threshing floor after threshing or on the drying floor after drying.

The estimated loss was then expressed as a percentage of the obtained yield (Anthony & Arboleda, 1987),(Table A2.1). The percentage loss was classified as very low, low, medium, high and very high (Table A2.2). The classification made it easier to compare farmer's estimation with researcher estimation.

Table A2.1 Examples of farmer estimation of harvesting losses

Loss		**Obtained yield**	**Loss as % of obtained yield** (calculated by researcher)
2 3 bags	against	80 bags	2.5 - 3.8
5 bowls	against	3 bags	4.2
1 bag	against	16 bags	3.3
2 bowls	against	4 bags	1.2
1 bag	against	10 bags	10.0
6 bags	against	46 bags	13.0
1 bag	against	5 bags	20.0

1 bag = 40 bowls 1 bowl = 2.5kg paddy (approx.)

Source: Survey data

Table A2.2 Classification of losses

% Loss	loss class
<1%	Very low
1 - 5%	Low
6 - 10%	Medium
11 - 15%	High
> 15%	Very high

Source: Classification based on survey data

2. Survey estimate of loss

2.1. *Harvesting*

Loss of paddy during harvesting was estimated with the method described by Boxall (1986). Briefly, a square iron rod frame (0.34m x 0.34m, A = 0.12m^2) was thrown at random in harvested fields. All paddy enclosed by the iron frame were counted. Five measurements were taken per field. Using the 1000 grain weight for the rice variety harvested from the field, the loss of paddy per hectare was calculated. The loss was then expressed as a percentage of the yield per hectare obtained by the farmer. Losses were classified as before (Table A2.2).

Distribution of harvesting losses measured on 10 farms are shown in Table A2.3.

Table A2.3 Distribution of harvesting losses on 10 farms in Northern Region

% loss	Loss class	No. of measurements in class
<1	Very low	1
1 - 5	Low	29
6 - 10	Medium	11
11 - 15	High	5
>15	Very high	4
Total		50

Source: Survey data

2.2 *Threshing and Drying* (Estimation of extent of contamination with stones, sand, droppings)

A grid with 25 squares each measuring 5cm x 5cm was drawn on a cardboard. To measure the extent of contamination, a primary sample of about 200 ml was measured. A sub-sample of three 25ml-spoonfuls of paddy (heaped) were placed in the centre of the grid and evenly spread out on the grid. Squares with stones, sand, weed seeds etc were counted. Three sub-samples were analysed.

% contamination = 100 X (No. of squares with contaminants)/25

Contamination was also classified (Table A2.2). Contamination in all samples (N = 20) was high (11% - 15%)

This method was used in the field where there was no weighing scale and samples taken for analyses had to be given back to the farmer. This method can also be used to estimate extent of mould or insect damage in stored paddy or milled rice.