Harvest and Post-harvest Issues in Farming Systems Research

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I. Introduction[1]

There is a burgeoning literature on what has become known as 'farming systems research' (FSR) [Norman 1978, 1980; Gilbert, Norman and Winch 1980]. It can be seen as a response by the agricultural research community, and particularly its social scientific element, to repeated criticisms of new agricultural technology that was ill-suited to the requirements of certain types of user, especially small farmers: high yielding varieties that were unacceptably risky [Lipton 1968]; mono-crop recommendations inappropriate to mixed cropping systems [Norman 1972]; input-intensive packages where inputs were expensive, inaccessible or uncertain [Griffin 1974, Dasgupta 1977]; innovations that did not fulfil in the field the promise of the research station [IRRI 1977]—and so on [Bunting 1982; ICRISAT 1980].

Despite some differences in emphasis, most major agricultural research institutes are now moving towards similar FSR methodologies that are distinguished from traditional methods by two redeeming characteristics: in the first place, they begin with the complete farm as an integrated system and move towards specific changes in management practices only when the detailed context of constraints and opportunities has been subjected to multi-disciplinary scrutiny; and secondly, they place the farm family firmly at the centre of the research and development process with the tasks of helping to define priorities and of managing system-specific on-farm trials [Byerlee et al 1979, Byerlee, Collinson et al 1980, Shaner et al 1981, Zandstra 1980]. Although the new FSR methodologies have yet to be subjected to the acid test of widespread application outside the international research institutes, they do appear to offer a much stronger framework than has previously existed for multidisciplinary, farmer-oriented and relevant research.

But it is a curious fact that in the studies that have motivated the development of FSR, and in the manuals that are begining to appear, very little reference is made to issues surrounding the harvest and post-harvest system (HPHS). By far the greatest share of attention is given to problems of plant breeding and crop agronomy, and particularly to the procedures for designing and implementing on-farm trials on these matters. To the extent that the FSR methodology is of general applicability, this bias is unimportant; and the need for on-farm agronomic trials is incontrovertible. But the fact of the matter is that in practice the HPHS is likely to be central to FSR, for reasons discussed in Section II; at least in one real world case it can be shown to be central (Section III). And although no basic changes in the methodology are required, recognising the importance of the HPHS does lead to a reappraisal of the procedures used in FSR (Section IV).

II. The Importance of Harvest and Post-harvest Issues

The harvest and post-harvest system covers all operations from harvest to final disposal by consumption or sale. The number and sequence of operations will vary according to the crop, the level of technology, the size of the harvest and the marketable surplus as well as the nature of the socio-economic environment, but for most small farms in developing countries, producing and selling mostly grain staples, the following may provide a basic model: cutting or harvesting by the entire farm family, often assisted by hired labour; carrying of the harvested material to a threshing or shelling area, either in the field or back at the farmhouse; threshing or similar operation to prepare the harvest for sale or storage; and sale of part of the harvest, with the rest being stored for consumption or later sale. Obviously some crops will not require threshing (cassava, tomatoes) and in some cases crops may be sold or stored without being processed in this way, (rice on the panicle, maize on the cob); the practices adopted are also likely to be different for cash crops, either because of the nature of the product (tea, coffee, cotton) or because of the relationship of the farmer to the market. These differences serve to underline the need for careful analysis to be made of existing harvest and post-harvest practices before planning any modification. What is clear is that the range of possible actions is wide, including changes in *infrastructure* such as storage or threshing facilities, changes in *technique* such as harvesting or threshing

[1]I am indebted to Martin Greeley and Peter Giles for discussion of the issues treated here; and to Alan Bojanic, Charles Stutley, Melvin Pozo, Michael Allen and other colleagues who participated in farming systems research in Santa Cruz. Responsibility is mine.

methods and changes in *organisation*, such as marketing practices.

The case for saying that these sorts of changes are likely to be central to FSR has two foundations. In the first place, changes to the HPHS are potentially very profitable because the HPHS is a major cost item and by virtue of its relationship to marketing and price a major determinant of enterprise and farm profitability. In the second place, the HPHS occurs at the end of the production chain and is therefore particularly vulnerable to disturbance by technology change further up the line. The first argument suggests that the HPHS is likely to be high on the list of priorities for its own sake, and the second suggests that even if it is not, it is likely to force itself onto the agenda as a derivative, second-order problem: it is necessary to look at each of these arguments in turn.

The first argument, that the HPHS is likely to be a priority in its own right, can be broken down into five separate propositions:

1. The HPHS accounts for a major share of the labour required for crop production; this labour is needed at a busy time of the year and thus has a high opportunity cost.
2. The requirement for cash is often high, to hire labour, contract threshing machines or transport produce. Cash is also particularly scarce during harvest with a high opportunity cost.
3. The cumulative effect of losses at different stages of the HPHS can be an important hidden 'cost', as also can quality deterioration, especially during storage.
4. Harvest and post-harvest technologies affect marketing strategies, which in turn affect the price obtained and thus profitability.
5. Appropriate adjustments to the HPHS can be devised which save on scarce resources or otherwise increase income.

That the first proposition holds for a broad range of crops across a broad range of technologies can be seen from Table 1, which summarises the importance of harvest and post-harvest inputs in 65 sets of input-output data provided by Ruthenberg [1980]. The crops included range from rice, maize and sorghum to coffee, rubber and cocoa, produced under a broad range of production systems with different technologies and in many different countries. The value of the table is that despite this diversity of options it shows that the share of total labour required for the HPHS is uniformly high and in most cases accounts for the dominant share of total labour input. The figure tends to be lower in shifting cultivation systems because of the heavy burden of land preparation and higher in the cultivation of permanent crops, for the opposite reason; but for fallow and arable systems, whether irrigated or not, a remarkably consistent pattern emerges with the mean share of the HPHS settling at about 40 per cent. This figure will of course be affected by the level of mechanisation in any particular system: logically the share of the HPHS in total labour should rise when land preparation is mechanised and fall when harvest is mechanised, other things being equal. In practice, the picture is complicated by the tendency for mechanisation to be associated with multiple cropping so that on a whole farm basis, mechanised harvesting may be associated with an increase in HPHS labour inputs in both absolute and relative terms. The 13 sets of rice data included under 'irrigated arable' break down as in Table 2, which shows some decline in means but very high variation. The two highest figures, of 73 per cent and 80 per cent are in fact for the manual cultivation of double and triple-cropped wet rice [Ruthenberg 1980:249].

The labour required for the HPHS will inevitably be concentrated during a relatively short-time period because of the need to harvest crops when they are ripe and process them before they rot. If we can say that the typical production cycle for a grain crop lasts 150 days, including the HPHS, then we might find 40 per cent of the total labour requirement concentrated in 20 per cent of the cycle, or less. The same sort of argument applies to cash (proposition 2): clearly the size of the cash requirement will depend on the size of the enterprise relative to family labour availability and the proportion of the crop that is marketed. However studies of labour use and cash flow commonly show that hired labour and cash expenditure peak during or immediately after harvest, and confirm that the period leading up to harvest is often the most difficult from a seasonal point of view [Ahmed 1981, Hart 1981, Chambers et al 1981]. Both labour and cash, therefore, will have a high opportunity cost during the harvest so that any savings will be more than proportionately worthwhile.

With regard to losses (proposition 3), it is now agreed that they are usually lower than has sometimes been thought and that the total loss is made up of the cumulative effect of many small losses during various stages of the HPHS [NAS 1978]. However, losses will be higher in some systems than others, especially when the harvest takes place in humid conditions or when storage periods are extended; and although mean losses may be low for the population as a whole, the disastrous impact of total loss on the individual may justify improvements to the HPHS as a form of risk insurance [Lipton 1982].

The final element in the HPHS has to do with marketing strategies. These are determined by a complex of technical, economic and social factors but it is clear (proposition 4) that changes to marketing practices can make a major difference to price and to the relative profitability of different enterprises [Harriss

table 1

Share of harvest and post-harvest operations in total labour input by type of system, various crops

share of harvest and post-harvest	*type of system*											
	shifting		*fallow*		*upland arable*		*irrigated arable*		*permanent crops*		*total*	
%	*no*	%	*no*	%	*no*	%	*no*	%	*no*	%	*no*	%
0– 16	—	—	2	22	1	7	2	9	—	—	5	8
17– 33	4	100	3	33	4	29	7	30	1	7	19	29
34– 66	—	—	4	44	9	64	12	52	8	53	33	51
67–100	—	—	—	—	—	—	2	9	6	40	8	12
total	4	100	9	100	14	100	23	100	15	100	65	100
mean %		26.37		39.23		41.28		40.14		60.63		43.68
sd		4.46		26.21		16.50		18.25		20.61		20.25

Source: Ruthenberg [1980] tables 3.3, 4.5, 6.3, 6.11, 7.3, 7.4, 7.12, 8.9, 8.13, 8.15

table 2

Share of harvest and post-harvest operations in total labour input, rice cultivated under irrigated arable conditions, by level of mechanisation

level of mechanisation	*share of harvest and post-harvest %*			
	$\bar{x}$	*sd*	*range*	*n*
manual only (hoe)	44.40	29.18	15–80	6
semi-mechanised (ox-plough)	33.74	14.04	19–37	3
fully-mechanised (tractor)	28.34	9.04	20–40	4
total	37.00	21.50	15–80	13

Source: Ruthenberg [1980] tables 7.3, 7.4, 7.12

1980]. Some of these changes may not be technical but may have to do with reducing dependence on middlemen or avoiding forced sales at low prices; but others will be based on technical change in the HPHS. Examples might include improved storage to permit the farmer to take advantage of seasonal price movements; improved threshing methods to improve grain quality and obtain a higher price; intermediate transport technology to permit the farmer to transport his own grain and avoid dependence on lorry owners/buyers.

All these factors, then, the importance of HPHS in labour and cash requirements, and the effect of losses and different marketing strategies, combine to suggest that changes in the HPHS offer great potential for improving farmers' well-being. An opportunity exists: it remains to show that there also exists some potential for seizing it. That is to say (proposition 5), either technologies exist that can be adapted for use in any particular environment; or such technologies can be developed by research with a level of effort that appears at the outset to be feasible and cost-effective. Past achievements in modifying the traditional HPHS give some grounds for optimism, particularly with respect to mechanisation of the harvest or of threshing operations [Mettrick et al 1976]; and there has been a great deal of research on storage which shows that technical improvements are possible in certain circumstances. There is then no reason to doubt that HPHS improvements are likely to be important on their own account.

But this is only half the argument: HPHS research is also likely to feature in FSR because of the position of the HPHS at the end of the production cycle. This is for two related reasons:

1. In the first place, changes to enterprise systems further up the line may require concomitant adjustments to the HPHS. A new variety may require a different harvesting technique; or it may be that the new variety stores less well and requires more sophisticated treatment; or it may be that maturity peaks more sharply than in the previous case so that the harvest cannot be staggered and must be organised differently. In all these cases, which are not mutually exclusive, the original changes to the enterprise system are simply not feasible unless the HPHS also changes.

2. Secondly, the HPHS is likely to be disturbed because one of the results of FSR will be to change both the overall quantity of crop produced and the balance of enterprises. A successful variety improvement programme in wheat, for example, may improve the

yield per hectare: even if the same number of hectares is grown as previously the total amount of wheat produced will increase. But in addition, because of the increased wheat yield it will become more attractive relative to other enterprises and there will be some movement into wheat from competing enterprises: thus the total amount of wheat will increase even more. The marketed surplus in particular is likely to rise very fast and it is by no means necessarily the case that the traditional HPHS will be able to cope: in many cases adjustments will be needed. In some cases these adjustments will require research, and it may be that the HPHS research issues thus generated will prove to be the major problems in FSR for a particular group of farmers as agricultural development takes place. A further point should be made: as whole groups of farmers adopt new techniques there will be repercussions on factor and product markets that may have implications for the HPHS. For example, the cost of harvest labour may rise, or the post-harvest price trough may deepen. The HPHS will therefore have to respond to changes outside the farm system.[2]

To conclude: the argument is that when an FSR team begins to short-list possible interventions, looking for possibilities that appear to be both technically feasible and economically worthwhile, it is likely that issues surrounding the HPHS will be prominent because of the heavy commitment of scarce resources to the HPHS. Furthermore, improvement to the HPHS may be a necessary condition for the adoption of improved technology further up the line, particularly as output increases and the marketed surplus grows.

III. A Case Study: Colonist Farmers in Santa Cruz, Bolivia

The purpose of this case study is to illustrate the arguments in the previous section with data gathered during three years' research on farming systems in Eastern Bolivia; and to examine briefly research carried out on the HPHS in the area. The data includes material gathered by rapid rural appraisal, surveys and multiple-visit case studies: it confirms the importance of the HPHS and assists in identifying priority areas for intervention.

The study area is comprised of one segment of the ring of colonisation that stretches around the Amazon basin from Brazil to Venezuela and that contains around 15 mn people [Barbira-Scazzocchio 1980]. It is a subtropical area some 160 km square that has been settled from the original high forest over the past 20 years; it contains some 15,000 families or about 22 per cent of the rural population of Santa Cruz Department, living in nine main colonisation areas that have received varying degrees of government support. Typical farm size ranges from 20-50 ha and agriculture is based on slash and burn techniques with upland (unirrigated) rice as the main cash and subsistence crop [Maxwell and Pozo 1981].

Agricultural development in the area is characterised by the descent into and escape from the 'barbecho crisis' [Maxwell 1980]. A new settler will clear forest manually at the rate of two to five ha a year, cultivating each field for two to three years before moving on to a new patch: agriculture thus moves round the farm with relatively high returns despite heavy land clearing costs. After a number of years, however, cultivation returns to the starting point where there is no original forest, only regrowth *(barbecho)*: although clearing costs are lower, weeding takes twice as long and yields are only about half the previous level. Income falls and the farm enters the barbecho crisis. However, escape is possible by de-stumping and mechanisation, the development of livestock enterprises, permanent cropping or new rotations, and some farmers are able to develop, diversify and stabilise. This process is associated with increasing social differentiation in the area [Maxwell 1980a].

Most farms in the area are caught in the barbecho crisis: 1979 survey data show 54 per cent overall [Maxwell and Pozo 1981:66]. The barbecho farm therefore represents the starting point for analysis; The characteristics of a typical farm are summarised in the first column of Table 3 which makes use of data gathered during a case-study programme in 1980-81 [Maxwell et al 1982]; (the second column of the table is discussed below). The farmer has almost no resources apart from the land he works and cultivates only 2.5 ha with summer rice, representing eight per cent of the land available. The same land is cropped in the winter with maize, and some cassava, but the maize contributes only a fifth of crop sales by value. Farm profit of $b21,720 (US$869) comes almost entirely from crops with only about 10 per cent derived from livestock; similarly, nearly all cash expenses are associated with crop production, including the hiring-in of about 60 days of labour. About a third of the gross income comes in cash, the rest being accounted for by subsistence or changes in stocks, and about a third of profit is also cash. Seasonal peaks in activity are to be found during land preparation in August-September and harvest in March-April; cash outflow peaks at roughly the same time.

We can now return to the arguments of the previous section and assess the importance of the HPHS in such a system. The first task is to look at the share of the HPHS in total labour requirements: Table 4 presents input-output data for the four main crops in the area,

[2]The employment effects of changes in the HPHS is an issue not discussed here, as it falls outside the immediate scope of FSR. But see Greeley [1980].

table 3

Characteristics of typical 'barbecho' and 'arado' farms, Santa Cruz, 1980-81

		barbecho			*arado*
1.	**Resources**[1]				
1.1	*Land* (ha)				
	barbecho (cultivated)		3		—
	barbecho (uncultivated)		26.9		22
	destumped		—		7
	pasture		—		—
	permanent crops		0.1		1
	total		30		30
	hired in		—		2
1.2	*Labour*				
	male adults		1		1
	female adults		1		1
1.3	*Capital*				
	fencing (m)		—		—
	sheds (no)		2		—
	hand tools		minor		minor
	back-back sprayer		—		—
	livestock: pigs		2		1
	sheep		2		—
	chickens		±10		±10
	cash ($b)[2]		±1300		±1800
1.4	*net worth* ($b)		84900		105500
2.	**Activities 1980-81**				
2.1	*Crops* (ha)				
	rice		2.5		4.43
	maize		2.0		4.57
	bananas		0.1		1.00
	cassava		0.5		—
2.2	*Crop sales*	*qty*	*value ($b)*	*qty*	*value ($b)*
	rice (fanegas (=408 lb))	14	12310	21	26000
	maize (quintals (=100 lb))	20	2600	116	19500
	bananas (bunches)	—	—	177	3338
	other		40		1910
	total		14950		50748
2.3	*Crop inputs* ($b)				
	labour		4910		19650
	other		3930		26607
2.4	*Livestock sales*		860		—
2.5	*Off-farm*		—		—
3.	**Margins and productivity**				
3.1	farm profit 1980-81 ($b)		21720		20148
3.2	farm profit as % net worth		25.58		19.09
3.3	farm profit/ha ($b)		724		671.6
3.4	no of days worked		211		168
3.5	farm profit/day worked ($b)		103		119.93
3.6	total cash outlay ($b)		8840		46257
3.7	farm profit as % cash outlay		246		44

Source: Maxwell et al [1982]

Notes: [1]resources as at 1 October 1980
[2]$US1 = $b20

table 4

Input-output data for principal crops, Santa Cruz, 1979

		manual system (ha^{-1})							
		rice		*maize*		*cassava*		*bananas (established)*	
		days	*$b*	*days*	*$b*	*days*	*$b*	*days*	*$b*
1.	land preparation	15	—	22	—	16	—	—	—
2.	sowing	3	80	2	30	11	195	—	—
3.	weed control	20	—	18	—	35	—	13	—
4.	pest control	2	200	—	—	3	—	—	—
5.	harvest	16	—	11	—	13	—	8	—
6.	threshing	4	—	4	—	—	—	—	—
7.	other post-harvest	3	—	3	100	1	—	8	—
8.	freight	—	350	—	605	—	3835	—	2000
	sub-total	63	630	60	735	76	4030	29	200
9.	contingencies	6	63	6	73	8	403	3	—
	total	69	693	66	808	84	4433	32	2200
10.	% harvest and post-harvest	33	50	27	87	18	87	50	91

Source: Maxwell and Pozo [1981] tables 3.8, 3.11, 3.12, 3.13

Notes: $US1 = $b20

and it can be seen that under the manual system used, the share of HPHS in total labour is 33 per cent for rice, 27 per cent for maize, 18 per cent for cassava and 50 per cent for established bananas. These figures are comparable to those presented earlier for shifting cultivation. As regards cash expenditure, the role of the HPHS is even greater, at least when crops are sold and marketing expenses are incurred: the HPHS then accounts for 50-91 per cent of total expenditure even before any labour is hired.

The seasonal implications, and the need to hire labour, can be assessed by considering the cropping pattern given for the representative farmer in Table 3. This is done in Table 5, which shows that nearly a third of all the labour hired-in is required during the rice harvest in February-March with a further 15 per cent being required during the winter-maize harvest which coincides with the final land preparation and sowing of rice in October-November. These figures are consistent with survey results that show 78 per cent of all farmers hiring labour at some time during the year, with 62 per cent doing so for harvest and about 45 per cent of barbecho farmers doing so for land preparation and weeding: in the area where the case study programme was carried out, survey results showed 31 per cent of total expenditure on hired labour falling in February, March and April, the busy months for harvest [Maxwell and Pozo 1981: tables 62-64].

The opportunity cost of both labour and cash used during the harvest peak is very high. The *average* rate of return given for cash expenditure in Table 3 was over 200 per cent so the *marginal* rate during the peak period should be even higher: this makes sense when it is considered that the amount of rice that can be harvested during one day by a labourer costing about $b100 has a farm-gate value of approximately $b500, ie a return of 500 per cent.

To add to these high costs of the HPHS there will be an extra cost in losses. No detailed figures are available, but it can be assumed that harvest losses are low (for reasons discussed below) whereas threshing and storage losses may be rather high, especially because of the humid conditions and the very simple storage techniques used. Preliminary research shows that the percentage of the grains damaged after 12 weeks in traditional storage reaches six per cent for maize and nine per cent for rice: these figures will overestimate the total loss in weight but imply losses of 1.3 per cent and 4.5 per cent respectively.[3] The value of the loss would be about $b62 per hectare for maize and $b500 per hectare for rice, assuming average yields and prices.

[3]Peter Giles, personal communication. The conversion from damaged grains to weight loss is based on figures given by Adams and Schulter [1978:93].

Finally, it is necessary to say something about marketing strategies and price variation: this is an important item because both rice and maize are cash crops as well as subsistence crops, with a mean 64 per cent of rice being sold and a mean 27 per cent of maize [Maxwell and Pozo 1981:40]. Farmers often sell very soon after the harvest, partly in order to meet the cash cost of hiring labour for harvest: one study showed that more than 70 per cent of the number of rice sales, accounting for 75 per cent of the total quantity sold, were made within five weeks of the harvest [Hebblethwaite et al 1981]. However, by doing this farmers miss out on price rises which can be as high as 40 per cent from the beginning of the post-harvest period to the end. The question is whether some way can be found to transfer part of this surplus from the trader or the consumer to the farmer and what part improved storage can play.

The discussion so far provides a solid basis for saying that the HPHS should be studied carefully in any FSR programme in the area: it is indeed a major cost item which causes a sharp seasonal peak in labour and cash costs, and when the effect of losses and marketing strategies is taken into account it does seem to be worth casting about for improvements. Before looking at interventions, however, it is necessary to return to the other leg of the case for HPHS research and look at the indirect arguments discussed in the previous section. In so doing it becomes obvious that HPHS research is not only desirable in Santa Cruz conditions: it is in fact unavoidable.

The first indirect argument had to do with adjustments to enterprise production systems forcing a change in the HPHS. For the barbecho farmer being considered

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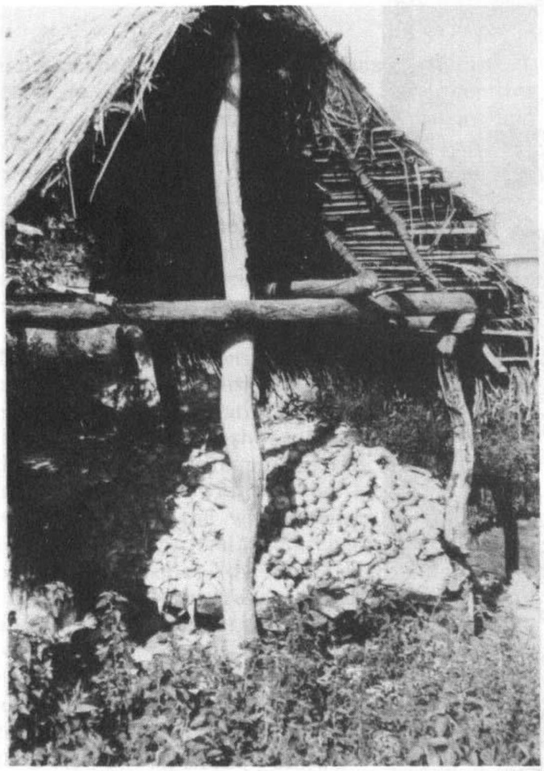
Unloading panicle-cut rice from a lorry, for mechanical threshing, San Pedro.

here the problem resolves into the effect on his HPHS of changing rice varieties. The change is from the traditional long-stemmed varieties, Durado and Bluebonnet, to new, higher-yielding short-stemmed varieties, CICA-6, CICA-8 and IR-1529. The problem is that the farmer simply cannot harvest these with his traditional harvesting technique which involves cutting each panicle individually with a knife: the new varieties are shorter so more bending is required, but more importantly, the panicle is buried in the leaves and is very hard to reach. The only alternative is to cut with a sickle, but as will be shown below this forces a change in all other elements of the HPHS: the change in variety therefore requires a complete reappraisal of the HPHS.

The second indirect argument for HPHS research had to do with larger amounts of a crop being grown, because of yield increase, of substitution between crops or other changes in the farm system. In the case of the barbecho farmer, the interesting question to ask is what happens as he escapes from the barbecho crisis, and particularly if he follows the destumping/ mechanisation route. In 1979 about 14 per cent of farmers had done this. The answer is to be found in the second column of Table 3 which provides data, again from the case study programme, of a farmer with seven ha of land destumped. Two and a half hectares of this was under rice in 1980-81 and four and a half under maize. The investment in de-stumping has made possible a large increase in the scale of farming, with a tractor being hired in to prepare the land and the total cash outlay rising by 500 per cent in comparison with the previous case. The amount of labour hired is four times the previous case at 250 days, but it is interesting to note that farm profit is actually lower at $b20148 (US$806): as a result the return on capital is considerably lower. The data raise various questions, not least the viability of the strategy being followed by the farmer as an escape from the barbecho crisis. But from the point of view of the HPHS the points to note are that far more is being produced, the marketed surplus has increased more than proportionately and the marketing problems have increased as a result. If rice is grown it becomes very difficult to harvest the increased area with traditional methods because the labour required is not available or cannot be afforded; furthermore the difficulty of handling the crop becomes a bottleneck. Maize can be grown in the summer but it is much less profitable. Here again, then, the need is for a change in the HPHS to accompany other production changes.



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Traditional storage of maize on the cob in an open-sided 'galpon'. San Pedro.

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Research station trial with rice of thresher designed by CIAT, Colombia.

table 5

Monthly labour requirements of typical barbecho farmers

					total		
months	*rice 2.5 ha*	*winter maize[1] 2.0 ha*	*cassava[1] 0.5 ha*	*bananas 0.1 ha*	*labour required*	*family labour*	*hired-in*
August—September	37.5	14	6	—	57.5	40	17.5
October—November	7.5	36	6	—	49.5	40	9.5
December—January	55	—	—	1	56	40	16
February—March	50	—	8	—	58	40	18
April—May	7.5	—	2	2	11.5	40	—
June—July	—	30	12.5	—	42.5	40	2.5
total	157.5	80	34.5	3	275	240	63.5

Source: tables 3 and 4 *plus* Maxwell and Pozo [1981] paras 4.15—4.26

Note: [1]Figures adjusted from those in table 4 to allow for lower land preparation costs of sowing directly after rice, and lower weeding costs in winter.

HPHS research appears therefore to be essential, to deal with new rice varieties, to permit an expansion of cropped area, to make better use of scarce resources and to permit a more flexible response to a changing market situation. The problem is then to identify which parts of the HPHS provide the 'best bet' for change and to decide whether or not research is needed. In fact the problem lies partly in the past since the above conclusion was reached before survey work had been carried out in 1979 and some field work on the HPHS was initiated while the survey was underway.

Change in the harvest method of rice was an obvious candidate for intervention, since labour was a major bottleneck at harvest and new varieties could not be grown without a change. Research in 1979 and 1980 showed:

a) that using sickles instead of knives reduced labour input at harvest by two thirds from 16 day/ha to less than 10; and

b) that the change allowed a shift to varieties that yielded up to 50 per cent more; *but*

c) that the saving in time and the increase in yield was partly offset by harvest losses which appeared with a sickle to be as high as 21 per cent; *and*

d) that the change in harvest technique required a change also in threshing technique since sickle-cut rice could not be stored directly as was often the case with panicle-cut rice [Allen et al 1981].

The 'harvest technique project' thus became a 'threshing project' in which alternative threshers were assessed for their efficiency, cost-effectiveness and suitability for small farmers. Eight threshing systems were studied with a high score being given to small, portable, motorized threshers that were suitable for various crops, including maize and groundnuts. Even these would probably not be profitable unless harvesting losses could be reduced so that further research was recommended on how to reduce shattering at harvest [Allen et al 1981]. The 'threshing project' thus became in part a 'variety selection' project and the wheel had turned full circle.

HPHS research has not ended with this exercise and other avenues are being explored. Work is being undertaken on improved storage to reduce losses and improve quality which has led into research on drying techniques; and the work on harvesting and threshing techniques is being pursued. Furthermore, new research on farming systems will pay more attention to the HPHS and to the compatibility of research on different components of the farm system. The HPHS will therefore continue to be an important research area.

IV. Implications for FSR

Having reached the conclusion that the HPHS is important in FSR it remains to ask whether more is needed than simply to underline the existence of the HPHS and plead for more attention to be given to the

HPHS in FSR programmes. What specific changes in procedures, personnel or other resources will be required?

To the extent that HPHS changes represent simply one more set of potential 'technological best-bets', no real changes in FSR procedure are required: the issue boils down to the question of whether specific improvements can be devised and whether or not such improvements appear likely to be profitable [Byerlee, Collinson et al 1980]. The data required to answer these questions are similar to those for other components of the FSR programme and will include both technical coefficients and financial costs and benefits, expressed in opportunity cost terms: it should merely be noted that HPHS improvemetns will often involve investments with a life of several years so that discounted cash flow analysis may have to be added to the partial budget analysis commonly used to asses agronomic recommendations [Perrin et al 1976].

However, when the importance of the HPHS is considered in broader terms as a problem that appears as the farm system adjusts to new technology, a more serious change in FSR procedures may be needed. This is because most of the analytical techniques developed for FSR treat technological changes at the enterprise level in isolation, as marginal changes: this is analogous to the assumption in social cost benefit analysis that the project being considered is always marginal, in the sense of leaving prices in the economy unchanged. In practice many projects are not marginal; and in FSR it has been shown that the stability of the HPHS is particularly vulnerable to changes in other parts of the system. It may therefore be necessary to do two things: first, to make sure that when a new technology is being considered, the screening process includes a kind of 'HPHS validation' to make sure that any changes in the HPHS are included in the analysis; and secondly, to make more use of whole farm budgeting, so that changes in the enterprise mix and in the total quantity produced and marketed can be monitored. It will also be necessary for evaluation exercises to pay particular attention to changes in relative costs or prices that might affect the HPHS. These changes are perfectly feasible, but they do serve to complicate the analysis in FSR.

With regard to personnel and other resources two points need to be made. The first is that HPHS research tends to be more expensive than some other components of FSR, especially if trials are to be conducted on farmers' fields on a large scale: this is because of the capital cost of threshers, silos and other investments and because of the cost of holding grain in storage trials. From the point of view of research economics, this should be offset by a high rate of return (especially since the HPHS is an under-researched area with high potential), but the cost means that special attention should be paid to selecting the critical components of the HPHS for investigation. The second point is that HPHS is likely to feature prominently in FSR only if HPHS specialists are assigned to the project team: one of the reasons for the relative neglect of HPHS issues may result from the under-representation of such people in FSR programmes. This is true despite the emphasis on breaking down disciplinary barriers and on training specialists in cropping systems for FSR programmes.

Finally, the action-oriented, holistic and farmer-centred nature of FSR should be stressed. While FSR in general will benefit from a closer attention to HPHS research, the reverse is also true: HPHS research will become more cost-effective and more responsive to farmers' real needs if it can be integrated into the comprehensive framework that FSR provides.

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