

# HIDDEN HARVEST

A systems approach to postharvest technology

David Spurgeon



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# FOREWORD

In this booklet, David Spurgeon presents a cogent and potent argument in favour of a substantially greater investment in postharvest systems research and development, particularly in developing countries.

For reasons that may be more evident to the psychologist than to food and agricultural scientists, investment in increased agricultural production — the creation of high-yielding varieties and multiple-cropping systems — appears an infinitely more attractive venture than a rigorous effort to reduce the wastage of crops after they are harvested. Yet, as the author points out, postharvest losses in many tropical countries exceed 30 percent of the crop harvested. Since an increase of 50 percent in the crop grown is needed to offset a 30 percent postharvest loss, one would feel that this alone would be sufficient to encourage a greater investment of time and effort in protecting harvested crops, bearing in mind that total food production in developing countries increased by barely 3 percent per year between 1952 and 1972.

The author presents several convincing arguments to encourage a new and energetic approach to the postharvest problem.

First, both governments in developing countries and those agencies that offer technical and economic aid must recognize the totality of the postharvest system and must seek to comprehend the system as a whole before trying to improve or modify any of its components.

Second, applied and adaptive research into the system as a whole and into its components is necessary. Many attempts to translocate preservation and processing technologies in the past have proven disastrous to the recipients on account of the inappropriateness, technically and economically, of the attempted transfers.

Third, research and technical cooperation among developing nations having similar postharvest problems is to be encouraged to avoid duplication of effort and to gain maximum benefit from postharvest improvement projects.

Fourth, there is an urgent need for cooperation among multilateral and bilateral donors if confusing and seemingly competitive programs of postharvest assistance are to be avoided.

The author directs his text principally to policy makers in both developing countries and assistance agencies; however, scientists and

technologists may also find that many of the facts and suggestions will encourage a more systematic and less compartmentalized approach to postharvest improvement.

It is hoped that those who are in a position to bring relevant influence to bear will be encouraged by this booklet to adopt a more imaginative and courageous approach to postharvest systems research and development, and thereby serve to increase the food available to the people of many less-privileged nations.

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The global food shortage that developed early in the 1970s has drawn attention forcibly to the whole world-wide process of food production, distribution, and consumption. Once the extent of the food crisis was realized, attempts were begun throughout the world to deal with it through increased production, stepped-up research, plans for stockpiling, and so on.

One aspect of food supply that has received little attention to date is the fate of a food crop in developing countries from the time it is ready for harvest to the point where it reaches the consumer's table. What happens here is a whole series of events that, taken together, constitute a system — a postharvest system. It is this system this booklet is about.

One of the unfortunate attributes of this postharvest system, as it is now constituted, is the large amount of wastage it involves. Accurate figures are difficult to come by, but in the case of food grains, some estimates suggest that in less-developed countries as much as one-quarter to one-third of the total crop may be lost as a result of inefficiencies in the postharvest system. If these losses could be prevented, the effect on the world food picture would obviously be enormous. One can imagine the publicity that would follow the development of a new crop variety that would produce one-fourth to one-third more than existing varieties. Yet elimination of waste, using existing crops, could accomplish the same end.

The monetary value of this loss alone is horrendous. The value of a crop depends on the cost price at any particular time, and prices vary over a wide range from year to year. But taking a price of \$7 a hundredweight (a conservative figure), it can be seen that a loss of 25 percent of a food crop of 27 million tonnes (the total cereal and pulse production in semi-arid Africa in 1971) would amount to more than a billion dollars.

Reports by the International Rice Research Institute show that, in its core and outreach programs in the Philippines, losses in the postharvest rice operations range from 1 to 3 percent for harvesting, 2 to 7 percent for handling, 2 to 6 percent for threshing, 1 to 5 percent for drying, 2 to 6 percent for storage, and 2 to 10 percent for milling. This suggests that losses cumulatively could reach as high as 37 percent even where more-than-usually advanced agricultural techniques are used.

Significant increases in production have resulted from the breeding of new high-yielding varieties. Unfortunately, improvements in the postharvest system have not received the same intensive study.



Estimates of quantitative losses during the handling and processing of rice in Southeast Asia.<sup>a</sup>

Operation	Range of losses (%)
Harvesting	1-3
Handling	2-7
Threshing	2-6
Drying	1-5
Storing	2-6
Milling	2-10
<i>Total</i>	10-37

<sup>a</sup>D. B. de Padua, University of the Philippines at Los Baños, College, Laguna, Philippines, personal communication, 1975.

In semi-arid Africa, the situation is much worse: storage losses alone have been variously estimated to range from a low of 10 percent in cereal grains to a high of 75 percent for the more vulnerable pulses. With some crops, insect infestation occurs before storage, and losses run to 50 to 60 percent by weight, with sometimes the entire crop suffering kernel damage.

Such losses are unconscionable in an era of world food shortage and inflated prices. Recent research offers promise of technologies that will yield up to 10 times or more the present average in food crops in some areas. But much of the advantage of such improvements in production could be lost unless it is matched by an equivalent improvement in postharvest technology systems — systems that make possible the delivery of the food crops to the consumers who need them.

#### **What kind of loss is involved?**

When we speak of losses of food crops, we refer to many different kinds of loss, produced by a variety of factors. These include weight loss, loss of food value, loss of economic value, loss of quality or acceptability, and actual loss of seeds themselves. These losses may be brought about in many ways: chemical changes may occur; microorganisms, insects, or mites may proliferate in the crop; rodents may feed on it; or humans may mishandle it by inefficiently storing the grain in poor containers, or exposing it to extremes of temperature and moisture.

Weight loss can result from spillage, or a portion may be eaten by insects, rodents, or birds. In just one Indian city, Bombay, one estimate is that at least 3600 tonnes of cereals are lost annually from rodent damage alone. Since 1 tonne of cereal will feed six people for a year, it can be seen that the loss is considerable — the equivalent of a year's supply for 21 600!

Loss of food value can be caused by overexposure to the sun, which destroys certain vitamins; by the use of high temperatures during artificial drying, which causes thiamine loss in rice; by the development of fungi; or by insect attack. Infestation, for example, can cause a loss of about 12 percent of the available protein in peas and beans. In some areas, where protein deficiency diseases are prevalent, up to 81 percent of the cowpeas and beans in farmers' stores are damaged by insects after 12 months of storage.



Estimated range of losses from a variety of causes in the postharvest system of a number of countries during storage of various crops.<sup>a</sup>

Crop	Country	Weight loss (%)	Period of storage (months)
Legumes	Upper Volta	50-100	12
	Tanzania	50	12
	Ghana	9.3	12
Maize	Zambia	90-100	12
	Benin	30-50	5
	USA	0.5	12
Rice	Malaysia	17	8-9
	Japan	5	12
	United Arab Republic	0.5	12
Sorghum (unthreshed)	Nigeria	2-62	14
	(threshed)	USA	3.4
Wheat	Nigeria	34	24
	India	8.3	12
	USA	3.0	12

<sup>a</sup>After Hall, D. W. *Handling and storage of food grains in tropical and subtropical areas*. Rome, Food and Agriculture Organization of the United Nations, FAO Agricultural Development Paper No. 90, 1970, 20-21.

Contamination by foreign matter is particularly prevalent in developing-country crops. Whereas in the United Kingdom, good quality wheat flour must, by statute, contain less than one fragment of foreign matter per 100 grams of flour, samples of maize meal from Africa were found in one survey to contain up to 475 000 fragments per 100 grams.

#### **What causes this loss?**

A whole variety of causes contribute to this gargantuan loss of food. These include inefficient harvesting and drying methods, poor processing techniques, inadequate methods of storage and distribution, and even — at the consumer end — poor preparation or use of foodstuffs in the home.

Traditional methods of grain distribution in some parts of the world make use exclusively of sacks, for example, rather than bulk shipments that may be more efficient and less susceptible to leakage and spillage. In some places, grain is heaped on mats or tin sheets for marketing, where dirt that falls on it from passing traffic reduces its

One of the most undesirable aspects of the present postharvest system, and one that must be corrected, is the high amount of loss that occurs during storage.



value. Traditional marketing systems often also reduce the return to the farmer by involving too many intermediaries between him and the buyer. Some methods of storage provide insufficient protection against the rain, or against insect pests. Road and transport systems in some countries make distribution to key points extremely difficult and in some seasons impossible.

A state-of-the-art survey of postharvest rice technology in Indonesia, Malaysia, the Philippines, and Thailand,<sup>1</sup> sponsored by the International Development Research Centre and written by Dante B. de Padua, of the University of the Philippines at Los Baños, refers to a variety of postharvest-system defects in Southeast Asia. These include rice-milling technologies unsuited in scale, versatility, labour demand, and cost of operation to the system as a whole, and drying mechanisms ill-designed and too far removed from the point of harvest. A number of the innovations, proposed for or introduced

<sup>1</sup>de Padua, D. B. *Post-harvest rice technology in Indonesia, Malaysia, the Philippines, and Thailand. A state of the art survey.* Ottawa, International Development Research Centre, April 1974, 66. (Unpublished).

Improper storage results in losses through attacks by microorganisms, insects, birds, and rodents.



into the rice postharvest system, revealed that those responsible for the innovations were inadequately aware of the difficulties of threshing, storing, and milling high-moisture rice crops harvested during rainy conditions. Too often attempts had been made to transfer technology unsuited to local conditions.

#### **How suitable is the new technology?**

Recalling the effects of the introduction of the new, high-yielding varieties of rice and associated agronomic practices into the Philippines in 1968–69 (the Green Revolution), Dr de Padua says it focused attention on the inadequacy of postharvest practices and infrastructure capability. The farmers' inability to harvest and dry their dramatically increased yields caused severe losses and damage to the overall quality of the crop, with the result that the exported rice was downgraded in price in the world market.

Dr de Padua described the disheartening process of expectations raised and then dashed because there was no appropriate equipment available to help the farmers capitalize on their now bountiful crops:

“This breakthrough generated a demand for mechanical

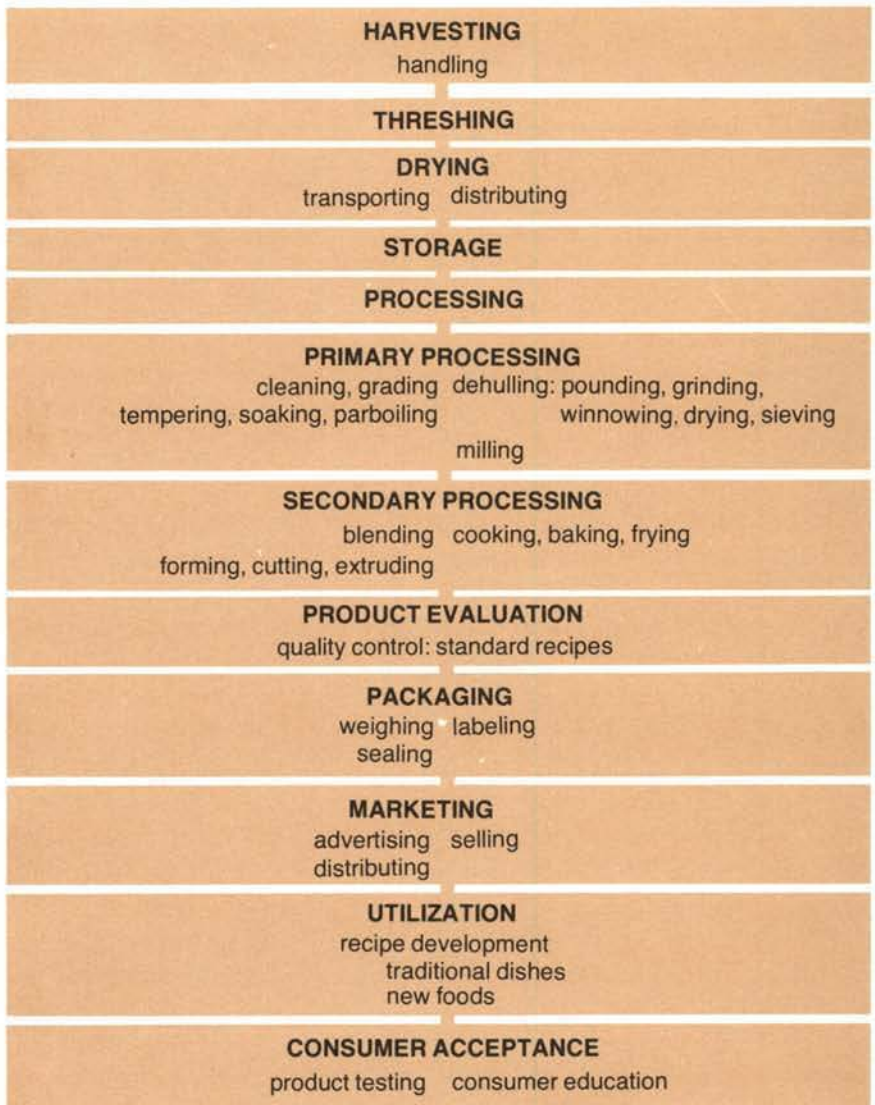
harvesters, grain driers and storage silos. Overnight, equipment dealers, equipment manufacturers, financing institutions, research institutions, international assistance organizations and missions and their experts, and businessmen came alive and responded to the situation. Equipment and other facilities usually designed for wheat and cereals other than rice were imported. Hurriedly-manufactured locally-designed versions of Western models were produced and demonstrated. . . Today all of these imposing structures, owned by government and the private sector, still break the landscape, lonely in their emptiness, slowly rusting away like the relics of a war spawned by sane men in a moment of hysteria, and with continued feeble attempts to preserve them. . .”

One could continue through many pages of weary litany of past mistakes born of attempts to transfer ill-suited technologies; excessive preoccupation with a single component of the total problem; insufficient awareness of traditional and prevailing technical, environmental, economic, and social conditions: in summary, too little appreciation and understanding of the total system by all concerned. “Economic domination by some industrialized countries,” says de Padua, “has foisted on many Asian countries an entirely new technology of milling.” The Japanese, for example, have been aggressive in selling rubber-roller rice mills, but these mills are designed for *japonica* varieties of rice, which are short grained, and they do not work well with the medium- and long-grain Asian varieties. Nor are new milling techniques necessarily what is needed: Asian millers still prefer the traditional mills. Unfortunately, however, some aid-donor agencies will finance *only* new mills that use new mill technology.

It is apparent, then, that losses can and do occur at all points in the postharvest system, and that, in order to cut down on these losses, the system must be examined *as a whole*. Strangely, this has rarely been done. Yet perhaps it is not really so strange, after all. Experts always tend to look exclusively for improvement in their own specialties, and government officials naturally are most concerned about the aspects involved in their own ministries.

In thinking about the problems of postharvest systems, most

Flow diagram of a total postharvest grain system.



international agencies, too, have been concerned mainly with only one aspect — storage. Yet this is only one part of the overall system.

Frequently, aid agencies have even appeared to be in competition with one another in presenting developing nations with a variety of

Proper drying is essential for safe storage and efficient processing. Although sun drying is usually practiced, the use of mechanical driers may become a necessity, especially during the rainy season.



cure-alls for postharvest losses: irradiation by radioactive fission products; extensive use of chemical pesticides; elaborate and costly hermetically-sealed storage bins and prefabricated silos; and even large, refrigerated grain stores for tropical countries, for example. Many of these so-called solutions appear to have been influenced more by the dictates of tied-aid policies than by the real needs and capacities of developing nations.

Properly considered, the postharvest system should be thought of as encompassing the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency, and maximum return to all involved. Such a perspective is provided by a relatively new approach called the “systems approach” — a way of looking at large, complex systems that has recently made possible some of the most remarkable feats in the history of man — one of these being the landing of men on the moon.

# THE SYSTEMS APPROACH

The landing of the first men on the moon by the Apollo spacecraft in 1969 was a triumph not only of technology and the human spirit, but also of a problem-solving technique called the “systems approach.” One dictionary definition of a “system” is “a regularly interacting or interdependent group of items forming a unified whole.” In the systems approach (also called systems engineering), the interaction of these individual elements is analyzed and then the elements are interconnected in such a way as to maximize the performance of the system as a whole.

That was what was done with the multitude of human talents and mechanical and electronic components that made up the Apollo lunar landing “system.” But this approach can also be applied to problems much less complex, such as the scheduling of all the components of a number of standard meals prepared in a large restaurant during a peak period. This is done by first deciding on the menu, then considering how long each item requires for preparation. Then the various steps of preparation are scheduled on the basis of experience, so that each item is ready as needed, and the total number of people served is maximized while the total effort required is kept within acceptable limits according to labour costs.

The systems approach is feasible whenever a model of the system can be constructed — that is, when the system’s elements can be described in quantitative terms and a criterion selected to measure performance. The performance of the system as a whole is improved by adjusting the various elements that make it up. The success of the system depends on how well this can be done.

## **The parts of the postharvest system**

The postharvest food-grains industry can thus be described as a system, with the following main components:

- 1 Harvesting and threshing
- 2 Drying and storage
- 3 Processing (conservation and/or transformation of the grains: e.g. wheat into flour, flour into bread)
- 4 Utilization by the consumer (including home processing)

Other components of the system include:

- 1 Transportation and distribution

- 2 Marketing
- 3 Grading and quality control
- 4 Pest control
- 5 Packaging
- 6 Communications among all concerned
- 7 Information, demonstration, and advisory services
- 8 Manufacture and supply of essential equipment and machinery
- 9 Financial control (price stabilization, credit)
- 10 Management and integration of the total system

If this industry were analyzed using the systems approach, great improvements could be made in its efficiency. Yet at present, this is rarely done by those responsible for the various elements of the system. A mission sponsored by the IDRC to study the postharvest food-grain industry in semi-arid Africa found in talking to highly specialized individuals or agencies that “many tended to look upon their own particular component field as being central in the post-harvest food grains industry, and appeared less aware of the importance of other activities in the system.”<sup>2</sup>

The magnitude and complexity of the system vary from country to country according to the crop involved. Where subsistence farming holds sway, it is only a question of harvesting, storing, and processing the crop on the farm itself. But there is an obvious need, particularly with the growth of rural towns, to produce more than the individual farmer needs. Then the crop must go through a more complex system.

One African country, for example, has a system consisting of socialist-type villages with common land and cooperatives for selling and buying crops. Each region has a headquarters responsible for all villages in it, and at the top of the system is a national grain marketing board that constitutes the production channel.

### **Problems that must be overcome**

All sorts of problems arise within the system whatever it may be. For example, where should the storage points be established for surpluses — in the districts, or in the regions? The question is not simply, how big a storage place is needed or what kind? Because the

<sup>2</sup>Forrest, R. S., T. A. Petersen, J. J. Hogue, and J. Steckle. *The post-harvest food grains industry in semi-arid Africa*. Ottawa, International Development Research Centre, February 1975, 14. (Unpublished).



Storage and handling in bulk, rather than in sacks, can be more efficient and less susceptible to leakage and spillage.



rainy season arrives soon after the harvest, the grain must be transported to the storage points quickly, or the opportunity will be lost because the roads become impassable after the rain and the crops will rot. Thus, the transportation aspect of some postharvest systems is the factor of maximum constraint.

Other parts of the system are the grading component, for quality control, and the processing unit, if there is to be one. A processing unit is not always essential, especially if grain is processed at home into various products. But such a unit may have certain distinct advantages, depending on the system of which it is a part. One of these advantages is that it can contract with the farmer, giving him an incentive to produce more than he would solely for his own consumption.

If a processing unit is decided upon, it must be of a kind that will cater to the needs of the region it serves: the varieties of grain to be milled and the kinds of products required determine the type of machinery it must contain. For example, in Maiduguri, Nigeria, the people known as Kanuris prefer millet grain that is coarse-ground for

making *burabusko* (a steamed couscous); whereas, just a little further south people grind all their grain into fine flour, which is made into *tuwo* (a kind of thick porridge). On the other hand, nomadic tribes in some parts of Africa prefer a granular semolina-type grain, which they mix with animal blood and milk in gourds or pouches attached to the animals they ride. Other people prefer flour that can be made into noodles.

Rice mills typical of larger Japanese and Western enterprises that are designed to process well-graded paddy of uniform grain size, frequently prove totally inefficient when applied to the widely heterogeneous mixture of varieties that customarily is delivered to many small Asian mills.

Another consideration in the postharvest system is the method of drying grain. If rice is to be stored, its moisture content is an important factor, because it will become degraded more quickly if it is moist.

Many of the new high-yielding varieties also mature more quickly than traditional rice varieties. This enables Asian farmers to grow two and sometimes three rice crops each year on the same field. This results in at least one crop being harvested during the rainy season with a consequent high moisture content above 25 percent, compared with 15 to 18 percent in a traditional crop.

Thus, if the drier is sited close to the mill it may be too far away from the farm, in which case the high-moisture crop may deteriorate by the time it reaches the mill. Such a situation indicates the need for small village driers located close to the paddy fields. However, appropriate equipment for this purpose is hard to come by. The result is often that attempts are made to transfer Western-type equipment that may be wholly inappropriate. A drier suitable for drying wheat in a temperate climate may be worse than useless in a tropical climate. Mills designed for the short-grain, well-graded rice produced in the West will damage much of the kind of grain found in South and Southeast Asia. The situation is further complicated by the farmers' practice of deliberately planting many varieties of food grain for safety, on the principle that if one variety fails, another may survive. In Africa as many as 40 different cereal varieties may be planted in the same field.

In order to deal with such situations, the equipment used must be

flexible: one mill may have to accommodate many different types of grain. Such a mill may not be as efficient in terms of throughput as one designed for a single grain, but what is important is that it is adaptable to local conditions. What is needed, in other words, is to tailor the system to the needs of the area it serves.

Many different problems plague the postharvest system in different countries. In Africa, the food-grains industry is predominantly an “on-the-farm” industry, and virtually the whole set of postharvest activities occurs there. Only about 10 to 15 percent is diverted through what might be called, in developed economies, formal market channels. That small proportion goes mostly to the large urban centres, where native dishes requiring local food grains are in demand. The subsistence farmers sometimes tend to respond to this demand with insufficient and irregular supplies from whatever surplus crops they may have produced.

Harvesting and threshing methods for food grains in semi-arid Africa are completely unmechanized, except for a few large holdings, mainly in northern Tanzania, Kenya, and the Sudan. The bulk of food grains is stored on the farm where it is produced or by housewives who have acquired grain by purchase or barter. Almost all farm and household containers are small, and usually are made from local materials, thus they vary widely from country to country and even community to community. Commercial pest control chemicals are rarely used because most are prohibitively expensive.

Storage itself is a problem: little of the food grain produced in Africa is stored and handled in bulk. Several countries have tried various methods, such as metal silos or bins, or butyl-rubber silos, but none has had much success. But in countries where labour is cheap and plentiful, bulk-storage systems are far from the panacea they may appear to be to the visiting foreign expert. Where bag stores are efficiently managed, losses can be significantly reduced. There are many examples in tropical countries of bagged crops, particularly cash crops for export such as cocoa beans, coffee, and oilseeds, in which losses have been minimized by efficient handling and storage and reliable overall postharvest management.

### **Second generation problems**

Communications, information, and extension education are other

activities vital to the postharvest system, but they are difficult to manage because several decision-making groups are involved and there are a large number of decision-makers within each group, farmers being the largest.

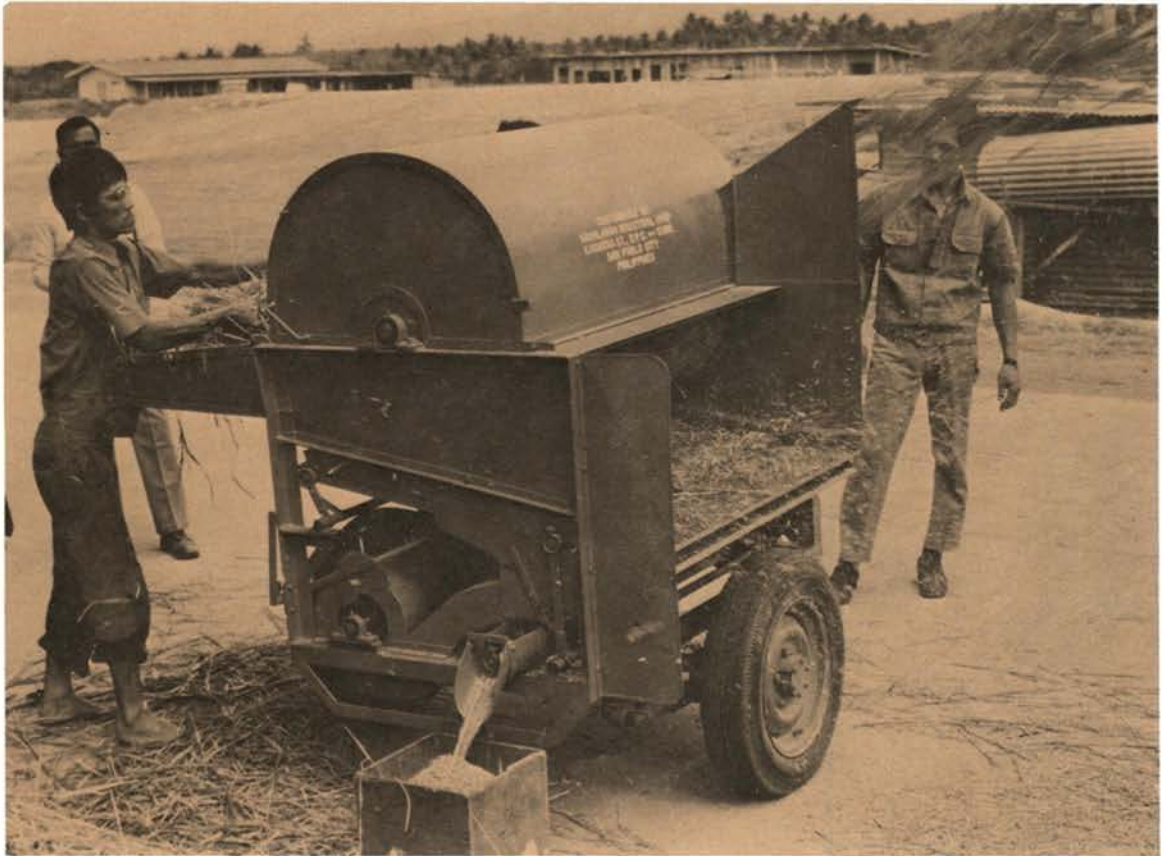
Often the areas involved are by their very nature difficult to serve with a communications network: newspapers and radio, television, and telephone facilities provide only a limited coverage of the communities they are meant to serve. This is true, for example, in the Sahel. Agricultural extension departments also vary greatly in their comprehensiveness and coverage from country to country. Until recently, for example, Ethiopia had only a handful of extension personnel for several million farmers. Tanzania has shifted the extension function to a large extent from the ministry of agriculture to the Prime Minister's office. In Senegal, an extensive program exists in the heavily farmed region east of Dakar, but there is scarcely any service elsewhere. On the other hand, countries like Kenya, Nigeria, and Ghana have extension networks similar to those in North America and Europe.

It is worthwhile noting that, whereas efficient postharvest systems do not as a rule exist in developing countries for crops destined to feed those countries' own people, they *do* often exist in those same countries for crops destined for export. A good deal of the knowledge and experience gained in postharvest systems for export crops could be applied to reduce losses and improve the quality of subsistence grains.

Many less-developed countries rely heavily upon imported cereal grains to feed their expanding urban populace. If they are to reduce this dependence upon foreign grain supplies, their governments must assign higher priorities not only to increased grain production, but to more effective postharvest systems, in order to expedite grain movement from rural to urban areas.

In addition, a number of Asian and African research institutions, whose mandates include some components of the postharvest system, have not been tackling the urgent practical postharvest problems with which their farmers, small processing factories, and distribution channels are confronted. Thus, in many regions the facilities for research, development demonstration, and training in postharvest systems already exist. What is required is a shift in the

Care must be exercised in the adaptation of new technology to the present postharvest system. Any innovation must be extensively tested under conditions prevalent in the area for which it was designed.



orientation of their existing programs, and a close working relation between scientists and technologists on the one hand and the food producers, processors, and distributors on the other.

One sometimes is presented with the opinion by technologists from developed countries that no new postharvest research is necessary; that all that needs to be known is known; and that all that is necessary is the “transfer of existing and proven technologies.” Although many of the essential underlying scientific principles have been elucidated, a great deal of applied and adaptive research — into both the technical and economic components and the postharvest system as a whole — is still urgently needed in most developing countries in the tropics.

# A WORKING EXAMPLE OF THE SYSTEMS APPROACH

Perhaps the best way to understand how a systems approach can work in a postharvest system is to study an example of such an approach in operation. One good example is the Maiduguri Mill Project, a joint venture of Nigeria's Ministry of Agriculture and Natural Resources, the North Eastern State's Ministry of Natural Resources, and the International Development Research Centre.

Maiduguri, a city of some 150 000, lies in the centre of an area in which the main crops grown are sorghum (Guinea corn), millet, maize, and cowpeas, with smaller amounts of wheat. The Maiduguri Mill Project is concerned with the postharvest grain system in rural Nigeria. A modern yet simple milling unit is the heart of the system, but the project encompasses the entire range of postharvest activities, from threshing, drying, and storage, through primary and secondary processing, to product evaluation, packaging, and marketing, to consumer utilization and acceptance.

The project was set up to reduce losses of grain involved in traditional methods of handling and storage, and to increase monetary return to the farmer by using more economical methods of grain purchase, storage, transportation, processing, and sale. At the same time, it was designed to process a variety of local grains into nutritious, high-quality, and in some cases new, food products.

## **The existing food-grain industry**

The first task was to obtain information on the existing postharvest food-grain system in the project area. An agricultural economist's 1972 survey showed that most of the crop production in the area was retained by farmers for their own needs, and that only 10 to 15 percent of the total entered market channels. Most of the grain entering the market was moved from a central market place to secondary and terminal markets through a large number of speculators who bought, stored, and resold it, causing wide variations in price. The price difference for sorghum, for example, amounted to 30 to 40 percent among four regional markets. Most of the grain was ground on a custom basis in small plate mills driven by diesel engines and located in the towns. Further processing was done by hand, either by women in the home, or by flour vendors.

In most Maiduguri households, flour is prepared from purchased grain two or three times a week. The most common practice for

The Maiduguri Mill Project is a good working example of the "systems approach." As such, it has been integrated into the overall postharvest system in Nigeria and encompasses the entire range of processing activities.



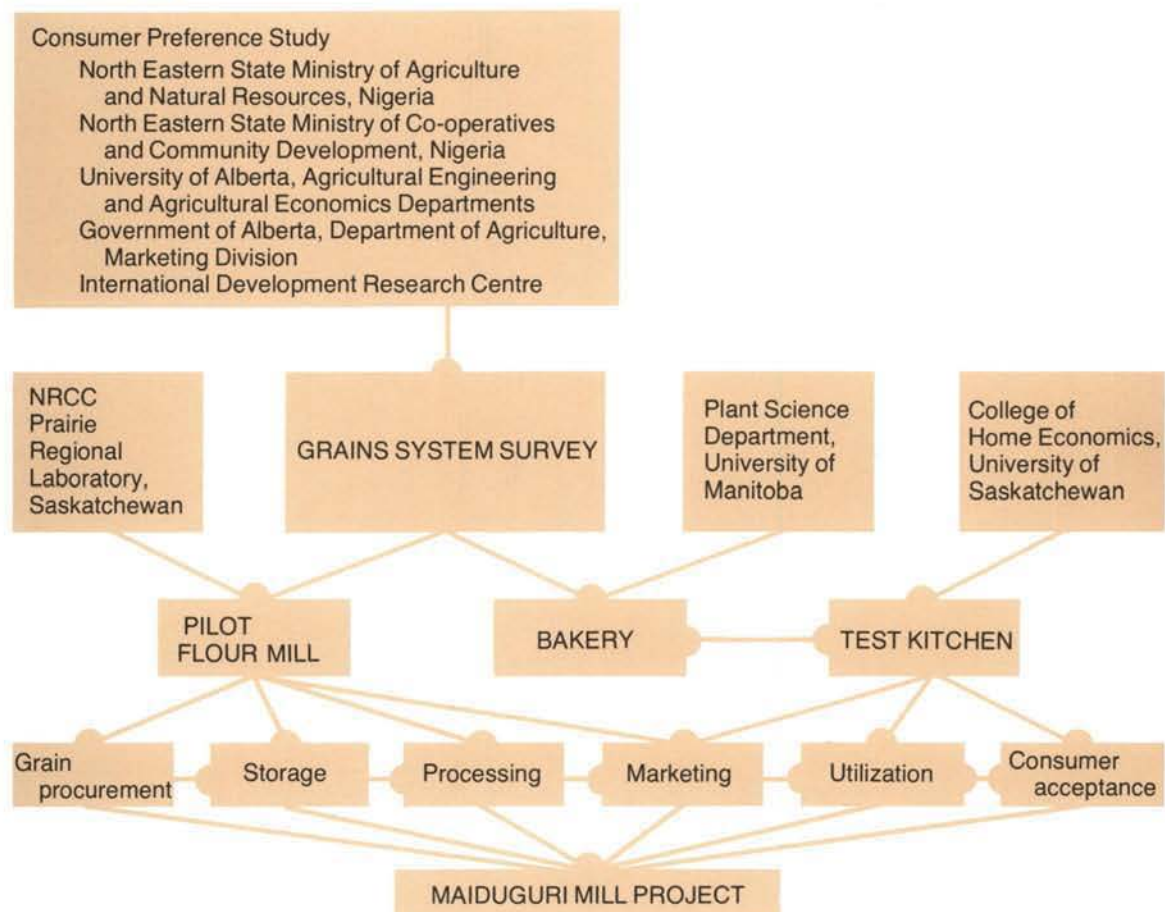
dehulling is hand-pounding with a mortar and pestle, followed by winnowing. A large majority of the households send this dehulled grain to local mills for grinding into flour or grits (a practice promoted by the introduction of plate mills about 15 years ago).

Another early step required was to find out how families preferred to process and prepare the various grains and legumes for consumption, because this would determine the type of milled products required, as well as the packaging methods and marketing techniques. Therefore, a consumer grain-preference study was undertaken.

Next, a Mill Managing Committee was set up, thus forming a single system embracing supply (through the state Ministry of Co-operatives and Community Planning); mill management (through the Ministry of Natural Resources); marketing (through cooperative stores); and access to household consumers (through the Ministry of Natural Resources' Home Agents).

A training scheme was also worked out, involving two employees of the Ministry of Agriculture associated with the mill

Schematic diagram of the Maiduguri Mill Project.



operation who were sent to Toronto to assist with the assemblage and testing of the mill machinery at the manufacturing plant, and the appointment of a Canadian University Services Overseas volunteer who acted as technical adviser to the project.

### Fitting the mill to the system

The pilot mill itself was, from the beginning, considered to be simply part of the overall postharvest system. It was of a comparatively simple type, consisting of four units: a precleaner, a dehuller, plate and hammer mills, and a flour sifter. A unit for heat-sealing plastic



bags was included. Power requirements, totaling 30 horsepower, were supplied by two diesel engines.

The straightforward system for mechanically processing sorghum, millet, and maize begins with grain cleaning, to remove foreign matter. Dehulling is next. The dehulling unit, which operates on the principle of abrasion, represents a technological innovation in grain processing for the area because traditional dehulling is done by hand. The dehulled grain is subsequently passed through the plate and hammer mills, and the sifter separates the milled grain into three fractions: fine flour, semolina (grits), and middlings.

During construction of the mill the initial consumer-preference study was expanded. Eleven hundred households in Maiduguri were surveyed to determine the type and volume of flour that would be required from the mill, and to develop a consumer education program for improving the household utilization of cereals and grain legumes in the diet. The entire Home Economics Department of the North Eastern State was involved in this study.

The study showed that there had been an increase in recent years in the use of packaged flours for preparing traditional staple cereal foods, and a shift to processed foods. This created an opportunity to develop more nutritious foods from cereal and legume flours. The survey also indicated that nontraditional foods made from prepared flours were gaining popularity: bread, for example, was fast becoming a popular breakfast food. However, most of these processed cereal foods were being made from imported wheat.

These changes in the country's traditional food patterns suggested that the consumer education program should include: (1) supplementation of traditional cereal dishes with high protein dishes; (2) substitution of sorghum, millet, and cowpea flours for imported wheat in traditional foods; and (3) development of new dishes containing sorghum, millet, and cowpea flours.

Snack foods were also popular — children in 40 percent of the households received money to buy them — so considerable potential was apparent for developing new and more nutritious types of such food.

### **Putting the system to the test**

A test kitchen was established at the mill, with a Nigerian home

In most of Africa, the most common practice for dehulling is hand-pounding with a mortar and pestle, followed by winnowing.



economist in charge. The kitchen work involved milled-product quality control, gathering and testing traditional food-product recipes, and development, testing, and determining the consumer acceptance of recipes. Recipes were also demonstrated to Home Agents, for introduction to the peoples' homes.

With some technical assistance from a Canadian research institution, a variety of new products was developed in which imported wheat was replaced by local grains. These efforts have shown considerable success. A technique has been established for preparing fried snacks containing various blends of sorghum, millet, and cowpea flours, and nutritional evaluation confirms their superior, high-protein composition. Nigerian noodles (*taliya*) have also been prepared, with up to 50 percent replacement of wheat flour by blends of flours made from local grains. These noodles resemble conventional all-wheat noodles with respect to both cooking quality and texture, and contain between 12 and 16 percent protein.

The Maiduguri experience demonstrates the importance of carrying out in-depth marketing research before setting up a production

Initially, information on marketing and processing in the food-grains industry was gathered to identify problem areas and to ensure smooth integration of the mill into the overall system.



unit. Without knowledge of what the consumer wants to buy, it is impossible to make a realistic decision about what to produce.

Construction of a bakery was also started in 1975. Bread was to be prepared both in the traditional manner without modern equipment, and by novel techniques using comparatively simple equipment. The bakery will serve as a training centre to introduce the technology for preparing bread from composite flours containing both wheat and local grains. A Nigerian baker will be in charge of the operation, and the entire project will remain under the direction of the mill manager.

The Maiduguri Mill Project serves to illustrate that a postharvest system is made up of a variety of interrelated activities that can be combined to form a more efficiently functioning whole. Most important, it shows that a rationally designed and integrated system can provide a stimulus to local grain production and utilization and a reduced dependence upon imported cereals.

# BENEFITS OF THE SYSTEMS APPROACH

Many benefits will flow from the establishment of an orderly, efficient, postharvest system. Such a system creates the climate of confidence required to persuade subsistence farmers to produce grains beyond what they require for themselves alone. It substantially increases the availability of food grains, improves people's well-being through improved nutrition, reduces outflow of foreign currency, and results in general economic benefits.

Rationally conceived and well-administered postharvest systems help to make the supply of food crops more consistent and discourage cycles of regional and seasonal surpluses and deficiencies, with their resultant wildly fluctuating price levels. In addition, an orderly postharvest system offers many opportunities for increased rural and urban employment: employment in harvesting, grading, storing, transporting, processing, and marketing grain; and employment in constructing the facilities and distributing the machines necessary to all these functions. Such employment could be even further increased in developing countries if more attention was given to designing postharvest machinery that made use of local materials and labour.

A good postharvest system has other benefits too: by reducing spoilage, it may enhance the acceptability, utility, and nutritional quality of food grains. It also leads to the establishment of entirely new industries for producing processed foods, thus providing a consistent, year-round demand for local grains.

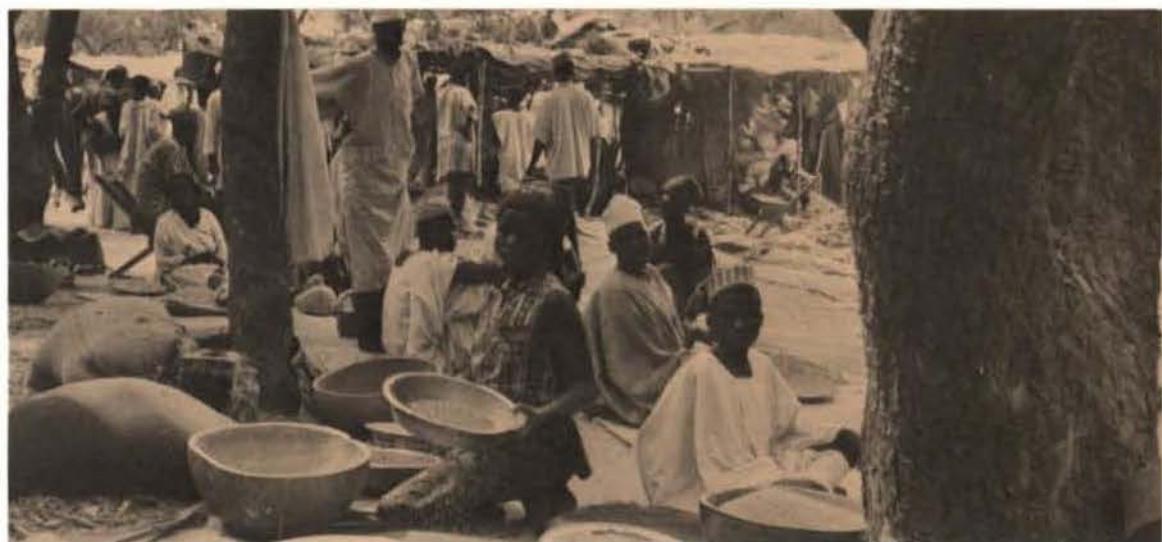
The potential demand for such processed foods has already been demonstrated: urban populations in developing countries are buying more and more imported processed foods. For example, the demand for North American and European types of bread is increasing in Africa in almost perfect correlation with the increase in the urban population. Much of this bread is made from imported grains, as are the cereal-based weaning and infant foods that are imported in substantial quantities by developing countries.

There is no reason why similar products could not be made, in large part, from local food grains. Ample evidence exists to suggest that technologies could be developed to permit significant proportions of indigenous sorghum, millet, maize, and tropical legumes to be used in place of imported cereals. Such technologies, applied commercially, would open up many possibilities for local workers and entrepreneurs. The demand they would create would also stimulate food-grain production.

Consumer preference studies were undertaken to determine the type and volume of flour that should be produced, and to develop a consumer education program for improving the household utilization of cereals and grain legumes in the diet.



A more uniform demand has been created for the mill products by selling them throughout the town and in the market.



Although earlier in this booklet I used the U.S. lunar landing program as an example of what can be accomplished through the systems approach, I do not propose that a material or human investment equivalent to that program be invested in postharvest research and development. Nevertheless, an analogous total systems approach to postharvest improvement is essential, because anything short of it — particularly an ad hoc, piece-meal approach — will actually aggravate rather than ameliorate the present dismal postharvest situation.

Nor do I suggest that new research institutions need be created. Many institutions that already exist could be used in the system — but they will need reorientation and a policy of reciprocal cooperation.

The first essential for the establishment of a new approach to postharvest systems problems is recognition by national policy-makers that a total systems approach is necessary. Next, the political will is needed to create more efficient postharvest policy, relevant and appropriate to national needs, resources, and capabilities.

Existing international, regional, and national facilities for postharvest research, training, and information must be considerably strengthened. Their individual efforts must be more efficiently coordinated, and adequate mechanisms for technical guidance, cooperation, and exchange of information must be created.

## **International action and cooperation needed**

International action is necessary to help governments in developing countries understand what steps are necessary to create efficient postharvest systems. Individual components of such systems — crop drying, processing, storage, etc. — will all continue to benefit from imaginative applied research. But unless the relevance of each component to the total system is understood, imagined improvements to the individual components may prove to be detrimental to the system as a whole.

More attention must also be given to the economic, human, and social factors within the postharvest system, particularly as they relate to the attitudes and demands of the consumers for whom the system is designed. This means that more applied research must be undertaken under real-life conditions — in the rural areas rather than in laboratories. If laboratory research is necessary, it must be done in

Sorghum, millet, and cowpea flours are available locally, and efforts are now being made by the test kitchens at the Maiduguri Mill to substitute these flours for wheat in traditional foods.



consultation and close cooperation with farmers, processors, and consumers.

If research should lead to a new or modified machine, the feasibility of manufacturing this machine in the country or region in which it is to be used should be explored. And feasibility studies of new techniques should take account of engineering, economic, and marketing factors in that country or region.

Although creation of new research institutions is not necessary, there is a definite need for a central coordinating advisory and information service in each region. Such services could be created through international action and supported through multidonor

participation. It might, for example, be coordinated through the Consultative Group on International Agricultural Research sponsored by the World Bank Group, the United Nations Development Program, and the Food and Agriculture Organization of the United Nations.

Technical advisory teams would need to be established to serve regional interests. Composed of several relevant specialists in both economic and technical disciplines, their responsibilities could include:

- (1) Advising interested governments of the region on the postharvest systems for their cereal grains and legume crops.
- (2) Identifying constraints and problems in existing postharvest systems, particularly problems common to several countries.
- (3) Defining research, development, training, and information programs.
- (4) Identifying institutions where these programs could be carried out and assisting these institutions to obtain financial support.
- (5) Providing information through regional workshops on planning and postharvest systems, and encouraging governmental cooperation.
- (6) Encouraging cooperation between scientists and technologists in developed and developing countries.

These technical advisory teams would best be located at, or close to, existing agricultural research stations, in order to link postharvest research closely to crop production research. For it must be emphasized that the postharvest system is in fact a subsystem of the total integrated process of producing, protecting, distributing, and utilizing food crops.

In addition to these advisory teams, each region should explore the possibility of creating policy advisory groups of senior administrators and scientists from each of the participating countries. Through these bodies, agreement could be reached on the distribution and integration of research efforts among cooperating countries. Such groups could also make recommendations to donor agencies concerning bilateral aid required by countries within the cooperating network.



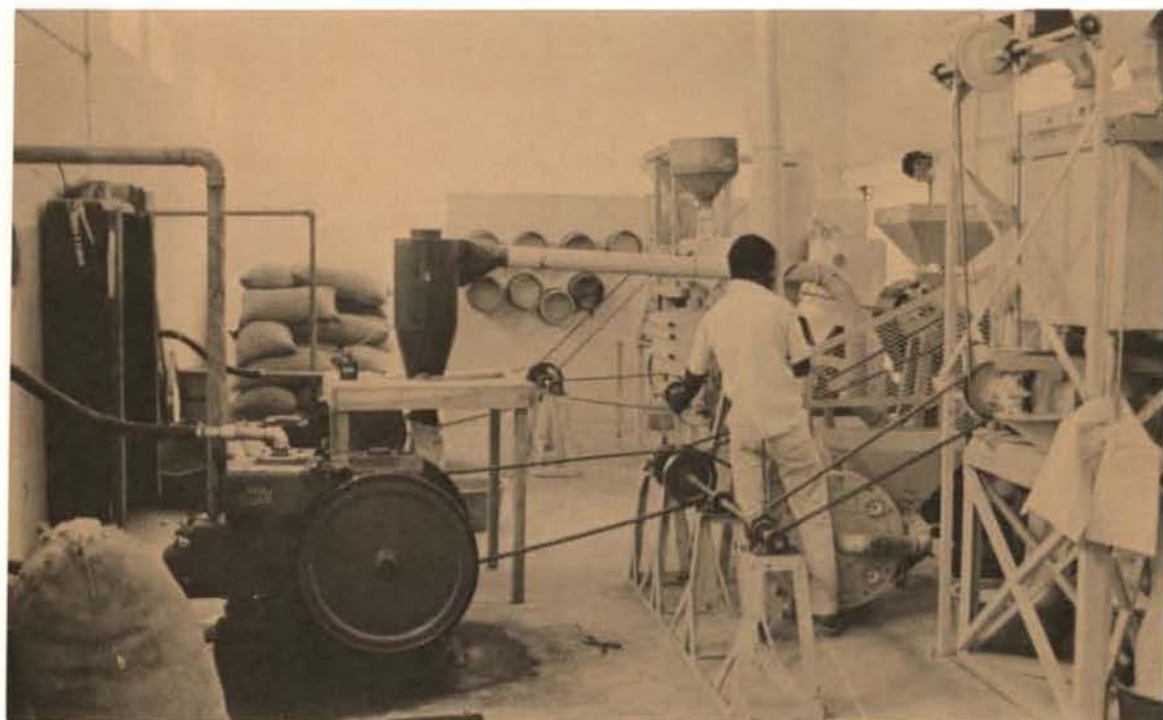
A bakery, started at the Maiduguri Mill in 1975, produces bread both in the traditional manner (without modern equipment) and by novel techniques using comparatively simple equipment.



The technical advisory teams need not consist of more than five persons, and the cost of maintaining each team, including technical and administrative support, travel, and consultant services, should not exceed \$500 000 annually. Research, development, and training programs would of course require more funds, but if carried out as recommended — within the rural areas and in existing institutions — the cost should not be exorbitant.

An important function of such teams would be to encourage cooperation among different multilateral and bilateral donors. One could cite an unhappy series of examples in which different donors supporting postharvest projects have appeared to work in competition, rather than in cooperation, with one another. A splendid example of donor cooperation is to be found in the Consultative Group on International Agricultural Research referred to above, a group of nations and foundations that has served to increase crop production through support of the International Agricultural

By careful integration, the Maiduguri Project has been successful in reducing grain losses, increasing monetary returns to the farmers, and at the same time initiating the production of improved food products.



Research Centres. This serves as an excellent model for a similar cooperative support for postharvest systems.

Whatever the amounts of food-aid developed countries contribute to ease the plight of developing countries during the coming era of probable food shortage, and whatever the amount and kind of technical assistance they see fit to provide, the final answer to the developing world's food supply rests with those countries themselves.

Similarly with postharvest systems: the extent to which they can be improved depends ultimately on the nations that must employ them. Not only are the necessary technical and political decisions theirs alone to make, but most of the research, development, and training involved in new or improved technologies must be carried out under the developing countries' jurisdictions.

### **Immediate action required**

It is of the greatest urgency that the governments of developing

countries recognize that postharvest problems exist, and that these problems can largely be attacked through existing institutional and other facilities. All that is needed is a strengthening of effort, or in some cases a shift in emphasis.

It is also important that the postharvest problems that, in the past, have received the greatest attention (such as storage, pest control, and processing) should be recognized as components of a total system — and that, before any significant progress can be made, the desirable postharvest system must first be defined and understood.

Considerable opportunity exists for regional and international cooperation in the creation of more efficient postharvest systems. Given the political will on the part of all nations concerned, and using the mechanisms proposed in this booklet, major progress can be made quickly in creating economically and technically effective postharvest systems in the developing world. Such action will go a long way toward solving the problem of supplying food for the majority of the world's people, and will, in effect, uncover an enormous hidden harvest for the developing countries.

