A REVIEW OF SELECTED RESEARCH ON POST-HARVEST LOSSES OF GRAINS AND THE UTILIZATION OF FARM LEVEL STORAGE IN DEVELOPING COUNTRIES

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To my family

and friends - brothers

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I. INTRODUCTION AND PROBLEM SETTING

An analysis of food production and population trends reveals that mankind will continue to struggle to feed itself. From 1970-1976, annual per capita food production increased 1.4% in developed countries and at less than 1% in developing ones. Population growth rates have been declining in the former, but have remained more or less constant and at much higher levels in the latter. Therefore, increasing food supply is more critical in developing countries.

Three approaches are often mentioned to help cope with the possible world food shortage:

1) Increase food supplies by increasing production
2) Reduce future increase in demand by slowing population growth
3) Increase food availability by reducing post-harvest losses.

All three approaches are necessary in an overall strategy to solve the world food problem. The third approach has recently received major attention.

The VIIth Special Session of the United Nations General Assembly in 1975 set a goal to achieve a 50% reduction in post-harvest food losses by 1985 (19, 20, 65,

66, 67). Since then, several studies of storage techniques, losses and factors affecting them have been developed.

There has been a great deal of discussion about the magnitude of these losses and the accuracy of their assessments; nevertheless, the general belief is that the amount lost is significant. Inadequate storage facilities and poor storage practices are often blamed for this fact.

Post-harvest food losses can occur during a wide range of activities. As Bourne (9) pointed out, the task of providing more food is not completed at the moment of harvest. There exist possibilities for losses through the entire marketing chain until the consumer is reached. Thus, the marketing dimension of the problem cannot be neglected.

Given this fact, and taking into account the possible length of this paper, the study will be restricted mainly to problems of grain storage at the farm level in developing countries. This is because grains (cereals, legumes, oilseeds), among the agricultural commodities consumed as food, contribute the bulk of the world's calories and protein. The following points will be examined:

1) The extent and causes of post-harvest food losses, with special emphasis on grain losses during storage
2) Capability and opportunity of farmers to make appropriate management decisions about consumption, storage and sales of their food grain.

Considering these two aspects it will be necessary to

look at empirical results, trying to reach a conclusion about the magnitude and conditions in which food grain losses occur, and about factors affecting farmers' storage decision-making processes. Therefore, the objectives of this plan B paper are:

1) To review recent research on post-harvest loss reduction and grain storage at the farm level, with special focus on the problems of small and medium size farmers;
2) To review research on factors influencing use of on-farm storage facilities by different types of farmers;
3) To develop a conceptual framework for achieving a more integrated understanding of farmers' decision-making about consumption, storage, and sales of food grains. This will help to orient research and extension efforts to improve grain storage and farmers' management decisions about storage in developing countries.

The remainder of this paper has been organized in the following manner: Chapter I presents the introduction and problem setting. Chapter II treats recent research on post-harvest loss reduction and on-farm storage problems. Chapter III refers to research done on factors influencing farmer utilization of on-farm storage facilities. Chapter IV delineates a conceptual framework for orienting research and extension efforts. Finally, Chapter V presents a

summary and conclusions.

II. RECENT RESEARCH ON POST HARVEST LOSS REDUCTION AND ON-FARM STORAGE PROBLEMS

In 1975, resolutions of the United Nations General Assembly set a goal to eliminate half of the world food losses by 1985 (19, 20, 66). Since then, research on post harvest losses has been carried out more intensively. Most of the initial literary work is concerned with on-farm storage of food grains and has focused primarily on biological and physical aspects of the problem (3, 4, 5, 11, 12, 16, 17, 28, 30, 31, 41, 45, 46, 63, 67). On the basis of the literature reviewed in this report, international and national organizations have recognized the different dimensions of the problem of post harvest food losses and the need for multi-disciplinary work in the area.

There are several institutions conducting research on this subject, among them the Food and Agriculture Organization of the United Nations with a leading role. Its activities are characterized as advisory, training, applied research and extension for improving on-farm storage practices, improvements in milling technology, off-farm storage, and collaboration with other technological institutions and bilateral agencies (18).

There are also many other organizations in different geographical areas working on the same problem. However, it would not have been possible in this report to review all the work done by those institutions. A more workable approach has been used to present a brief summary of the most important and recent studies carried out about post harvest loss reduction and on-farm storage problems. It is appropriate to mention two excellent reviews of literature on the subject, one by Adams (1) and the other by the U.S. National Academy of Sciences (68).

2.1. Definition and Classification of Losses

Many people have categorized post-harvest food losses, but found it difficult to make precise definitions. Regarding this point, Adams and Harman (2) mentioned two different approaches, the biological and the economic. For the former, loss depends on the definition of loss. It could be of quantity or quality, but the problem is to obtain a measure that can be translated into economic terms. The latter studies the economic consequences resulting from the reduction in the quality and quantity of a product. Evaluation of these consequences could be made from the point of view of the farmer or person experiencing the loss as well as from that of the whole country. The most important underlying evaluation is to assess a past opportunity or intended usage.

At this point it would be convenient to define certain

terms that will be used in this paper following Bourne's terminology.

"Post-harvest Losses" are those occurring between the completion of harvest and the moment of human consumption.

"Food" is the wholesome edible material that would normally be consumed by humans.

"Loss" is any change in the characteristics of food products so that their edibility or wholesomeness is reduced, or the products turn unfit for human consumption.

"Weight Loss" is the loss in weight of food grain resulting from spillage or activity of insects, rodents, mold or other pests. Weight loss reduces food value. (Changes in volume and weight due to moisture are different. For example, grains harvested at 21% moisture could be dried by mechanical means or aeration to a 15% moisture content, therefore there is a reduction in weight but not in food value. Thus, moisture loss is not included as a part of weight loss.)

"Quality Loss" is assessed by using a standard of quality, and measuring loss as the difference between the standard and that of the damaged grain. The relevant standard will depend upon the intended use of the grain.

"Direct Losses" is the waste or consumption of grain by non-human agents (e.g. insects, birds, fungi, bacteria, rodents, others).

"Indirect Losses" are the cost of insecticide or other treatments used to minimize losses.

"Damage" is considered the percentage of grain infested, broken, molded, etc., but it does not necessarily mean a high weight loss. Indeed, several studies found that high grain damage represented low weight losses (10, 17, 31, 60, 63).

2.2. Causes of Losses and Assessments Problems

Food losses have occurred under a great variety of conditions as has been reported in most studies. Recently, several studies have tried to identify the causes of losses for major food grains (2, 5, 10, 14, 17, 23, 27, 29, 30, 31, 41, 60, 63, 65). Among the factors reported as causing food losses, the following are the most important:

1) Preharvest factors (e.g. genetic characteristic of grains)
b) Harvesting factors (e.g. early or late harvest, weather conditions, and regular combine losses)
c) Threshing and hulling factors (e.g. different methodologies)
d) Drying factors (e.g. under or overdrying)
e) Storage conditions (e.g. temperature, humidity)
f) Biological factors (e.g. insects, mites, fungi, bacteria, rodents). These can cause losses during the growing period or after harvest when grain is stored.

Amezquita (4), in a seminar sponsored by the Inter American Institute of Agricultural Sciences, pointed out

that losses have two origins: (1) technological and (2) socioeconomic. Under the first category are those causes coming from deficiencies in concepts, methods and their application and lack of knowledge or inadequate technologies, even though favorable socio-economic conditions exist for their application and execution. Under the second category are those causes which directly or indirectly lead to conditions in which a technological solution is difficult or inappropriate to apply. They are usually the result of nonexistant, inadequate, ignored or improperly handled conditions (e.g. policies, resources, education and training, services). There are no strict boundaries between each category. Furthermore, losses normally are caused by more than one factor.

Even though the causes of losses can be identified, most studies reflect the difficulty in measuring the percentage of food grain production that losses actually represent. The measurement problem is complicated further because the reliability of findings could vary greatly depending on loss assessment techniques.

The enormous variability of local post harvest situations dictates that no complete or definitive loss assessment methodology for all situations is now possible. Although, as Harris et al. (32) pointed out, "A methodology for assessing post harvest grain losses will not in and of itself reduce those losses, the methodology is essential to post harvest operational programs so that priorities for

loss reduction can be determined."

One of the first works done in the 1970's on loss assessment techniques was a very complete manual on evaluation and prevention of crop losses by pests, diseases, and weeds published by the Food and Agriculture Organization of the United Nations and the Commonwealth Agricultural Bureaux (16). This work is the result of a Symposium held in Rome with representatives of 36 different countries. It summarizes loss assessment methods developed in different areas of the world and classifies them by crops, cause, symptoms and country.

In 1978, two other important works on this subject appeared. The first is the Manual of Postharvest Grain Loss Assessment Methods compiled by Harris and Lindblad, and published by the American Association of Cereal Chemists in cooperation with the League for International Food Education, the Tropical Products Institute, FAO and GASGA under a grant of USAID (32). It was a joint effort to present a reliable grain loss assessment method yielding standardized and reproducible results. The methods for measurement of loss are classified by causes and situations where the losses occur. An approach for conversion of losses into monetary values is also presented.

The second work on post harvest food losses and their assessment was published by the U.S. National Academy of Sciences (67). Losses are classified by causes and commodities groups such as cereal grain, grain legumes and

perishables. Other authors have presented alternative ways of estimating percentage loss in food grains including Kryshnamurty (40), Adams and Harman (2), Hamilton (31), Sorenson, Petersen, and Ives (60).

2.3. Magnitude of Losses

There is an extensive debate in the literature about the magnitude of post-harvest food losses. The results of the studies could be separated roughly into two groups, those claiming that losses represent a high percentage of grain production (25-40%) and those claiming that the percentage is low (5-10%). Reusse (54) has pointed out that most often judgements about high losses have had little relevant on-farm survey work to substantiate the assessments. Part of this problem is also due to the use of different loss assessment techniques and sampling procedures, as well as the existent confusion between damage and loss. For this reason it is convenient to keep in mind the definitions presented earlier.

Another main problem in deriving reliable estimates of storage losses is that grain losses vary considerably by region, type of grain and type of storage. The condition of moisture and temperature in which grains are stored will also influence the amount of losses.

Amezquita's (4) work belongs to the first group which claimed losses are high. He has presented the results of several local studies in Latin America about physical losses

of grain during the post harvest period. Depending on the crop, losses ranged from 15-60%.

The Food and Agriculture Organization of the United Nations (15), from its survey of post harvest food losses in developing countries, has pointed out that for maize in Tanzania and Brazil the percentage of weight losses ranged from 20 to 100% and from 15 to 40%, respectively. For rice in Sri Lanka and Bolivia these percentages were 13.4 to 40% and 16%, respectively. Finally for sorghum in Rwanda and Sudan weight losses varied from 10 to 20% and from 6 to 20%, respectively. The U.S. national Academy of Sciences (according to FAO estimations) has cited a minimum overall loss of 10% for durable crops like grains and 20% for non-grain staples and perishables (15, 67).

Results from studies in the second group present different values. For example, the Government of India Expert Committee on Post-harvest Losses (3) estimated that overall food grain losses accounted for 9.33% of production, with storage losses representing 70% of that amount. Guggenheim (29) studied post harvest losses of millet in four different regions from the Dogon area in Mali. His report presents the analysis of one hundred and forty heads of millet from fourteen different granaries. He found a variation from 1.29% to 9.79% in overall post harvest losses for two different years of harvest, 1975/76 and 1976/77. Grolleand and Kottler (28) have cited a study made in Bambay-Senegal by NCAR (50) about the efficacy of simple

technical processes used by Senegalese farmers to reduce storage losses. It was found that annual storage losses for millet and sorghum varied from 2.2% without mixture to 12.4% when the commodities were mixed.

The Kansas State University/Senegalese Grain Storage Mission (12) found that three types of cereal storage exist in Senegal and 80 to 85% of millet, sorghum, and rice are autoconsumed or traded at the village level. The storage operation is completely on-farm and losses were described as low as 3% during the first year of storage.

Hall (30) has cited the results of studies made in India by O. P. Garg and N. S. Aggarwal (1966), S. V. Pingale (1964), and V. Wolpert (1967), on rice, wheat untreated and food grains for seed, respectively. In these, it was found that with over a year of storage there was a total weight loss of 5% in the rice and food grain for seed cases and 8.3% in the untreated wheat.

Adams and Harman (2) studied storage losses of maize in Zambia during 1973-74 from surveys made in the areas of Chivuna and Chalimbana. In the former, maize stored on the ear with husks attached was typical. In the latter shelled maize storage was typical. Simulation of farmers' storage was carried out using stores similar in construction to those of farmers in the samples. Simulation stores were filled with maize obtained from farmers in the study areas. Samples were taken regularly to simulate the way in which farmers removed grain from their stores. From these

simulation stores they found weight losses were 1% or less in the treated shelled grain stores, 3% in the untreated shelled grain stores and 13% in the stores containing unselected ears with husks. Maize ears without husks suffered a loss of 9% in store. Losses of maize in farmers' ear stores were 8 to 10% at the end of the storage period. However, when the reduction in stocks during the season is taken into account losses averaged 2-5% over the storage period.

Sorenson, Petersen and Ives (60) studied maize in Zaire. No rodent damage was found on grain stored at the farm level. Insect damage on grain during 1 to 5 months in storage was estimated to average 4% of weight loss. A total of six representative samples of seeds was used. From each sample, 100 kernels were selected and visually examined one by one to find evidence of insect, rodent and/or extensive germ damage.

The African Rural Storage Centre Project at Ibadan, Nigeria (17) presented a summary of three years of experiments on the effectiveness of various insecticide dusts on dehusked maize stored in cribs. In this case, our interest is on the control treatment without insecticide, as it is done traditionally. This group presented a 19 to 54% damage range corresponding to a weight loss in the 5 to 8% range.

Giles (25), in Northern Nigeria, reported 4% weight losses in millet and sorghum stored at the producer level. These results agree with those from Ejiga's study (14) and

Caswell (10) on cowpeas in the same part of the country. The former reported 3.4% weight losses almost totally caused by insects. The latter found from five years data a damage average of 30% in cowpeas stored for three months and 50 to 60% after six months of storage. This damage represented an average weight loss of 5 percent. The researcher pointed out that since sales in Nigeria are by volume rather than by weight, these weight losses may not be considered as serious as the downgrading of the cowpeas caused by insect damage.

In conclusion, despite the fact that there are authors such as Reusse (54) who believe losses have been exaggerated, one can conclude that losses can vary widely depending on climate conditions, storage conditions, type of storage, length of storage period, chemical treatments, etc. It is not possible to simply affirm that in general losses are high or low. Furthermore, it should be recognized that losses are related to the size of operation. Larger amounts of grain stored will require better management capabilities as well as larger amounts of labor in order to maintain the grain in appropriate storage conditions.

2.4. General Approaches for Reducing Post-Harvest Food Losses

Regarding the means for reducing post harvest food losses, several different approaches have been found in the literature. Amezquita (4) presented a methodological

approach adaptable to the conditions in Latin America. The methodology consists of a systematic diagnosis and analysis of the problems. A general study of the marketing system and the construction of a model of the system for observation in a quantitative and qualitative manner the magnitude and causes of losses. This model would, after improvement, permit an evaluation of the efficiency of remediable programs and projects being implemented. Amezquita is obviously concerned with losses occurring along the entire production/marketing system. His approach seems to follow the marketing system approach used by Harrison et al. (33) in Latin America.

Other researchers that agree with the use of a system approach are Spurgeon (61) and Bourne (9). The former is against a "piecemeal approach" for reducing post harvest food losses. Instead, he suggests a system approach for better adjustment of the various elements in the system that creates the conditions for improved performance. The latter emphasizes the differences between developed and developing countries which preclude the use of certain technologies. He pointed out the need for generating country-specific storage technologies by taking into account important prerequisites for their implementation, such as infrastructure, educational level, etc.

Other perspectives have also been used. Schermerhorn (57) analyzed the problem of food loss reduction from an individual farm standpoint. The keystone of his argument is

the concept of profit. According to him, the most important factors affecting the decision-making process about whether to adopt managerial or technical procedures for reduction of such losses, are cost and returns of the action. Therefore, these should be carefully taken into account. There is an optimum level of losses beyond which the further cost of reduction is not compensated.

Greely (26) used a social cost-benefits analysis to evaluate food loss reduction programs, and shows the appropriateness of taking into account the effects of advanced storage technologies on employment, distribution and balance of payments as a way to measure their influences towards development.

The Committee for the Study of Post-harvest Food Losses in Developing Countries (67) has pointed out, in agreement with Greely's approach, that "food losses are related as much to social phenomena as to physical and biological factors." However, a problem found was that the lack of data about post harvest food losses was more acute with respect to economic and social aspects of losses. Thus, the cost effectiveness of food loss reduction could not yet be adequately demonstrated. The Committee's approach is that "there is no known simple and inexpensive technology that can, by itself, make a profound impact on post-harvest losses. On the contrary, post-harvest food conservation can be achieved only through a combination of location-specific organization, problem identification, training, information

and adopted technology."

The FAO (18) activities to reduce post harvest food losses are represented by various cooperative efforts with different international institutions, but principally supporting development programs. Basically these programs consist in the improvement of loss assessment techniques, technical assistance and training. As well as, the development of improved technologies for drying grain, pest control, off-farm storage and processing. Several recommendations (15, 18, 65, 66, 67) have been made regarding the reduction of post-harvest food losses in developing countries. The following are recommendations commonly mentioned:

a) Encouraging developing countries to undertake self-help measures
b) Establishing a national policy for reducing losses
c) Developing an agency or post harvest food conservation unit
d) Implementing programs to reduce post harvest losses
e) Creating effective mechanisms of communication among planning agencies
f) Adopting standard loss estimation methodologies
g) Considering socio-economic aspects of food loss
h) Developing guidelines for loss estimation of perishables.

No careful assessments have been made as to how closely

these recommendations have been followed in developing countries.

2.5. Specific Means for Decreasing On-farm Storage Losses

Most of the studies on traditional storage systems (2, 3, 5, 10, 11, 17, 23, 25, 28, 29, 31, 35, 45, 46, 67) have mentioned technological and biological problems when using traditional storage technology. This has led to different types of solutions for reducing on-farm storage losses.

There are large numbers of control measures suggested for improving on-farm storage. The following are mentioned as the most important measures: storage hygiene, careful use of insecticides and/or pesticides, keeping separate new dry grain from old stored grain, mixing ash with grain and smokings, use of local herbs, and improving facilities to accomplish better storage conditions. Several different storage techniques have also been proposed, including: air-tight storage, plastic sacks, metal drums, sheet metal silo, India pusa bin, baskets, vertical racks, clay jar, gourds, platforms (timber and grass), cribs, horizontal cords or creepers, etc. The selection of the appropriate storage technology is influenced in general by various factors:

1) Bulk or bag handling
2) Purpose and period stored
3) Whether or not storage is used only for one grain

and type of grain

4) Capital investment
5) Operating and recurrent cost and returns per ton handled
6) Demand of time for construction
7) Labor availability
8) Marketing, transportation and infrastructure in general.

The Committee on Post-harvest Food Losses in LDC's (67) has presented three particular approaches for solving the problems of traditional storage systems:

1) Improving small-scale on-farm storage
2) Centralizing grain storage with efficient collection, drying and large scale stores
3) Breeding new varieties of crops that are less susceptible to storage losses.

To apply these approaches and different control measures it would be necessary to measure possible cost and returns before their implementation.

2.6. Analysis of Cost and Benefits of Loss Reduction

For carrying out a cost benefit analysis, food grain losses must be expressed in monetary terms, thus allowing cost (investment in potential improvement measures and operating expenses) and benefits (expected reduction of food losses) to be weighed against one another. The value of the reduction in quantitative losses is obtained by pricing the

expected weight losses according to what use the lost grain would have been put and the effect of its loss on the owner. In the case of qualitative losses, value is estimated by grading grain stored and pricing it according to that common standard for both the traditional and improved facilities. The amount of qualitative benefit will be:

$$Qb = Vi - Vu$$

where

Qb = qualitative benefit of grain stored in economic terms

Vi = total value of grain in improved store

Vu = total value of grain in unimproved store.

The costs of adopting a particular system of storage may be divided into: 1) materials and labor used in constructing the storage, and 2) the expenses for any treatments applied to the grain. The cost of any purchased inputs, including labor, will be the actual amount paid. In calculating imputed costs (i.e. in the case of farmer or family labor) the opportunity cost of the item should be taken into account (33, p. 143).

There exist mainly three methods of relating cost and benefits of food grain loss reduction: rate of return; a cost-benefits ratio; or a comparison of the additional benefits from taking a particular action with the additional costs incurred. Finally, a cost-benefit analysis of loss

reduction could be carried out from the individual farm standpoint or from the standpoint of society.

In fact, Greely (25) has pointed out that on-farm level storage problems and, consequently, reduction of losses could be focused with two different concepts. First, he identifies an "engineering concept" "that normally has led to generation of technical solutions independent of identifying need (measuring loss), identifying efficacy (operational feasibility) and identifying impact (socio-economic effects)." Secondly, he identifies a "welfare concept" measuring the effects of proposed new technologies on the economy. He made a comparative evaluation of three different types of storage facilities in India:

1) The domestic "metal bin" manufactured by the Andhra Pradesh State Agro-Industries Corporation
2) The improved platform for the outdoor "gade" (Bamboo basket)
3) The improved base for the "puri" (a large circular paddy straw rope structure).

All three structures were designed at the Indian Grain Storage Institute (IGSI); the metal bin in collaboration with the FAO/UNDP team according to the engineering concept, and the two improvements to traditional structures with the IDS team applying the welfare concept. All the calculations were based on storage of one 75 kg. bag of paddy. The following loss-levels by cause in the traditional paddy stores were used: rodents 2%, insects 2% and

molds 1%; it was assumed that the maximum saving possible through storage improvement was 5%. Other values used in the comparison were the initial construction costs both of the structure and the improved base/platform, the annually recurring costs, the price of paddy, the effective life of the structure (conservatively estimated as 15 years) and a discount factor of 12%. It was assumed also that no credit had been taken to purchase any of the structures so no loan or interest payments were due. The benefits were measured by the grain saved. The results are presented in Table 1, and shows the sum of the stream of discounted benefits and costs over the 15 year life of the structures.

Table 1. Benefit-Cost Ratio of Different Storage Facilities.

	Total Benefits[a]		Total Cost[a]		Benefit/Cost Ratio
Metal Bin	25.58	:	38.32	=	0.67:1
Improved Gade	25.58	:	18.40	=	1.39:1
Improved Puri	15.35	:	10.49	=	1.46:1

Source: Greely (25, p. 45).

[a] Rupees at 1976 prices.

The comparison between the "gade" and the "metal bin" by the different causes of grain losses was ineffective because both prevented all three major causes of loss. This was not true for the "puri" where fumigation was not possible.

The comparison was concerned only with the private rate of return. If wider welfare implications were to be considered (such as employment effects) the benefit-cost analysis should be calculated using social prices. The improved "puri" presented highest benefit-cost ratio, despite grain loss savings over the traditional storage, were only 3% compared to 5% with the improved "gade" and "metal bin". This was due to the fact that the "puri" tended to be used by large farmers and there were important scale economies in its use. Therefore, it can be concluded that the improvement of the traditional "puri" storage facility was the best alternative technology choice. The possible advantages of the improvement in terms of employment, use of local raw materials and potential distribution suggested that most social cost-benefit comparisons would support that result.

Adams and Harman (2) have used a cost-benefit analysis to evaluate improved storage techniques in Zambia. Their analysis used the farmers' point of view as well as society's. They concluded that new or improved storage techniques involving significant use of resources should be submitted to cost-benefits analysis before being introduced or implemented.

Finally, other studies (4, 5, 10, 17, 24, 25, 30, 40, 65) have mentioned requirements and priorities to be taken into account when doing research to produce desirable, operational and feasible policies for improving on-farm

storage levels in developing countries. The following are the most important factors to be considered:

1) regional variations
2) study of local techniques that could be replicated
3) measure of improvement in different income groups
4) potential impediments for the improvement program
5) flow of inputs and goods to the area
6) labor management disposal
7) measure of secondary effects.

2.7. Conclusions

Different results have been reported about the magnitude of grain losses. Based on these findings it could not be affirmed that losses are high or low. The magnitude of grain losses will depend on the type of food grains as well as physical factors such as temperature and humidity; chemical factors such as oxygen supply; biological agencies such as bacteria, fungi, insects, rodents and methods of handling, storing, transporting and disinfesting the produce. Losses will also depend upon the length of the storage period and of the volume of grain stored. With respect to means and approaches for improving on-farm storage technologies and reducing food grain losses, there is a need to analyze their cost and returns in order to adopt a meaningful and feasible strategy. Also, consider that different types of farmers will have diverse needs and abilities to adopt different improved technologies.

III. FACTORS INFLUENCING FARMERS' UTILIZATION OF ON-FARM STORAGE FACILITIES

The literature reviewed reveals amazing contrasts of beliefs regarding the role that the storage of grain plays in the farmer economy of most developing countries.

Reusse (54, p. 3) considers that "farmers usually find it remunerative to store the marketable share of their staple food crop and release it gradually to the market instead of selling immediately after harvest." He points out several comparative advantages that on-farm storage has, in his opinion, over commercial storage operations, including:

a) Farmers' experience in farm level storage operations

b) The skillful use of abundant locally available material for storage structures, drying operations and pest control

c) The low opportunity cost of on-farm labor for building, repairing and renewal of storage structures during weeks of low labor demand in the dry season

d) The continuous personal control by farmers and members of their families over a relatively small

quantity of stored produce (e.g. screening infested maize for shelling and fast sale, repairing damaged tubers by sealing with pepper paste, etc.)

e) The transport cost advantage of taking regular consignments along on periodic visits to market towns.

Hall (30, p. 2) asserts that in many of the developing parts of the world people live in relatively isolated communities. Each produces its present food requirements plus small quantities of food or other agricultural products to provide money for clothes, bicycles, sewing machines, taxes, small quantities of meat, etc. "Experience has taught the grower that, if produce is stored, it goes bad. Thus, a sufficient quantity is grown to feed the family and any produce surplus beyond their own food requirements is immediately sold after harvest (when usually prices are low) in order to meet the accumulated debts." Thus, one of the major contributing factors responsible for the economic nonviability of farming areas is the farmer's inability to handle and store food efficiently so that he can sell good quality produce when it is scarce and commands a high price. The standard of living of a rural community depends not only upon the range of foods grown, but also upon the facilities for handling, drying, storage and marketing.

Clearly, there is a major conflict between the former statements. Food grain production in developing countries is often viewed in a static manner and assumed to be

allocated either to consumption or disposal. As a result, this chapter will review literature in an effort to find evidence about how farmers utilize on-farm storage facilities and the main factors influencing their decisions.

3.1. Marketed and Marketable Surplus of Food Grain

In the literature, much more work has been done on marketed surplus behavior than directly on farmers' use of storage and factors influencing their behavior. An understanding of on-farm storage decisions is, however, closely related to marketable surplus behavior. In fact, each aspect "is one side of the coin." At this point, it is convenient to clarify the interpretation of marketed and marketable surplus, because in the literature there has been a great mixture in terminology. Marketed surplus will be considered as that portion of production which actually enters the market (including distress sales). Marketable surplus then, includes marketed surplus as well as current production in storage, gifts, in kind transfers, any amount of grain stored carry over from other years, less any repurchase.

One can only partially understand how farmers use on-farm storage by looking at marketed surplus, because this represents only one part of the decision-making process. In short, one should understand marketable surplus behavior in order to know exactly what are the purposes, the time period and the cost of farmers' food grain storage. This

is in disagreement with the authors that maintain you can understand farmers' storage decisions by looking only at the end result, i.e. marketed surplus. However, most of the research done has been on marketed and not on marketable surplus behavior because of the greater difficulty the latter presents for collecting data.

Several studies (6, 7, 8, 12, 22, 23, 27, 36, 39, 48, 49, 51, 52, 53, 56, 59) have examined which variables affect marketed surplus behavior. These studies can be classified into two groups, those examining mainly price effects and those considering the effects of non-price variables.

3.1.1. Price Effects on Marketed Surplus

Most authors recognized that the price of staple foods can affect the behavior of subsistence farmers both as producers and consumers. Askari and Cummings (6) point out that in general the literature concentrates more on calculating elasticities while paying little attention to the conditions determining them. Newman (51) completed an excellent review of this subject. He points out that among researchers studying price effects on marketed surplus, there exist three basic groups of thought: the first claiming that supply is inversely related to price (49); the second postulating a positive supply response to price changes (8, 39); and the third sustaining that producers respond randomly or irrationally to price (7). Newman concluded that the contradicting findings are usually due to differences in researchers' hypotheses about farmers'

demand for money as well as price and income elasticities of marketed surplus and of production. If one hypothesizes that farmers have a fixed demand for money it is logical to think that an increase in price of the produce will allow farmers to sell less grain in order to cover their monetary needs. However, this hypothesis could not be correct given the diverse circumstances faced by farmers. Clearly researchers' assumptions differentiate the three basic groups of thought mentioned by Newman (51).

Hamilton (31), from his study in Botswana in 1974, reported that the farmer that covered his family consumption needs tried to sell the marketable surplus. In the case of sorghum it was a big surplus that year, then other farmers were in the same position as he and the price of the produce went down drastically. Therefore, farmers in general did not sell the sorghum, but stored it and considered the possibility of planting less next year.

Accordingly, Grewal and Johl (27), from their study in the Punjab, concluded that producers' decisions to market their produce were clearly influenced by the level of prevailing prices relative to the prices realized in the preceding marketing season. Lele (43) has also expressed that a producer will choose to market more or less of his produce if he finds the harvest price too low or a higher price is expected later in the year. These actions are based on knowledge of the market conditions.

It is likely that, owing to a very restricted view of

the grain market, a producer's decision to withhold supplies may not always be determined by correct information. Philip Garcia (22) studied small farm maize marketing in northern Vera Cruz, Mexico. Farmers were classified in three different types: 1) ejidatarios which are small farmer members of the ejidos[1], 2) ejidatarios with sales to the government marketing agency (CONASUPO), 3) private property owners. He found that farmers in the second group generally checked more sources of price information and were more willing to increase their marketings in response to changes in price than the other two groups.

Larger producers within the second and the third group probably had the best access to accurate price information and were able to delay maize sales past the harvest period. Only the most commercial producers indicated that they would increase their sales of maize, which had been stored for domestic consumption, in response to a change in the post-harvest price.

Members of the first group were the less likely to have checked alternative sources of price information. They had less access to transportation and sold to local buyers. Regardless of the size of operation a high level of inter-group discussion concerning market prices prior to sale existed. This fact clearly demonstrates the farmers' need for marketing information in order to make appropriate

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[1] Ejidos are the Mexican government's land reform unit.

decisions about marketing produce.

The results of the studies reviewed about response of food grain marketed surplus to grain prices conflict in some cases. This is logical taking into account the disparity of hypotheses and assumptions sustained by researchers about farmers' demand for money, the price elasticity of marketed surplus and home consumption, farmers' consideration of leisure, information availability, etc. Despite this fact, the price of grain is an important variable when considering the farmers' decision-making process.

3.1.2. Non-price Variables Effects on Marketed Surplus

Among the non-price variables considered in several studies affecting marketed surplus, the following are the most important: resources endowment, debts and obligations (distress sales), farm size, on-farm income, off-farm income, family size, production, storage capacity, and risk and uncertainty. The proportion of grain marketed immediately after harvest has often been used as an index of the resources endowment of the farmer. It is assumed that the higher the holding power given by his resources endowment the lower the proportion marketed after harvest when price is low.

Lele (op cit.), studying five wheat markets in the Punjab area, found that proportion marketed varied from market to market, and that improved holding capacity may not necessarily result in a reduction in the amount marketed in the immediate post-harvest period. Rather, the high

seasonality may be due to other factors as 1) storage losses on farms may be higher than those incurred by traders, 2) risk in storing may be too great from the farmer's point of view. Therefore they choose to sell soon after harvest. She concluded that "the statement that farmers sell their produce immediately after harvest because debts and obligations (distress sales) may not be altogether true, except for small farmers."

Hays (34), like Uma Lele, found no evidence of distress sales in Northern Nigeria of millet and sorghum by either small or large farmers. For both grains over 80% of production was stored at harvest time. Then he asked, if little grain is sold at harvest time, why is there usually surplus grain and lower prices in the markets? He presented two possible reasons: a) some of the grain given as gifts finds its way into the market, b) in the rural areas everyone has grain at harvest and it is brought to the rural markets, goes to assemblers and then on to urban centers where it becomes plentiful, forcing the price down.

Results from other studies are in disagreement with those above. For example, Grewal and Johl (27), studying maize in the Punjab area, found that a substantial portion of the produce (about 70%) was marketed in the immediate post-harvest period in order to satisfy cash needs, debts of obligations (distress sales) with the consequent severe effect on farmer's income given the low market prices of the produce at that time.

Several other studies (14, 22, 31, 48, 62) are in agreement with the results above. Adams and Harman (2), from their study in Zambia, reported that maize was grown by farmers mainly for family needs and very few sold maize from storage. But, farmers were encouraged by the government to sell maize surplus as soon as possible after harvest so that it might be known whether the country had any for export, or required import. The researchers also pointed out that even without encouragement farmers would sell maize at that time, due to the need for cash to cover family needs, or buy material for farming. Most of sales would be invariably made to the National Agricultural Marketing Board.

Parthasarathy and Rao (53), from their study in India, used land holding size as a proxy for income. They found a U-shaped marketed surplus function, meaning that small farmers would have distress sales and large farmers would increase marketed surplus once they satiated food grain consumption.

A totally different pattern was found by Krishna (39) in India and Matlon (48) in Northern Nigeria. Both areas had similar results, marketed surplus of grain decreased as holding size increased until around 15 acres and then increased with holding size. Matlon estimated marketed surplus function by fitting a set of regressions. Evidence was found showing that this was positively related to household size measured as consumer-man equivalent and

strongly inversely related to the value of both off-farm income and cash crop production among low income producers.

King and Byerlee (38), in Sierra Leone, used subsistence ratios for measuring the proportion of consumption that was home produced. They discovered a relationship similar to that reported by Krishna and Matlon.

Sharma and Gupta (59), from their study in Bajra, concluded that the most significant variables affecting marketed surplus were production and family size, accounting for 93% of the variation. There was a positive and large elasticity of sale with respect to production, and a negative relation between family size and marketed surplus. These results are in agreement with those presented by Garcia (22) from his study in Mexico. He found that in terms of marketed surplus, both private property owners and ejidatarios with recent sales to the official marketing agency (CONASUPO) were inclined to increase their sales in response to changes in the quantity produced. These two groups of farmers also had more mobility (meaning owned more trucks) and experienced more extensive contact with different participants of the marketing system, including CONASUPO, than those farmers within the group of ejidatarios.

The non-price variables affect the marketed surplus behavior in diverse ways, as observed in the results presented above. Nevertheless, the key point is that they should be included in the analysis in order to improve our

understanding of the farmers' storage decisions.

3.2. Specific Studies on Farmers' Storage Utilization

Despite the fact that there is very little research about farmers' actual utilization of storage, it is important to look at the limited empirical results to better understand whether or not farmers store their grain.

Newman (51) has pointed out that on-farm or village storage covers an interface between production and ultimate use, allowing lagged allocative decisions or intentional savings. He identified alternative purposes for the use of these facilities:

1) As short run security in consumption, assuring food availability between harvests
2) As a store value, because stored grain can be used in sale, barter or transfer for obtaining other goods not produced at home
3) As a way of providing social status, satisfying customary obligations
4) As a means for avoiding risk (of a bad harvest, for example)
5) For speculation, on the ability to reap gains bigger than storage costs and take advantage of price fluctuations.

Reasons for storing grain are influenced by existing differences in income, productivity and consumption patterns of households. While low income households might be able to

store grain for security in consumption, the relatively small amount that they produce would be a constraint for storing grain for other purposes. On the other hand, a high income producer may be able to satisfy consumption needs as well as social obligations and have some grain for speculative purposes.

The use of storage to satisfy short run or long run security in consumption would be affected by the degree in which the supply of food grain in the local market is assured. Farm level stocks are also related to the time preference of households in terms of consumption of food grain versus other goods for which it might be necessary to sell or exchange the staple.

3.2.1. Storage and Selling Decisions

Hays (35), studying disposal activities in sorghum and millet by different size farmers in Northern Nigeria, broke down production into sales and gifts, with consumption assumed as the residual. He defined small farmers as an average household size of 8.3 people and an average field area of 2.1 ha. Large farmers were those averaging 13 people and 7.4 hectares. He found that small farmers sold a larger percentage of millet and a smaller percentage of sorghum from their production than large farmers. This was probably due to relative differences in consumption patterns. Large farmers sold larger amounts of both grain than small farmers.

The part used as gifts remained constant in both crops

for all farmers. He explained that there is a set of complex noncommercial transactions derived from religion and kinship. These transfers and exchanges represent a large amount of the farmers' production. A large farmer gives more of his production in both absolute and relative terms. This tends to demonstrate status and affirms his prestige in the community. Large farmers stored 70% of sorghum and millet until six months after harvest while small farmers stored 31% and 50% of both crops, respectively, during the same period.

Farmers considered grain storage as a store of value. During interviews most of them declared that they did store their grain surplus. If not they said they would have spent the money coming from grain sales.

O. Ejiga (14), from his work on cowpeas in Northern Nigeria, reported that farmers' incentive for growing the crop was its salability. In both locations of the study (Shinkafi and Lafia), the largest proportion of the crop was sold. The farmer's cumulative cowpea disposal was studied. The difference between these figures and sales represent the amount consumed, used as seed or given away. Total disposal and sales percentage tended to keep pace because sales accounted for most of the cowpea use of the 1972-73 crop.

It was found that farmers, in both locations, stored 50% of their production for four months after harvest and 25% for a period of six months after harvest. Two methods

were used to examine the relationship between production and length of storage. The first method was to regress the percentage of the cowpea remaining at the end of April (half crop year) against production of each farmer. The second was to estimate the correlation coefficient between cowpea production and months from harvest when the last reported sale was made. A significant correlation between the two variables was not found.

In conclusion, there was little relationship between crop size and length of storage as applied to cowpeas, at least in the location of the study. A more complete analysis would have required weighing each sale by the length of storage.

The International Bank for Reconstruction and Development (37) cited a study made in India by the Institute of Development Studies -- University of Sussex, in which it was estimated that 18 million tons of grain were in "store" at the beginning of the 1980 crop year. It was also calculated that in farms with size .01 to 3.00 hectares, 62% of production is stored, from which 81% is used for consumption and 3% for seed. For farms with sizes 3.01 to 6.00, 6.01 to 9.00 and above 9.01 hectares, the proportion of production stored varies from 53 to 57%, from which a declining 61%, 49% and 36% of that amount is used for consumption in each farm size, respectively. In all cases, a constant 5% of the production stored is used as seed. Six months after harvest the farmers in the smallest farm

range (.01 - 3.00 ha) had only 36% of their production stored, while those in the two following ranges (3.01 - 6.00 ha and 6.01 - 9.00 ha) had 43%, and those in the largest range (9.00 ha and above) had 52%. Assuming that farm size is taken as a proxy for income, these results show that smallest and poorest farmers produce less and consume relatively more of their grain, thus logically selling less and sooner after harvest than medium and large farmers.

The results from different studies are very difficult to compare given the disparities among the situations. Nevertheless, the three studies presented show that there is a tendency for small farmers to store food grain for shorter periods of time after harvest than medium and large farmers. Thus, one could ask what are the reasons behind this behavior? In two of the studies mentioned farmers have been directly interviewed with the purpose of finding an answer to this question.

First, Hays (op cit.) mentioned that when looking at the reasons why farmers sell their production, the responses were not entirely satisfactory and many of them found difficult to explain their reasons. With respect to millet, the reasons of small farmers were as follows: 60% need of money, 18% good price (meaning higher than at harvest time), 22% no reason. Large farmers' reasons for selling the same crop were 66.7% need of money, 7% good price, 26.3% no reason. In the case of sorghum the reasons for both types

of farmers were 70% need of money and 30% no reason.

Secondly, Ejiga (14) interviewed farmers about which of the two following reasons, 1) price seems good, 2) need for cash, influenced them in selling their cowpeas crop. From a sample of 14 farmers in the area of Shinkafi, 50% answered good price, 35% need for money and 15% both reasons. In Lafia from a sample of six farmers, 20% mentioned the first reason and 80% the second one. One should be careful in generalizing these results. The samples were not large compared to the sample of the general survey carried out for the total study. Caution should also be taken with the results found by Hays. However, these results would be demonstrating that small farmers may need cash sooner than large ones, with fewer alternatives for obtaining it.

Unfortunately, interviews, like those mentioned above, present two general problems. The first is the educational level of the farmers that often makes it difficult for them to rationalize answers to these kind of questions. The second is the problem that given the first situation interviewers suggest answers and bias the results. This problem could be more common when interpreters are used. Also, Ejiga had already circumscribed the answers to only two possibilities, which may reduce the validity of the answers.

Finally, results from Ejiga's work (op cit.) are presented about economics of cowpea storage, despite the fact that it was calculated for traders and not related to

farmers' decisions. He wanted to test the hypothesis that cowpea storage paid only if it was held beyond the first few months after harvest. That required an analysis of seasonal price change and storage costs.

For traders in this case, if storage was going to be profitable, the price received by them should exceed the level at harvest and compensate for storage costs also. How long does it take for prices to increase that much? One way to check was to schedule or graph two prices, one the actual market price and the other an hypothetical harvest price plus storage cost. It was found that cowpeas should be stored about five or six months before any storage could have been worthwhile. This length could vary obviously from year to year. It was also found that the rise in average seasonal price, when compared to storage costs, did not seem excessive.

The researcher pointed out that given the length cowpeas should be held in storage to be worthwhile, and the storage losses that normally occur, efforts to find a cheap, safe, effective and easy control method should be intensified. The need to hold cowpeas for that long was also a reason why credit might be needed to bide the farmer over the period. The amount of crop the farmer was storing could be considered as a basis for such loans. It would be important to take into account this kind of analysis in trying to achieve a more integrated understanding of farmer's storage decisions.

3.3. Conclusions

As has been observed there are several commercial alternatives faced by farmers with respect to their food grain production. Non-commercial transactions are also very important and should be taken into account. Along with subsistence requirements for the farm unit they can determine the amount of grain available for sale.

The farmers' storage decisions depend on an overall strategy considering subsistence or commercial production or a mix of both. The strategy usually adopted is an outcome of the resources available to the farmer (i.e. labor, capital, etc.), marketing information, credit programs, minimum price programs, and non-farm employment, etc. Clearly, there exists an interaction among these factors. It cannot be said that farmers' decisions are based upon only one of them.

Furthermore, the differences should be recognized among different types of farmers and the disparity of circumstances faced by them within and across countries. Therefore, it is logical to think there is a great variation among farmers' wants and needs, as well as their management capabilities for dealing with different sizes of storage operations.

Given all the factors mentioned, it is not possible to compare results from different studies and to draw general conclusions about farmers' storage decisions. There is a need to interpret the dynamics of output allocation

between consumption, sales and other disposals by different types of farmers, in addition to their allocation of time between alternative production and leisure activities. A wide framework of analysis, involving all the factors already mentioned, will be useful for achieving a more integrated understanding of the decision-making process for different types of farmers.

IV. TOWARDS A CONCEPTUAL FRAMEWORK

So far we have observed that there is a great variety of factors influencing farmers' decisions about production, consumption, storage and sales of their food grains. Progress in improving grain storage at the farm level, and its use by different types of farmers in developing countries, requires identifying and eliminating the constraints faced by farmers for adopting improved technologies and marketing their produce.

In this chapter a broad conceptual framework will be developed to orient research and extension efforts. The basic objective is to outline an approach that facilitates a more integrated understanding of farmers' decision-making processes and the set of factors influencing them.

4.1. Conceptual Framework

Farmers' decision-making processes are influenced by a very complex set of variables, thus, it is very difficult to develop a simple mathematical model to explain them. Furthermore, there have been relatively few farm management studies on decision-making from which could be drawn strong generalizations to use in the model. Most of these studies, however, have focused on the representative farmer.

Therefore, a great variation among farmers was eliminated. It would also be possible for a vast majority of farmers in a sample to behave totally different from that which has been measured as average behavior (36). In general, the discovery of a positive or negative correlation between certain variables can tell the analyst very little about the nature of the decision-making. It could reflect several trade-offs.

Farmers are faced with several alternative decisions about their food grain production. They can sell or exchange their produce immediately after harvest, or they can store it for different purposes. Farmers faced two types of decisions with respect to storage of their grain production. First, whether or not to store the produce, which usually implies different ways of marketing the commodity. Second, if they decide to store the produce, whether to invest in new facilities or to improve the existing ones.

These decisions depend upon the types of farmers, their wants and needs, their education and management capabilities, the resources available to them, the size of the storage operation and the feasibility of using different types of storage facilities. The alternatives faced by farmers for marketing their produce will be a function as well of the real marketing opportunities and the information available to them. These opportunities will be according to the national food and agriculture price policies and the

private marketing channels. Lele (44) pointed out that in most developing countries food and agriculture policies affecting farmers, especially small ones, could be dangerously biased because of the following implicit assumptions made by policy makers:

1) There is an efficient, price responsive agricultural industry
2) Essentially all food passes through commercial marketing channels
3) There is a price for grain, at which one can buy or sell at will
4) The influence of trading activity in one part of the market is quickly and effectively transmitted to all parts of the market, and
5) The reliable information on production and market performance is instantly and freely available.

In most developing countries these implicit assumptions need to be explicitly recognized and subjective to serious analysis.

A broad framework of analysis is necessary to understand the interactions of the complex set of factors affecting the production, consumption, storage and marketing patterns of different types of farmers in developing countries. The framework can be composed by: a) a conceptual model of farmers' food grain production and disposition; b) the dimensions of farmers' food grain storage and marketing decisions; c) the farmers' wants and needs as well

as the information available to them.

Figure 1 is a conceptual model of farmers' food grain production and disposition in developing countries. It is based on one presented by Uma Lele for explaining marketing channels in the Sub-Sahara African countries. In general, in the majority of LDC's there are large scale farmers, traditional farmers, and subsistence farmers. There are two general ways for marketing production. First, the product can move through official channels, normally to a monopsonistic parastatal agency (semiautonomous public-sector entity), working through different official agents. Second, the product can move through private unofficial market channels, working through several types of private traders. Large scale farmers normally find it easier to sell relatively more by the first way, directly after harvest or out of storage, due to their larger size of operations and their better accessibility to information as well as to official minimum price and agricultural credit programs. It can be seen that their decisions clearly would affect urban more than the rural consumption, because the former is mainly supplied by their food grain production through official marketing channels.

Traditional farmers, theoretically, have both public and private sector sales options. However, they frequently use mostly the private sector channels. They also enter into some barter negotiations, as well as keeping some grain for self-consumption. It should be noted that in

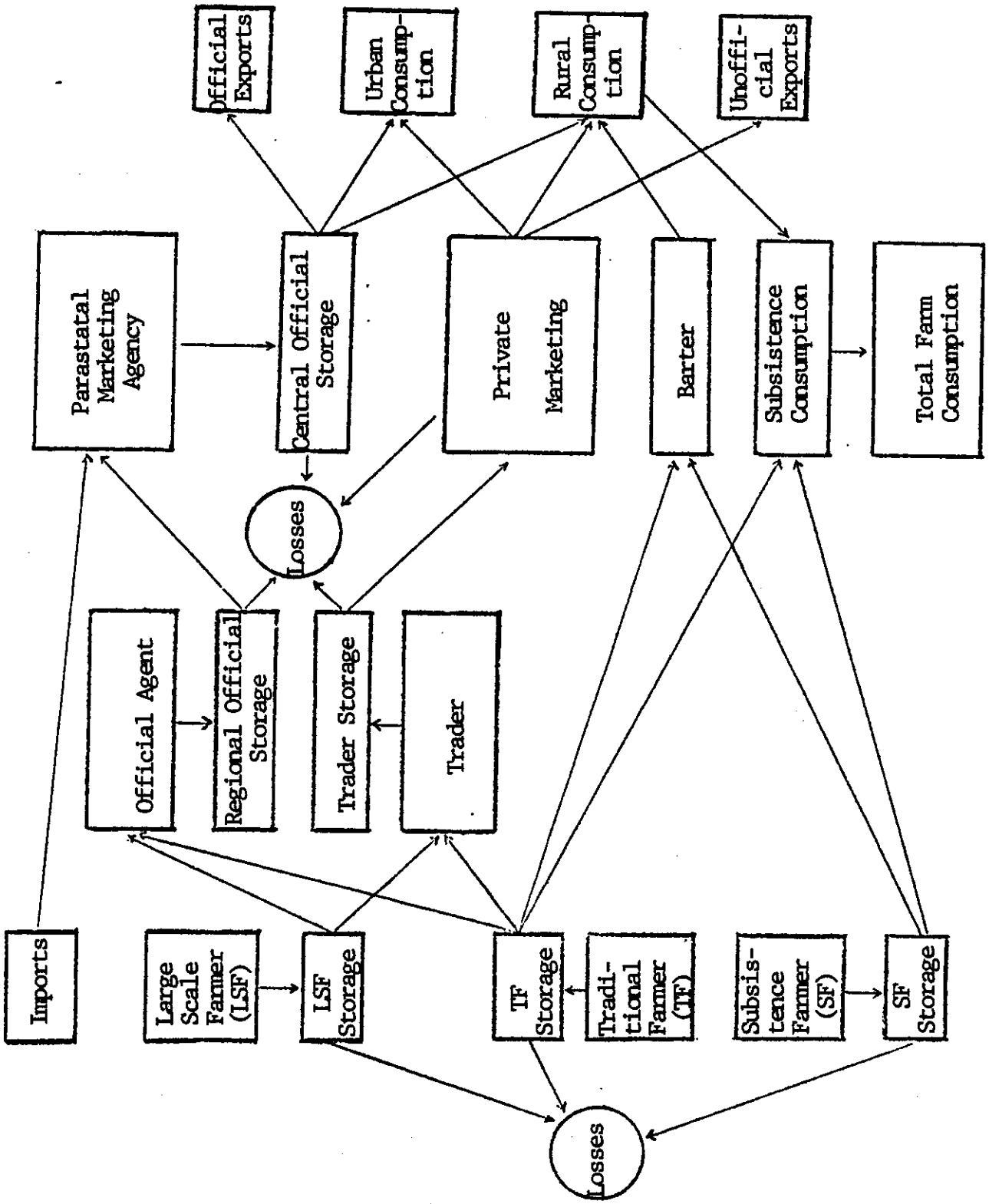

Figure 1. Conceptual Model of Food Grain Production and Disposition in Developing Countries.

this group medium sized as well as small farmers were considered able to market a small part of their production. Subsistence farmers use their production strictly for self-consumption, or barter to obtain products not produced by them. The decision to barter the produce would depend in part on the total amount of their own production, the consumption substitutability of the goods involved in the transaction, and the relative terms of the exchange.

The existing official agents and traders can either pass the grain directly to the parastatal agency and private market, respectively, or store it for a certain period of time. In the official agent case, behavior usually depends on the government policy, the urban consumers' needs and the central storage capacity. In the case of the traders, it is just a matter of profitability. If convenient they will buy and sell in the same day and possibly the same market. Lele (43) found traders had a more rapid turnover pattern of operations than she had initially assumed. In most cases it was for assuring a certain profit, while avoiding higher risk.

In developing countries the marketing parastatal agency is normally part of a marketing program developed to avoid instability in prices while distributing staple food production primarily to urban areas. It normally manages central storage facilities and undertakes official imports and exports. The unofficial marketing channels supply urban and rural consumption. There might be unofficial

exports as well, given government policy, the relative differences in official and external prices of the produce, and the need for gaining foreign exchangeable currency.

Losses can occur along the whole marketing system, from the producer to the consumer. In Figure 1, storage losses are shown, despite the fact that many other kinds exist, as mentioned in Chapter II. In all stages, storage could be the best technological solution but not economically. Farmers sometimes repurchase food grain. Repurchases often depend upon initial distress sale requirements, costs and risk of storage, frequency of harvests, and non-farm income activities.

Matlon (48) used a ratio of food grain purchases to sales for comparing different income groups of farmers in Northern Nigeria. He found in his sample that those in the lowest income group were net purchasers of food grains because their income mainly came from the production of groundnuts as a cash crop. Three scenarios might explain the decision to make sales followed by repurchases:

1) The household might have planned for the resources with which to repurchase necessary quantities later in the season (often the "hungry season").
2) The household might expect that early sales would enable greater repurchases than later sales, given storage costs, including losses.
3) Sales resulting from prior obligations or the need to satisfy ceremonial or social obligations reduced

reserves to less than sufficient levels, necessitating unplanned borrowing or other means of financing repurchases.

While one can speculate on the amount and timing of sales and their distributional impacts, the empirical evidence is sparse. However, on-farm storage levels may provide a locus for observation of the simultaneous actions of a household as a consuming and selling unit of food staples. The farmer decision-making process thus takes place in a very dynamic context.

Obviously, farmers' storage and marketing decisions are closely related to the real opportunities available to them by official minimum price and agricultural credit programs as well as several types of private traders. These opportunities influence their decisions in three different dimensions (Figure 2), how to sell (and/or store), when to sell, and how much to sell.

In LDC's, marketing intermediaries are often seen negatively, as if they were making high profits and taking away what otherwise should have gone to the farmers. There now exists a large list of empirical results in LDC's suggesting that traditional middlemen do a reasonably good job of providing marketing services, without making unjustified returns for labor, management skills, capital invested and levels of risk taken (14, 33, 43, 45). Tickner (64) has pointed out that the tendency to treat all traditional marketing intermediaries as undesirable often

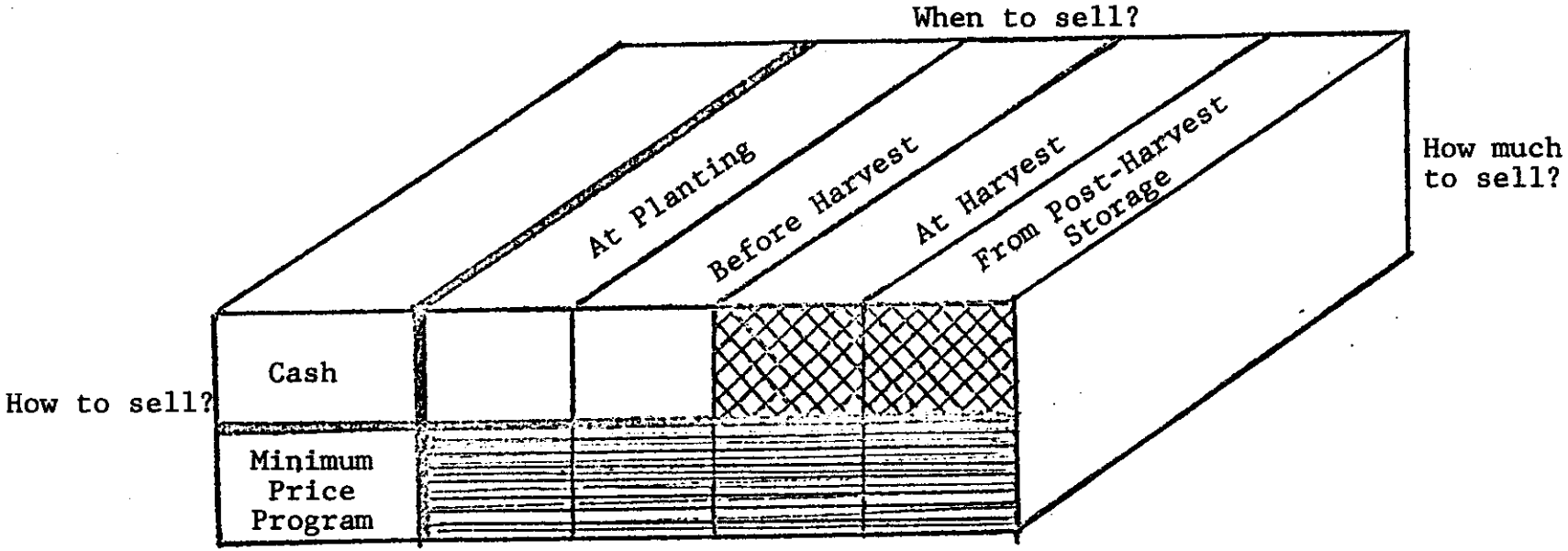

Figure 2. Dimensions of Farmers' Food Grain Storage and Marketing Decisions.

comes from an ignorance of:

1) The functions performed by the middlemen
2) The impact that supply and demand fluctuations have on prices, and
3) The particular trading difficulties faced by merchants.

He recognized that it could take some degree of exploitation, but suggested that indiscriminating efforts to control it "lead only to poor policies which impede the working of the system without providing a viable alternative."

Different studies have observed (24, 70) that the single concern about the level of prices paid and received by farmers, and the resulting income that these prices represent, have often obscured other important marketing shortcomings. "Low incomes can be as much a function of output levels, as of costs and prices, and for small farmers the variability in each of these, as well as the variability of the market opportunity at whatever price, is perhaps as relevant as the absolute price level" (70). Prices are obviously important, but efforts should be made to identify other factors that are constraining the farmers' abilities to market their produce to a greater advantage.

The other two dimensions within the marketing framework are 1) when to sell and 2) how to sell. In most developing countries two general options typically exist: one to sell cash, the other to do it through an official

minimum price program. The former implies doing it at harvest, or from storage during the off-season. The latter presents more options because it usually is accompanied by an official credit program. Thus, farmers can get cash in advance to cover whatever their needs are. Notwithstanding, small farmers in developing countries usually have problems in getting access to this kind of program. Several studies have pointed out (22, 45, 56, 69, 70) that given the sparse physical locations of the small farmers and their usually lack of adequate transportation facilities, government minimum price and marketing credit programs fail to reach a large number of them. Due to this fact, government agencies trying to enforce pricing policies, in certain circumstances, allow traders to get the benefits of the official programs if they agree to pay small farmers the minimum price stipulated by the government.

However, the conventional wisdom is that great numbers of small farmers sell their produce to intermediaries who usually supply them with inputs for production, consumption and/or production credit. Interest paid by the farmers for these credits is believed much higher than the subsidized interest rates charged by the official agricultural production credit. Empirical results from various studies (22, 33, 56, 69) have shown that the number of small farmers in this situation is not so large. Also, farmers usually borrow from their relatives first, from their friends next, and finally from traders. No interest is usually charged

in the first two cases. Interest payments in the last case exist, but evidence has not been found that these amounts were extremely high especially when compared to real costs of credit. Indeed, Garcia (22), from his study in Northern Vera Cruz, Mexico, reported that the effective interest rate (weighed by volume of quantity sold) received by traders was about 40 percent. He mentioned that although it is high, it was similar to the nominal interest rates that small producers paid to public credit banks.

With respect to the reasons why farmers sold their food grain production to intermediaries, Hays (35) found in Northern Nigeria that the more common farmers' answer was that the buyer was a friend, or the buyer came to the producer's farm to buy. In the case of millet and sorghum, for 6% and 8% of small farmers, respectively, the reason was that the buyer has lent money to them. For large farmers these percentages were 5% and 3% in both crops, respectively. These situations are not always the same, therefore the lack of access to official minimum price and/or marketing credit programs can place severe restrictions mainly on small farmers' marketing options and bargaining power.

As J. R. Block[1] pointed out, farmers, in making their alternative decision about grain production, storage and marketing, normally do a rolling assessment of the

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[1] Personal communication.

information available to them and match it with their wants and needs. They may be thought of as trying to keep a continuous balance between competing factors.

In Figure 3, such a hypothetical scheme is presented, describing farmers' strategy for storage and marketing of their produce. Here, alternative storage and sales options will vary with the particular conditions faced by farmers in different countries, regions, or even within the same region, and with their particular characteristics such as education, management capabilities, religion, etc. The farmers' wants and needs are obviously very different, but in general it could be said that these include cash needs, food consumption needs, labor/leisure allocation, reduction of risk and uncertainty, status, education and management knowledge, access to inputs of production, security against thievery, etc.

The information available to farmers also could vary widely, depending on their geographical location with respect to towns, their accessibility to communication and transportation means, as well as the efficiency and availability of extension services. The information needed includes knowledge about alternative produce prices, storage practices, demand and supply of produce at local, regional and national levels. Farmers also need accessibility to off-farm employment opportunities, markets, official minimum price and/or agricultural credit programs, as well as knowledge of produce standards, sanitation and

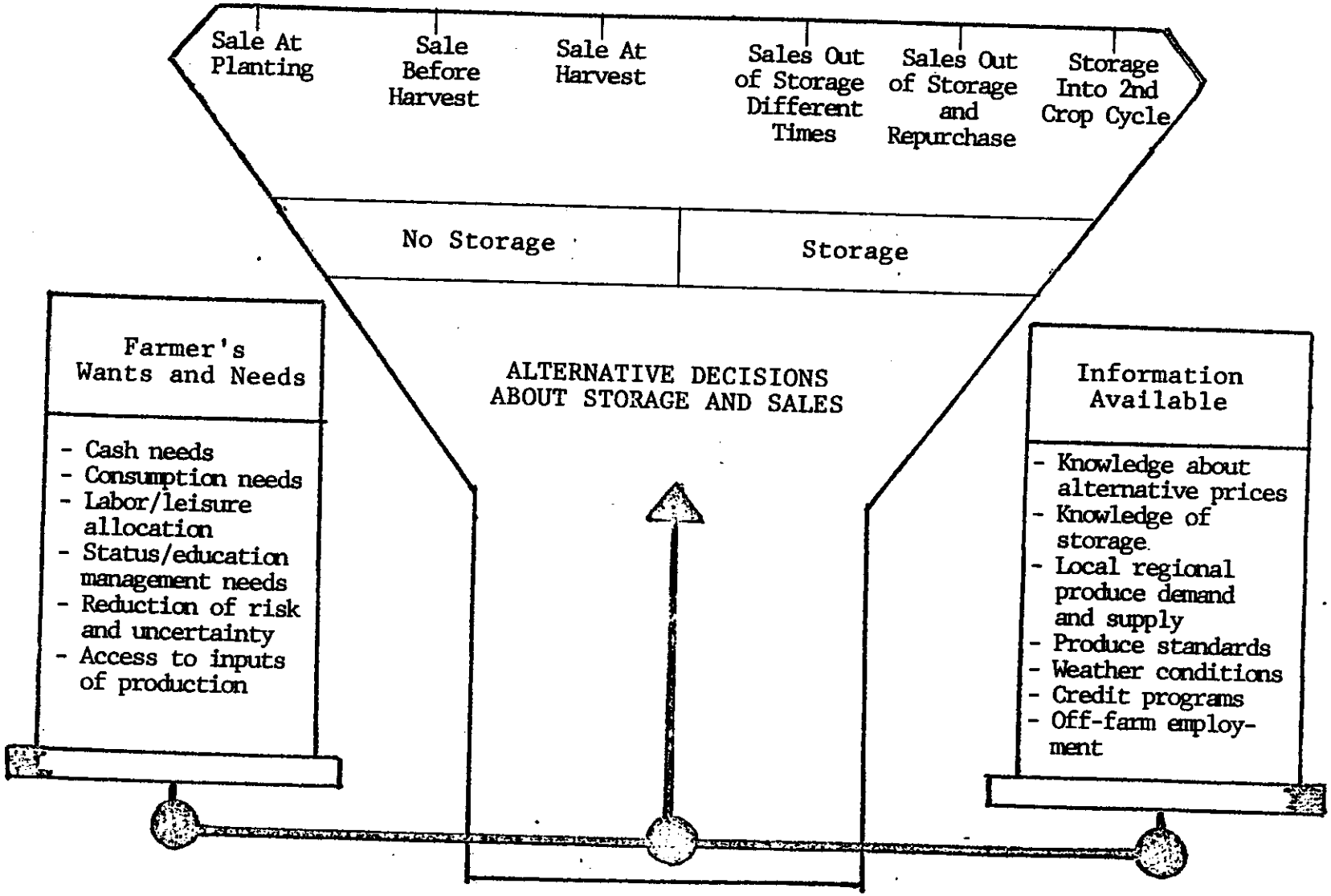

Figure 3. Hypothetical Scheme of Farmers' Strategy for Storage and Marketing the Produce.

nutritional level, weather conditions, etc.

In conclusion, the decision-making processes of different types of farmers is influenced by a complex set of factors. To achieve a more integrated understanding of these processes, the linkages between agricultural production and food consumption, between the rural farm and off-farm activities and between rural and urban segments of the economy should be taken into account. Therefore, a broad framework like that presented in Figures 1, 2 and 3 will be useful for analysis.

4.2. Research and Extension Efforts

The conceptual framework presented previously will help researchers and extension agents to reach the following objectives:

1) Identify the complex set of factors influencing the decision-making process of different types of farmers about consumption, storage and sales of their food grain production
2) Make a diagnosis about farmers' potential and constraints for making their decisions
3) Recognize differences among several types of farmers' behaviors, objectives, wants and needs, size of operations, as well as information available to them
4) Place priorities of research and extension with a broader perspective, and

5) Realize the need for supplying realistic recommendations and accurate information in a continuous way.

It should be pointed out that a more realistic continuous flow of recommendations and information may require inputs from different disciplines: For example, agricultural economics, extension, sociology, agricultural engineering, anthropology, biology, entomology, education, political sciences and statistics may be needed. There exists a great possibility for every discipline to contribute in developing alternative solutions and providing information needed by different types of farmers. This will help farmers adopt improved storage technologies and make appropriate management decisions, increasing their likelihood of reaching desired nutrition and income levels.

Education and extension can change cultural values and practices and teach farmers how to adopt and use new storage methods, although it is sometimes a long and slow process. However, before this stage is reached the basic design and feasibility of the new methods must be carefully examined. Before an improved storage technology is advocated for farmers, its technical, economic and cultural viability must be checked along with the ability of the extension services to successfully introduce it (46). To increase the likelihood of successful adoption careful applied research is required, exploring alternative possible approaches. Thus, the need for on-farm trials is clear. The trials should be carried out under different social, technical and economic

conditions in order to recommend more meaningful solutions for farmers in different situations.

Thus, extension services can be very important in encouraging farmers to adopt improved storage technologies. At the same time they can transmit opportune and accurate marketing information in order to facilitate farmers' management decisions. Often, marketing extension services in developing countries are inadequate or ineffective. There are several reasons for this fact, such as:

a) Insufficient number of extension agents and lack of transportation facilities to reach large numbers of farmers

b) Lack of economic incentives for the extension agents and lack of respect by farmers

c) Inadequate training of extension agents and insufficient contact with updated technologies and information

d) Marketing data is not analyzed and presented in meaningful ways for use by farmers

e) Overlapping of authority and duties with other offices

f) Use of the extension services for non-extension activities such as census, collection of data, credit management, etc.

The role of the extension agents and extension services should be reviewed at this point. Unfortunately, little work has been done on this subject. Notwithstanding, its

relevance should be recognized. Therefore, the possible constraints existing for the transmission of accurate and timely marketing information to different types of farmers should be overcome.

Logically these actions should be accompanied by other considerations if one tries to effectively help different types of farmers to overcome their production, storage and marketing problems. Improved storage facilities, per se, without change in price cycles or the level of prices received by farmers for their produce would not induce them to increase and use storage to cover their consumption needs throughout the year, to manage their sales according to future high prices, to even out price fluctuations and to stabilize the supply of produce in the market. Furthermore, any government price policy would be totally effective without considering efficient extension services (as has been mentioned), adequate transportation facilities, basic marketing infrastructure, necessary market information and effective access to credit.

By the same token, food security policies that imply developing centralized storage schemes should be carefully addressed. Several considerations must be taken into account regarding different types of storage use (e.g. technology prevailing in the market, available infrastructure, number of varieties to be stored, flexibility of storage size, etc.) as mentioned in Chapter II. In all cases the importance of private participation on increasing

national storage capacities should be considered. "The socio-economic usefulness and commercial viability of storage schemes will depend on their ability to integrate with the still predominantly traditional post-harvest system in a supplementary way, without aiming at its replacement" (53).

Lele (43) has pointed out that at any time a domestic food reserve has three major components:

1) The national food reserve made by government
2) The stocks held by the parastatal agency for its normal activities
3) The stocks held by the private sector, especially farmers.

Thus, to think about food security just in terms of government stocks would misplace one of the most important single contributors to it: the private sector. For this reason, the understanding of farmers' decision-making about grain storage at the farm level and its use within a broad marketing framework becomes crucial.

One role of the public sector could be to undertake storage. Another role could be to try to improve the traditional marketing system instead of arguing that the system is ineffective, undesirable and needs to be replaced. Government could undertake action in areas such as: 1) marketing evaluation and regulation, and 2) active promotion of innovations in order to effectively reach different types of producers and consumers with improved

marketing services (70). It could also have direct intervention in such activities as:

1) Improving agricultural marketing policy
2) Assuring fair exchange sales, protecting both buyers and sellers
3) Improving agricultural inputs of production and local availability
4) Increasing access to and use of credit by farmers and innovative marketing agents
5) Searching out and encouraging alternative institutional arrangements for accomplishing more effective market coordination
6) Providing or encouraging basic data collection, basic and applied research, as well as market research and analysis
7) Improving services such as special education and extension activities to disseminate improved technologies and market price, quantity and management information.

In conclusion, studies for improving grain storage at the farm level and its utilization by different types of farmers, could be organized on a regional or national basis, depending on the size of the country and the resources available. Research and extension should be focused in a broad conceptual framework in order to get a more integrated understanding of the complex set of factors influencing adoption of improved technologies by different types of

farmers, as well as the dynamics of their decision-making processes about production, storage and sales. Therefore, useful recommendations could be developed and accurate/ timely information could be transmitted that will allow farmers in different situations to reach desired nutrition, income and welfare levels.

Finally, policy makers can utilize new knowledge learned about farmers' consumption, production and marketing patterns in order to formulate more meaningful policies.

V. SUMMARY AND CONCLUSIONS

Reduction of post-harvest food losses has recently received a great deal of attention as a part of an overall strategy for coping with the possible shortage of food for the world population. Because of this concern several international and national institutions have conducted research dealing with on-farm storage of food grains. Currently, inadequate storage facilities have been blamed for important grain losses. Thus, research has been focused primarily on biological and physical factors of the problem. However, there is still an extensive debate in the literature about the magnitude of the losses and the accuracy of the loss assessment techniques used for its measurement.

Given the importance of grains in the human diet, this paper has focused mainly on grain storage problems at the farm level. It attempts to find evidence in literature about the real magnitude and the conditions in which grain losses occur. Thus, the circumstances in which a reduction of losses would be appropriate are identified. The need for a broad conceptual framework for studying the complex set of factors affecting farmers' decision-making processes is presented. This framework should help orient research and extension efforts for effectively improving

grain storage at the farm level and its utilization by different types of farmers in developing countries.

The results from several of the studies reviewed can be roughly separated into two groups, those claiming that losses represent a high percentage of food grain production (25-40%) and those supporting a low percentage (5-10%). However, one cannot conclude simply that the magnitude of grain losses is high or low in general, without taking into account specific situations. The amount of grain lost will depend on a great variety of factors such as type of grain, temperature and humidity, chemical factors, biological agencies as bacteria, fungi, insects, rodents and methods of handling storing, transporting and disinfecting the produce. It will be also important to take into account the length of the storage period. Furthermore, losses are related to size of operation. A larger amount of grain stored will require better management capabilities as well as a larger amount of labor to maintain the grain in appropriate storage conditions.

Several approaches for reducing post-harvest food losses have been reviewed from the literature. Most have pointed out the relevance of a system perspective, which tries to adjust the various elements in the system in order to improve overall performance. However, there is no known simple inexpensive technology that can, by itself, make a profound impact on post-harvest losses. On the contrary, post-harvest food conservation can only be achieved through

a combination of location-specific problem identification, training, information and appropriate technology. The technology must take into account important prerequisites for its implementation such as infrastructure, educational level, etc.

A great amount of control measures have also been mentioned in the literature, and several different storage techniques for decreasing on-farm storage losses have been proposed. The application of the approaches mentioned above, as well as the control measures or the adoption of managerial and/or technical procedures for reduction of grain losses, should be submitted to a cost benefits analysis before their implementation. This is needed to carefully take into account the cost and returns involved in those actions because there is an optimum level of losses beyond which the further cost of reduction is not compensated.

A major difference exists between the beliefs about the role that grain storage plays in each farmer's economy. Unfortunately, there has not been much research done directly on farmers' use of storage and factors influencing their behavior. Most of the studies focus on marketed surplus behavior and its response to price and non-price variables. These variables include resource endowment, debts and obligations, farm size, household size, on-farm income, off-farm income, production, storage capacity, risk and uncertainty.

The price and non-price variables affect the marketed

surplus behavior in diverse ways, as observed in the results from several studies reviewed. Nevertheless, the key point is that they should be included in the analysis in order to improve our understanding of farmers' storage decisions.

There are several commercial alternatives for farmers with respect to their food grain production. Non-commercial transactions are also very important and should be taken into account. Along with subsistence requirements they can determine the amount of grain available for sale. Farmers' storage decisions depend on an overall strategy considering subsistence or commercial production or a mix of both. The strategy usually adopted is an outcome of the conditions and resources available to the farmer (i.e. labor, capital, etc.), marketing and price information, household consumption, credit and minimum price programs, non-farm employment, etc. Clearly, there exists an interaction among these factors. It cannot be said that farmers' decisions are based upon only one of them.

Furthermore, the differences among farmers should be recognized and the disparity of circumstances faced by them within and across countries. There is a great variation among farmers' wants and needs, as well as their management capabilities for dealing with different sized storage operations.

Given the factors mentioned, it is not possible to compare results from different studies and to draw general

conclusions about farmers' decision-making processes. These are made in a very dynamic context. There is clearly a need to interpret how farmers allocate their production between consumption, storage, sales and other disposals. In addition, the allocation of time between alternative production and leisure activities should be studied. It will be helpful to use a broad framework of analysis that involves the complex set of factors influencing these decisions.

Such a broad conceptual framework will help researchers and extension agents to: 1) identify the set of factors mentioned above, 2) make a diagnosis about potential and constraints faced by farmers in making their decisions, 3) recognize differences among several types of farmers' behaviors, objectives, wants and needs, size of operations as well as information available to them, 4) place priorities of research and extension with a broader perspective, and 5) realize the need to supply realistic recommendations and accurate/timely information in a continuous way. Thus, farmers, in different situations, would be able to achieve desired nutrition, income and welfare levels.

Finally, these actions should be accompanied by other considerations. Policy makers should recognize the needs of considering the microeconomic knowledge about farmers' consumption, production and marketing patterns as well as efficient extension services, basic research, adequate transportation facilities, basic market infrastructure,

effective access to credit, necessary market information, etc. This knowledge will help formulate and implement meaningful national policies.

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