# THE PREVENTION OF FARM LEVEL FOOD GRAIN STORAGE LOSSES IN INDIA: A SOCIAL COST BENEFIT ANALYSIS

by

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**Abstract**

A report of a study of farm level food grain losses carried out in Andhra Pradesh, India, from 1976 to 1978 is summarised. The object of the project was to provide a social cost benefit analysis of farm level storage improvements. The study concentrated on the storage of paddy (rice) as the staple crop. Eighteen villages provided approximately twenty sample stores each during the two year period of the project. Samples were subjected to laboratory analysis with emphasis on physical dry weight loss. The final estimate of loss was 4.26 per cent ± 1.33 per cent. In the second year various improved storage practices were tested, including improvements to traditional stores, use of metal bins, and pesticides. Analysis of the data suggested a positive cost-benefit from these measures and support for the expansion of India's storage extension service, the Save Grain Campaign.

**Résumé**

Résumé du rapport rédigé à la conclusion d'une étude menée dans le Andhra Pradesh, en Inde, de 1976 à 1978 sur les pertes au niveau de la ferme de graines alimentaires. Le projet avait pour but de dresser une analyse avantages-coûts des perfectionnements apportés aux méthodes de stockage à l'échelon de l'exploitation agricole. L'étude se concentra sur l'entreposage du paddy, denrée de première nécessité dans le contexte indien. Dans chacun de dix-huit villages visités, quelque vingt greniers furent échantillonnés pendant les deux années couvertes par l'étude. Les prélèvements furent analysés en laboratoire dans l'optique, principalement, de déterminer la perte en poids sec. En dernière analyse, les pertes ont été estimées à 4,26% ± 1,33%. Au cours de la seconde année de l'étude, diverses méthodes de stockage améliorées furent mises à l'essai : modernisation des greniers traditionnels, utilisation de bidons métalliques, traitement aux pesticides... Le dépouillement des résultats aboutit à la conclusion que de réelles économies étaient réalisables grâce à l'adoption de ces mesures et cautionna des services d'aide à l'agriculture du gouvernement Indien, le mouvement pour la promotion des économies de graines (Save Grain Campaign).

**Resumen**

Se hace un resumen de un informe sobre un estudio de las pérdidas de granos alimenticios a nivel de granja llevado a cabo en Andhra Pradesh, India desde 1976 a 1978. El objeto del proyecto fue facilitar un análisis de beneficios en relación al costo social sobre las mejoras de almacenaje a nivel de granja. El estudio se concentró en el almacenaje de arroz en general como cosecha principal. Durante los dos años de duración del proyecto, dieciocho aldeas proporcionaron aproximadamente veinte almacenes de muestra cada una. Las muestras tomadas fueron sometidas a análisis de laboratoria con un estudio especial de la pérdida física por peso en seco. El cálculo definitivo de la pérdida fue de un 4,26% ± 1,33%. Durante el segundo año se pusieron en prueba varios métodos de almacenaje perfeccionados, entre los que cabe mencionar mejoras efectuadas en los almacenes tradicionales, así como el empleo de silos metálicos y productos antiparasitarios. El análisis de los datos sugirió la obtensión de un beneficio positivo en relación al costo con el uso de estos métodos y el apoyo para la expansión del servicio de ampliación de almacenaje de la India, la Campaña de Ahorro del Grano.

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## Introduction

This article summarises a two year research project conducted in eighteen villages of Andhra Pradesh, South India, The project was funded by the Economic and Social Committee for Overseas Research of the United Kingdom's Ministry of Overseas Development. A full IDS Research Report is available from the Institute of Development Studies, University of Sussex, UK (Boxall, Greeley and Tyagi, with Lipton and Neelakanta, 1978).

The project was originally proposed after a review of economic research relating to farm level storage losses (Lipton, 1971) had shown that whilst literature containing significant economic evaluation was scanty, the indications were that satisfactory returns could be anticipated and that research should be initiated. In 1973/4 a pilot project conducted by the IDS in collaboration with the Indian Grain Storage Institute, established the feasibility of loss assessment work and the collection of economic data affecting storage losses at the farm level. The period of field work during the pilot project was insufficient to establish reliable loss estimates; nevertheless it gave a clear indication that a full scale research project could be expected to produce the necessary quality of scientific results (Lipton, Cook and Nair, 1974).

The full project, which began in September 1974 and continued until October 1976, was designed as a multi-disciplinary field research activity. Its aims were to determine how much food was lost during storage in traditional farm-level stores and to examine alternative ways of reducing or preventing the loss. The rigorously derived loss estimates were then analysed in an economic framework in order to relate the findings to policy requirements for public sector investment in storage improvement programmes.

## Organisation of the study

The project base was established at the Indian Grain Storage Institute's (IGSI) field station at Bapatla, in Andhra Pradesh, one of the most important rice-growing states in India. The pilot project had been based there and a major inducement for the siting of the main project at Bapatla and indeed for the success of the project, was the opportunity to collaborate with local experts.

A selection of eighteen villages in Andhra Pradesh was made through a multi-stage random sample based on the five agro-climatic zones as defined for paddy by the Indian Council for Agricultural Research and on Taluk* and village level figures for paddy production per head, as this was the best index from the available data of relevance for storage. The project design allowed for six areas of study, each one being controlled by one locally recruited field officer. The relative importance of the Central coastal zone (41 per cent of the total area of rice production in Andhra Pradesh, contributing 5 per cent of the all-India total rice production) prompted the location of two units of study there.

The six field officers, each responsible for three villages, began their work with a preliminary census of storage structures and economic characteristics to provide data for selection of farmers and stores. Approximately twenty stores per village were randomly selected, different types of structure being chosen in proportion to their relative importance. In the selection of individual stores, farmer co-operation and crude income grouping were constraints on a pure random sample from the census data.

The field officers were responsible for sampling of stores, their treatment with pesticides, organising the construction of improvements and recording information relating to the stores. They also collected social and economic data pertaining to the sample households.

Sampling of stores began in the Kharif (summer) 1974/75 season and continued until August of Kharif 1975/76 season. In two double crop areas the Rabi (winter) crop was sampled in 1974/75 and to a limited extent in 1975/76. In the first year sampling was restricted to traditional storage structures (Figure 1) but in Kharif 1975/76 season a variety of improved storage practices were assessed. These included (a) improvements to traditional stores (Figure 2), (b) pesticide treatments and (c) substitution of metal bins for traditional stores.

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* taluk — local administrative area.

Fig 1. Traditional Outdoor Gade

Fig 2. Improved Outdoor Gade

a. The improvements to traditional stores were designed by the agricultural engineer at the Bapatla field station of the IGSI and finalised in discussions with village masons, farmers and labourers. Over fifty-five improvements to traditional stores were undertaken and the emphasis throughout was on the use of locally available raw materials. The improvements, constructed by village masons and labourers under the supervision of IGSI workshop staff, were designed to prevent access by rodents and damage by ground-water migration.

b. The pesticide treatments evaluated included the use of rodenticides and fumigants in common use in India, particularly fumigation with ethylene-dibromide and ethylene dichloride/carbon tetrachloride mixture. Consequently there was a large number of possible permutations amongst treatments and improvements.

c. Sixty metal bins (for indoor use) with a capacity of 1 ton and based upon IGSI designs were distributed in the study areas by arrangements with the National Office of the Freedom From Hunger Campaign.

The weight of grain in the selected stores was determined as accurately as possible and a representative sample to provide the baseline for loss assessment was taken at the time of filling. Sampling was thereafter at four to six weekly intervals with some slight variations (generally reflecting individual removal patterns).

Samples of approximately one kilogram were collected and despatched to the laboratory at Bapatla where they were analysed for moisture content, insect and mould damage, insect numbers, dust weight and weight of standard volume. Some milling tests and a rudimentary quality analysis were also undertaken

**Storage losses**

The ease with which the various categories of loss, eg weight loss, quality loss, may be determined, is largely dependent upon the prevailing field situations, access to stores, co-operation of farmers, and laboratory facilities. The project concentrated on establishing a reliable best estimate of dry weight loss of paddy as this provided the most comprehensive comparable measure of food loss.

It was difficult to assess accurately the total loss of milled rice experienced by sample households because of the uncertainty of the degree to which the laboratory tests reflected the milling practices at the village level. It was possible to examine certain aspects of quality loss under field conditions but valuation of the loss was found to be extremely difficult. The method of loss assessment adopted allowed three causes of loss to be categorised – insects, moulds and other causes.

The amount and frequency of grain removals was recorded in order to determine the total loss and the pattern of consumption. Estimates of loss in the samples obtained by reference to the changes in dry weight of the standard volume (reflecting the loss due to insects and to a lesser extent fungi) were applied to the quantities of grain removed at the sampling date and two to three weeks either side. This method gives an accurate analysis of the grain losses actually incurred by households in their normal consumption of grain.

The resulting loss figures were then totalled to give an estimate of the loss due to insects (primarily *Sitotroga cerealella* and *Rhizopertha dominica*) for the whole storage period. The difference between the total loss figure (from weighing records) and the total insect loss figure represents the loss due to other causes, eg mould, rodents, birds. Mouldy grain is rejected by the household only if damage is severe and so the actual weight of grain so rejected was recorded and taken as a measure of mould loss.

After allowing for insect and mould loss some additional loss still had to be accounted for and this was, in the main, attributed to rodents. It is likely that this loss includes losses due to birds, domestic animals, chickens and other unrecorded removals of grain. For example, women sometimes removed small quantities of grain unknown to their husbands, for barter. However from field observations it was concluded that the losses caused by these other agents were small and that to include them as rodent losses in the final analysis was perhaps justified. A summary of the storage losses recorded is given in Table 1.

Problems of transportation, communication, farmer co-operation, leave arrangements for field staff, availability of electrical power and laboratory machinery spare parts all interferred with the operation of sample collection and analysis and the benefits of a large sample were realized. Nearly 50 per cent of the first year and 25 per cent of the second year sample stores were not complete successes since samples were not taken regularly at the time of each removal or records of moisture content, grain movements in and out of stores, etc were incomplete. However these stores did provide much valuable supportive information on aspects of the research.

Defining food loss as a reduction in physical dry weight of paddy, the 'best' estimate of loss over a storage period of seven months was $4.26 \pm 1.33$ at the 95 per cent level of confidence. The result was based upon the weighted average of the findings from different sample stores and varying storage periods.

The results for the improved outdoor stores and metal bins as a substitute for indoor stores indicated the success of both techniques in reducing the traditional farm level storage losses to about 1 per cent. (Table 2). No clearly satisfactory improvement to traditional indoor stores emerged from the study although it was possible to demonstrate that losses can be reduced by the use of fumigants and rodenticides. However, use of these pesticides within dwelling houses may not always be possible nor advisable because of the safety hazard.

**Table 1**

**Comparison of the amount of loss occurring when traditional storage methods were used. The total loss is expressed as a percentage of the initial quantity stored and, where possible, it is attributed to cause.**

| STORE TYPE | AVERAGE STORAGE PERIOD (months) | % WEIGHT LOSS | | |
|---|---|---|---|---|
| | | Insects | Other | Total |
| Indoor Gade (Basket) | 6.7 | 2.3 | Rodents 3.1) Mould 0.8) 3.9 | 6.2 |
| Outdoor Gade (Basket) | 6.8 | 1.7 | Rodents 2.5) Mould 0.3) 2.8 | 4.5 |
| Puri (store constructed from paddy straw ropes) | 7.8 | 2.0 | Rodents 1.1) Mould 0.5) 1.6 | 3.6 |
| Patera (Underground pit) | 5.3 | 1.2 | Rodents 0.1) Mould 2.1) 2.2 | 3.4 |
| Mud Pots | 6.1 | 2.0 | Rodents 0.7) Mould 0.3) 2.1 Theft? 1.1) | 4.1 |
| Moola (Open Bulk) | 4.4 | 1.6 | Rodents (+ birds + mould?) 4.4 | 6.0 |
| Kotlu (Room inside house or separate building) | 9.0 | 1.3 | Rodents (+ birds + mould) 1.4 | 2.7 |
| Garise (Mud or Stone Slab 'bin' inside house) | 7.0 | 1.2 | Rodents (+ mould?) 2.4 | 3.6 |
| Bags | 6.4 | 1.5 | Rodents 2.4 | 3.9 |
| Katta (Special seed store paddy contained within a ball of straw) | 6.0 | 2.4 | Rodents? 0.5 | 2.9 |
| Indoor Puri | 8.6 | 1.7 | Rodents 2.5) Mould 0.3) 2.8 | 4.5 |

**Table 2 Comparison of Total percentage weight loss in traditional and improved storage conditions**

| STORAGE STRUCTURE | TOTAL % WEIGHT LOSS | | |
|---|---|---|---|
| | Insect | Other | Total |
| Indoor gade | | | |
| untreated 1975 | 2.3 | 3.9 | 6.2 |
| untreated 1976 | 1.5 | 2.2 | 3.7 |
| fumigated 1976 | 0.6 | – | 1.1 |
| + | | | |
| rodent control 1976 | – | 0.5 | |
| Outdoor gade | | | |
| untreated 1975 | 1.7 | 2.8 | 4.5 |
| untreated 1976 | 1.7 | 2.1 | 3.8 |
| fumigated 1976 | 0.6 | – | 1.0 |
| + | | | |
| improved base 1976 | – | 0.4 | |
| Outdoor puri | | | |
| unimproved 1975 | 2.0 | 1.6 | 3.6 |
| unimproved 1976 | 1.3 | 2.3 | 3.6 |
| improved base 1976 | 1.3 | 0.6 | 1.9 |
| Bin | | | |
| untreated 1976 | 1.4 | 0.7 | 2.1 |
| untreated 1976 | 1.4 | 0.5 | 1.9 |
| Fumigated 1976 | 0.4 | 0.2 | 0.6 |

**The social cost benefit analysis**

The estimate of loss (4.26 per cent) for traditional unimproved grain stores is considerably lower than most of the evidence in the literature.

Nevertheless, the social cost benefit analysis reveals that efficiency gains (by preventing losses) are still sufficiently large to justify an extensive public investment programme to reduce farm-level storage losses. The use of improved stores and metal bins can reduce losses to around one per cent and this saving of around 3.2 per cent constitutes the benefit. The storage improvements were assessed on both a financial and social cost benefit basis. The ratio of costs to benefits on a financial basis were 1:0.67 when using a metal bin and 1:1.33 for the improved traditional outdoor store. However, the results of the social cost benefit analysis showed that both the metal bins and improved traditional stores provide positive social-benefit cost ratios, although the improvement to the traditional stores has a far superior ratio (1:1.14 for bins and 1:1.51 for improved traditional stores).

Because of the physical characteristics of paddy, the loss estimates are likely to be lower than for other food grains which are more susceptible to insect infestation, and consequently higher social cost benefit ratios can be expected for other main dietary staples in India. The negative private rate of return for the metal bin suggests that in Andhra Pradesh there should be a bias towards improvements to traditional stores whereas the successful introduction of metal bins in the wheat growing areas of Northern India tends to confirm that private rates of return for wheat are higher than for paddy, and more emphasis can be given in these areas to the introduction of metal bins.

The substantial conclusion of the IDS work was that the on-going extension services of the Save Grain Campaign be expanded; that increased emphasis be given to the training of extension staff in improvements to traditional practices; that more attention be paid to the distribution of inputs through liaison with the private pesticides industry; and that further research be conducted in other areas of India along the lines of the IDS project to produce similar policy guidelines for the dissimilar agro-climatic conditions, cropping patterns and storage patterns in other states.

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