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FOOD LOSS PREVENTION: A MEANS OF SOCIO-ECONOMIC TRANSFORMATION

by

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Introduction

1.1 The main purposes of socio-economic transformations which have been brought about, unconsciously at first and then consciously, by human beings from their beginnings on earth were first for survival and security, and then for improvement of the quality of life, hopefully doing the least possible damage to ecology and enviroinment. These efforts, initiated at first to meet food needs, have today become very complex means of development. Therefore it is necessary to examine the total subject of prevention of food losses in the context of socio-economic progress through better use of the complex system of agricultural production and food conservation. This calls for the development of a new non-conventional integrated vision and perspective to understand the scientific inter-disciplinarity and social multi-dimensionality of the problem in a historical context. Prevention of losses must be recognised as a means of socio-economic transformation through the use of appropriate technological and socio-cultural knowledge to achieve better quality of life.

1.2 The challenge of feeding over 8300 million people adequately by the year 2025 AD and reducing poverty of over 50% of them, which is staring humankind in its face. The world population is rising annually at the rate of about 95 million, most of it is in the developing countries. Production of food through the use of high cost and hi energy inputs such as chemical fertilisers, pesticides, expensive irrigation schemes and costly equipment, which are difficult to obtain and maintain, have not provided meaningful solutions for many of the third world countries. On the contrary, it has often created new and more serious problems. Therefore a sounder and more appropriate approach is needed to use agro-food system more effectively to accelerate the development.

1.3 Indiscriminate use of chemical fertilisers is resulting in rapid depletion of organic matter in the soil, the level of sub-soil tubewell water which is being increasingly used for irrigation is dropping 5-10% annually in many areas. Extensive use of pesticides and toxic chemicals has become a serious health hazard specially for those 50% of the world people who are suffering from malnutrition, undernutrition and social under-development.

1.4 Prices paid for the food do not compensate the farmers for the high cost of inputs, and some of them do not even have the financial resources to invest in it. The subsidies being inadequate have not helped them, besides only a few developing economies can afford price-support for a large economic sector like agro-food system which supports 60-80% of their population.

1.5 Surpluses of food in the rich countries and as a result in the world do not solve the problems of developing countries, who are very short of foreign exchange. The only alternative is to increase food supplies by the needy countries themselves. Copying the food production and conservation system of advanced countries by the developing countries is neither possible nor desirable. For example the farmer in advanced countries uses energy equivalent of 300 litres of fossil fuel to produce a hectare of high yielding corn. Transfer of such technologies to developing countries can only lead to disaster. Table-1 gives the energy use per capita and the consumption of fertiliser per hectare of arable land in some selected countries. Where production and conservation pattern of rich countries has been adopted even partially in the developing countries, it has already resulted in rise of food prices far beyond the buying power of common people. In fact the buying power of animals to feed the rich in the world has become greater than that of a larger number of people to feed themselves.

1.6 The energy consumption pattern in the agricultural system in developed and developing countries is illustrated in Fig-1. The latter represents over 75% mankind, but uses less than 8% of the energy per capita in agriculture. If they were to copy the American or European pattern in this respect and succeed even partially, it would lead to disaster. In fact, looking at the present potential of available fossil energy resource, (Fig-2), both the developed and developing countries need an entirely new approach to deal with this problem. The future energy use pattern in the world and in particular for the agro-food system will have to be based on self-perpetuating and self-dependent cycles.

1.7 All countries, especially the developing ones, must re-examine their policies and learn to make more appropriate use of the wealth of scientific and technological knowledge available today by placing it in a new perspective. Based on these policies, more realistic plans and programmes of action, (including the future research and development activities) must be formulated and implemented. Any approach which is new is bound to meet with opposition from the conservatives and obscurantists who continue to be in position of authority. The fate of Gallileo and Copernicus should inspire the leaders of new thought and provide them courage to act. Development of this new approach requires fresh study in a more appropriate social and historical perspective so that we may not go off at a tangent as we seem to have done at present.

1.8 The objective of this paper is to examine the importance of prevention of food losses. A systematic approach to achieve even 25-50% of loss reduction at each stage of production and conservation, which should be possible, can increase food supplies by 2 to 5 times without additional demand on land or energy. In the process it will generate employment and reduce poverty, help in protection of fast deteriorating environment and ecology, reduce dependence of poor on the rich and eliminate political interference, give new sense of self-respect to nations and create conditions for much greater cooperation among countries eliminating obstructions to peace and prosperity. The purpose of this paper is not to offer a panacea, but to propose a different but viable appraoch through a more careful study, stimulate discussion and lead to possible action in areas which urgently need much greater attention, and which can offer meaningful and long lasting solutions to the complex problem of food and poverty. The present situation of the third world with respect to food and poverty is summerised in Table-2. It brings out more than adequately the need for a rather non-conventional and radical transformation to change the long lasting stagnation, poverty and starvation as traditional approach has not offered any significant solutions.

1.9 Historically for the premitive human societies of the food gatherers and hunters, prevention of losses, particularly at the post-harvest level, was very important. They therefore learnt to conserve and store their food even before they learnt to cultivate land. Their survival and food security depended upon what they could save for difficult days. In this effort through trial and error, they learnt the artisnal methods of preservation of food to prevent losses making use of the most abundant energy sources available to them, viz., human, animal and the sun. They learnt to dry their food in the tropics where plenty of solar energy is available; using natural advantage of low temperatures in the extreme north of the earth they learnt to refrigerate and freeze the food and discovered accidently in many areas the use of fermentation and of fire. It may be worth investigating why the importance of prevention of post-harvest food losses became only secondary to crop production. Today not only the national governments, but even organisations like FAO spend less than 0.1% of their budget on assistance for development of agro-food industries.In fact they spend much more on commodity trade and statistics which mainly benefit the rich countries to use the information for manipulation of prices for purchase of raw materials at the lowest possible prices from the poor countries. Perhaps another reason may be that prevention of food losses was of secondary importance to the rich countries who had plenty of land available for cultivation, and losses for them were less important. They had low population because their people had migrated to new continents and they controlled the policy structure of the world and of international bodies. They also had the control of technology which has remained tuned mainly to their own needs. The developing countries have tried often to apply the advanced country concepts of "cost-benefit" to their own conditions where other social and economic factors had more important role to play, such as foreign exchange shortage and need for greater self-reliance making use of endogenous resources. Thus the developing countries cannot afford to to copy the advanced, land- and energy-rich countries as examples of self-reliance for their own development.

1.10 A time has come to re-examine the important subject of prevention of food losses from a very different point of view, viz. to optimise the use of natural resources as a means of meeting future food and other needs, for generation of employment for protection of environment and saving of the limited world resources for the future generations at the place of need and not far away in other affluent resource-rich countries. The approach should take into considerations not just the immediate monetary cost benefits for profits purposes, but many other factors for the future of humankind and protection of their earth.

2. Recognition of food loss prevention as a priority

2.1 Starting with comparatively simple efforts to meet the food requirements and learning the art of preventing food losses under pressure of the survival struggle with the odds of nature the humans have gone much beyond today. They have created a great socio-technological complex in the process. The nature and magnitude of the problems of today's large populations within the confines of national and regional boundaries are different, but so is the volume of knowledge base.

2.2 The human society brought about a major revolution when it successfully created a conscious interaction between itself and nature (about 19th century) to understand the principles behind various phenomena. This gave humans the knowledge and power to make progress in geometric progression. As a result today they have the capability of dealing with the problems of meeting food and other needs for the year AD 2025 and beyond. The success in meeting future food need, inter alia, can best be achieved by prevention of the staggering losses. Its important role as a means of socio-economic transformation needs to be recognised today, without loss of time, much more than our ancestors did. It is also clear that the rate of progress of nations, social and economic, has become directly proportional to their capabilities to generate knowledge and to use it purposefully. Capabilities for this must be built in the developing countries so that they can deal with their own problems with the least possible negative impact of indiscriminate technology transplant from outside. Scientifically they must continue to learn from the world as a whole. Science is universal, but technology is the result of interaction between science and society. The interactions taking place between science and societies of Europe and America cannot be the same as those needed in Africa and Asia. The latter need capabilities to make the interaction more purposeful for themselves.

2.3 During the second half of the present century, much attention has been given to increasing crop production per hectare of land. This has gone to a level where ecological aspects of protecting natural resources and optimising their productivity have been neglected. The emphasis on increasing agricultural production should continue, but with greater caution. In fact as for the approach to energy use in the agro-food system is concerned, there is need for a completely different approach by the developing countries. They cannot afford to copy the pattern of advanced countries like the USA as illustrated in Table-3. Therefore other means of increasing food supplies must receive equal if not greater attention. What has become much more important now is the need to pay priority attention to prevention of losses in the total agro-food chain, and specially at the post-harvest levels where the beneficial impact can be the fastest.

2.4 In this brief paper it is not possible to deal with every component of the whole complex of socio-economic transformations which have already been brought about and many more which can be brought about in the future by the agro-food system. It would suffice to state that an effort has been made, perhaps with some exaggeration to focuss much greater attention on the urgency to develop an integrated systems approach to understanding the nature and magnitude of food losses at various stages in the complex for developing a comprehensive programme of action for their control and prevention. This will help to bring about in the near future a more purposeful transformation especially in the developing countries where 80% or more of the human kind will live in AD 2000. This approach would have meaning only if followed up with the formulation of sound national policies for food loss prevention, formulation of plans with dynamic programmes of action for implementation with speed within specified time frames. It will need not only properly oriented institutional framework, but human capabilities to manage each one of their activities realistically at the site of the problems.

2.5 Many disciplines of natural and social science with multiple dimensions will have to be involved in any purposeful assessment of food losses and in planning of action to prevent them in relation to each situation. The approach, therefore, cannot be free from varying opinions and contraversies in laying down paramaters for loss assessment and to take action on them. This should in fact help to enrich the entire approach and better harness the capabilities needed to meet the complex challenge. Reliable data on losses even when available is suppressed as it has often been politically embarassing for those in power. Thus the information available on quantitative losses may have to be of necessity estimates. Experience has shown that the figures of losses often provided by certain developing countries, who are really do not have the capabilities for assessment of the food losses, are lower than those provided by advanced countries. In reality quantitative and qualitartive losses often cannot be separated. For example 3-4% fungal damage may render the whole stock of food grain unfit for human consumption due to presence of toxins and off-odours but the stocks on the books may show no losses. The parameter of weight loss which has been used as a means of loss assessment is not only of little value but is misleading. Often damaged grain picks up more moisture and can weigh more than sound grain. There is an urgent need for more scientific studies of all factors involved but even a very conservative estimates based on field experience and several spot surveys, the figures of losses seem staggering (Table-4). The world and in particular the developing countries, can ill afford to wait for several years to plan action until after the detailed surveys are completed. While assessment studies and surveys may go ahead, comprehensive action must be planned and implemented now on the basis of information already available. It is clear that increasing availability of food and raw materials for industry through prevention of even 25% of the estimated losses would make a tremendous impact on national development of many countries.

The most relevant areas where urgent action is needed to prevent losses are:

a) Pre-harvest losses

- Pre-cultivation losses such as improper or inadequate preparation of soil for cultivation, poor quality seed, lack of water management, inadequate weed control, and defective cultural practices for want of information.

- Field losses due to vertebrates/rodents, insects, avians, and micro-organisms

- Field-to-farmgate losses due to the above factors, plus improper use of equipment and adverse effect of inclement wheather when the harvested crop is subject to it.

b) Post-harvest losses

- Losses in pre-packaging, storage, handling, and transport.

- Losses in milling, dehusking and processing

- Losses resulting from lack of use of waste for making by-products for food, feed and other purposes

- Nutritional losses and toxicity development due to qualitative deterioration in storage, milling and processing.

c) Losses in Distribution, marketing and at consumer level

- Due to cultural beliefs, superstition, and culinary practices, other social (affluence) losses

d) Losses in Scientific, technological and human resource

- Losses of expenditure incurred on institutional capacities and of scientific and technological research results achieved as the know-how developed is improperly or inadequately used.

- Losses of costly human resource capability in research and at the point of technology use.

3. Identification of the nature and magnitude of food loss in the agro-food system at various points

3.1 It is essential to identify more clearly the qualitative and quantitative losses at each one of the aforementioned "points of no return" and to estimate their nature and magnitude so that an integrated action can be taken without delay to minimise them. Even from very conservative estimates already available, it is fairly clear that the human beings end up with only a small portion of what they try to produce for their own consumption. At every potential point of preventing losses the possible social cost benefits must be worked out for laying down priorities for action to get maximum possible benefits from the inputs. The choice of the priorities may vary from nation to nation, from one situation to another and from crop to crop. For purposes of illustraiton, the following points should be examined, mainly for foodgrains, which account for nearly 80% of the peoples food in the developing countries, and a substantial amount of food and feed even for the affluent scoeities. It is not possible to go into losses of perishable foods such as fruits & vegetables, fish, meat, etc, for want of space and time.

3.2 Pre-harvest losses

a) Precultivation losses occur in the system even before the seed is sown for production of food and other crops. If the soil is not properly analysed, chemically, physically and biologically, to prepare it for cultivation, its productive capacity may be used only to the extent of 50% or less. Thus a good proportion of the costly inputs such as seed, fertilisers, pestiides, energy and labour may be lost and much damage done to this vital natural resource.

b) Poor seed viability can result in heavy losses which have already been estimated to be between 20% and 100% of the crops sown depending upon a number of factors. Paul Neergaard has reported reduction of 20-40% yield of soyabean in the USA. In case of Phaseolus beans loss of 20% of the crop was reported in 1965; due to the Fusarium root rot a crop loss of 95% was reported in New South Wales, Australia in 1941. In the USSR, Chang reported losses of 50-60%. In case of wheat the losses caused by bunt and smut infection in 1927 were 80% of the crop which with better control could be brought down to 4% in 1940. In 1935 Mitra reported crop losses upto 40% in N.W. India (1935). Similar losses were reported in the case of rice crops.

The losses are known to be much higher in case of sorghum and millet. In developing countries where the resources and capabilities for assessment and for prevention of losses are very inadequate the losses must be higher than those in advanced countries for which the data is available. The introduction of new high yielding varieties have created quite serious problems of field losses as these varieties are much more susceptible to infecton and infestation.

c) Water is another vital food production resource which suffers heavy losses. The total water available on earth is enough to cover even the land area to a height of 3 metres, 71% of earth already being sea. Only 1% of the total water supply is suitable for irrigation and for human use. Yet the recognition of the problem of water management is so poor that a large amount of it is lost by evaporation, especially in the open irrigation canals which often pass through hot areas of land and deserts where the temperatures go above 40-50 C. It is well known that the use of unpaved or badly maintained field irrigation channels can result in 20-40% seepage losses. Non-availability or inadequacy of irrigation water to all the cultivated fields when it is most needed reduces crop yields by 20-30% if not more. Inadequate investment on flood controls has often destroyed entire crops in countries like Bangladesh and India every year. On the other hand, one need hardly mention the wasteful use of water in urban areas, specially of rich countries, because of the obsolete sanitory systems and waste disposal arrangements. The cities in developing countries are already running into serious water problems mainly because of the obsolete urban water management technologies mostly copied from the advanced countries.

d) During cultivation, the field losses of crops are indeed high due to a number of reasons. For example, Cramer has given a conservative estimate of field losses in maize in Asia (excluding China) at 37% (Table-5). He has also estimated staggering annual world losses caused to rice, millets, sorghum and maize (Tables-6A and 6B)

e) Avians are known to cause very heavy losses. The percentage of such field losses vary depending upon the type of invading birds, the grain involved, time of the year, and availability of other food for their consumption. A study was carried out to use 4-amino pyridine for protecting ripening corn from Blackbirds where a number of fields were surveyed by Grazio et al in the U.S.. The losses caused are reported in Table-7. It has been reported by the same authors in 1970 that a large number of duckcissels (Spirza americana) consumed one entire grain sorghum planting in Nicaragua, and in Venezuala. The birds are knwon to crack the seed and eat the doughy centre, thus damaging the entire cob of corn or sorghum which loses value. Parakeets are known to eat 30-40% of their own weight (70-80 gms) daily; damages of different types are done by different species of birds. A detailed assessment and study of the published literature on losses caused by different species of birds for different grains would provide very enlightening data. Also much work has been done on bird repellents and other measures to control the damage. A study of this nature will help to lay down programmes of action and prepare meaningful research projects to develop more appropriate viable technologies to reduce losses. Considering the unemployment and low cost of labour in many developing countries, the measurs for prevention of these losses may be more economical for them

f) Rodents play havoc with crops in the field, along with other vertebrates. An emergency had to be declared in 1953 on the Island of Mindanao in the Philippines when the rats destroyed 70% of the crop. Again in 1965 they destroyed 80% of the crop in several areas. Similar havoc was caused by the rats in Senegal in 1976. A field study carried out by Ramakrishna et al in India has shown that between 46 and 78% of the crops can be destroyed by rats. This damage is done at different stages of growth, viz. freshly sown seed, seedling, half-blade and at different stages of cultivation and in storage. At a conservative estimate India is said to have a rat population of 2400 million and 6 rats eat the food of one human being as they are fast growing animals. Even if they eat only 50% of the food meant for humans, and get the rest of their need by scavanging on the waste, they can consume food of at least 200 million people. It was estimated by Stoner that in 1952 the rat population in the US was equal to human population. According to him, the rats cause more damage than they actually eat. An average loss caused by the California ground squirrel alone was calculated at US $ 8 million. 200 ground squirrels consume as much range forage as a 45 kg steer. Rodents are also great health hazards being carriers of some of the most deaded diseases. Recent studies on population of rodents and vertebrates in Bangladesh and Pakistan have thrown further light on the nature of field and storage losses by vertebrates.

g) A number of small animals such as jackrabbits, pocket gofers and other vertebrates are also known to cause heavy losses. It is often difficult to assess them separately from the losses caused by other verteberates which include Kangaroo rats, meadow mice, paramyscus and squirrels. The total economic losses due to these in California were calculated in 1968 at 32 million dollars. This was the result of damage done after taking control measures. In 1939 it was estimated that the field rodent losses were between 200 and 300 million dollars. The value of all these losses at todays prices would be at least six times more.

3.3 <u>Field to farm-gate losses</u>

a) Food and agricultural produce, after it has fully matured and is ready to be harvested has the maximum value. Therefore any losses after harvest are of the highest economic value. Not enough data is available on the losses which occur between field and the farm gate. Although it is recoognisd that these losses are quite large, there is an urgent need to assess them as they should be comparatively easy to prevent. It is clear that due to easy accessibility the rodents, small vertebrates, avians and insects play greater havoc with the harvested or threshed crop which often lies for 24 hrs or longer in open fields or on farm floors.

b) If the crop gets wet in rain or absorbs moisture from the dew it deteriorates fast due to fungal and microbial infection as happned during 1987 to a substantial portion of the wheat crop in North India. There are no buyers for such grains even at half the price. The grain millers, processors, bakers, biscuit manufacturers and pasta makers dread the supply of flour from this type of raw material. The fungus infected grain often gets contaminated with mycotoxins besides its bad appearance poor processing qualities and undesirable odours.

c) The methods of crop threshing and drying used in most of the developing countries are often primitive. The small farmers often spread the crop on the roads and let the traffic do the threshing. They do not have easy access to modern dryers. This results in quality deterioration, contamination, and heavy physical and biological losses.

3.4 Post-harvest losses

A large amount of information is available today on post-harvest losses but in the past there have been controversies on their nature and magnitude. Now there is a great deal of agreement on the loss figures. Yet much needs to be done to collect more detailed data that would help development of new and safe methods of loss prevention. A fair amount of data based on estimates of these losses was provided in 1963 and 1968 in papers prepared by the workers at the Central Food Technological Research Institute, Mysore, India, which took into consideration spot surveys and experience of field workers. Their position stands proven today. Most of this and subsequent data was found very embarassing for those in position of authority in the governments and they did their best to deny it but as time went on the figures on losses were confirmed by many others. The negative impact of these indiscriminate denials resulted in long delay in planning a quick aciton to prevent the losses. The US National Academy of Sciences, 1978, stated in their report on food losses in developing countries "Reliable studies indicate that post-harvest losses that occur between harvest of major food commodities in developing countries are enormous, in the range, conservatively, of tens of millions of tonnes per year and valued at billions of dollars". It further goes on to say that "it is clear that worldwide food losses are staggering and that they justify substantial investment of intellecltual and financncial resources to better understand and reduce them". Unfortunately the NAS study uses weight loss as its main criteria for estimating these losses. This single parameter is far from adequate in making a realistic assessment and can be quite misleading. For example, as stated earlier, grain damage of 2-3% by fungi may not result in any significant weight loss but because of mycotoxins produced and off-odours, the food becomes completely unfit for human consumption and even for use in animal feed. The recognition of urgency to prevent losses became more visible when the UN General Assembly in 1975 passed a resolution at its VII Special Session requesting the Member Nations to reduce the losses by 50% by 1985. The action taken to implement the resolution has been far from adequate.

b) Rodent losses: Like in the pre-harvest system, the rodents also take the highest toll of primary human food in the post-harvest system. With the urbanisation of rural areas and development of Magapolises the field rats have migrated to the cities and have adjusted their life-style to live with the people mainly because of the availability of large stocks of food in the warehouses, stores and homes and also the availability of waste to supplement their needs. In a comprehensive study carried out by a team of researchers, supported by the Rockfeller Foundation in India, it was observed in Calcutta warehouses that the population density of the lesser bandicoot rat was 190.7 during 11 month period with a mean density of 0.78 rats per sqaure metre. Similar studies have since been carried out in Bangladesh and other countries.

c) Losses of stored grain caused by insects can be very high. For example the pulse beetle passes through 8 overlapping generations in one year. The progeny of 50 eggs can reduce the weight of infested grains by 49% in just 6 months. In addition the grain is contaminated with metabolites like uric acid and is exposed to further contamination by toxin producing fungi. Depending upon the type of grain and the storage conditions the losses due to insect infestation can conservatively be between 10 and 40%. Nearly 60-90% of the food grains in most of the developing countries do not enter the marketing channels and are most often exposed to highly unsatisfactory conditions of handling and storage both in rural and urban areas.

d) Fungal contamination often combined with or followed by insect infestation results in rapid deterioration of grains due to moisture absorption and consequent microbial and accelerated enzyme activities, resulting in hydrolytic rancidity, off odours and production of carcinogenic mycotoxins. This problem arises much more during monsoon especially in underground and overground rural storages. The loss of such grain can be almost 100% as its consumption would be hazardous.

3.5 Losses in milling and processing

Usually one type of loss encourages another, thus there are further cumulaltive losses along the line. For example:

a) It is necessary to mill the grain legumes for removing the husk and to split them where necessary. This helps to reduce the roughage and to cut down the cooking time to about one third, saving a great deal on fuel. If the grain legumes have been insect infested and absorb moisture, there is a great chance of fungal contamination. The insect damaged grains result in powdering amounting to further loss. Table-8 shows that if the kernel damage is 15%, there can be a milling loss of at least 17%. Even if 50% of grain legumes suffer such losses in India, it can amount to about 4-5 hundred thousand tonnes of high quality food loss.

b) As in the case of grain legumes, the losses in milling of rice, wheat, sorghum, maize and millet can also be quite high due to kernel damage by insects. In case of oilseeds kernel damage results in rancidity due to enzymes released from the cells, high FFA and non-acceptance of the grains even for commercial purposes of extracting edible oils.

c) Besides kernel damage, in case of grain legumes, the use of improper milling technology can result in quite heavy technological losses. A comparison between obsolete and improved milling technologies now developed, is shown in Table-9. Greater retention of the outer, protein-rich surface by the use of improved technologies, retains the nutritional value of the grains besides raising the milling out-turn by about 10% which can provide over a million tonnes of additional foods containing 18-20% protein rich in lysine.

d) Rice is the main cereal consumed by the people of many developing countries. Use of poor milling technologies was resulting in 10-12% losses in the yield of head rice (Table-10) due to breakage, thus reducing the economic value of milled rice. Traditional hand pounding methods and use of single hullers for milling were the common practice in India and other countries. Today a very small percentage of rice goes through such processes. The introduction of modern milling technologies using rubber roller husking and roller polishing has brought about a great deal of improvement. The table shows the benefits that can be derived. It could amount to quantitative additiona of 2-3 million tonnes of rice to the national food supply, besides improving the quality. Additional cost of investment in new machinery can be recovered within a year or less from the economic benefits of less breakage and higher outturns.

e) Improvements in parboiling of rice have also been of great economic and nutritional value. The old process used to result in off-odours due to fermentation during long soaking period in cold water for a week or more. It also resulted in production of off odours and mycotoxins. The new technologies using short-time hot water soak, quick drying and milling have improved the milling yield by at least 1.5% which is not only adequate to offset the investment in equipment but have provided better quality rice rich in thiamin (vitamin B1) and free from mycotoxins. These new technologies developed in India and elsewhere have been widely accepted commercially. Also the rise in temperature of soaking inactivates the lipase in the bran layer which after milling can be used for solvent extraction of oil for human consumption and the extracted bran rich in protein can be used for animal feed. Rice bran contain 16-18% fat of high quality. India alone produces 65 million tonnes of rice, 50% of which is parboiled. All the rice in Bangladesh, is also parboiled. Thus the new technology has proved beneficial to public health and has improved levels of nutrition besides increasing food supplies by preventing losses.

f) Wheat is the main foodgrain of the world, but in most of the developing countries, especially of Asia, it occupies second place after rice. The tradiitonal practice in countries like India, Pakistan and in the middle East has been to consume non-leavened or even leavened bread made from whole wheat flour of 94-98% extraction. This type of flour retains all the nutrients of the whole grain because of the presence of germ and the bran layer. In order to offset the effect of phytic acid in bran and consequently in the whole wheat flour, it can be supplemented with iron and calcium. In recent years, the unfortunate impact of some rich countries of the North, especially in the urban areas of developing countries, has resulted in consumption of white bread made from 65% extraction flour which is lowering the level of nutrition. The remaining 35% flour goes mainly into cattle feed, except in some countries where it is sold to low income population. Thus introduction of white flour is a large quantitative and qualitative loss of human food.

3.6 Nutrition and food losses

It is more important and feasible to protect the natural nutrients present in the food to maintain or improve nutritional levels of the people than to supplement or enrich diets at high cost which is not possible in most of the developing countries. Table-11 shows that within 4 weeks of insect infestation the PER of wheat drops from 1.86 to 1.36 and that of chickpea from 2.21 to 1.85. Also Table-12 shows the adverse effect of infested sorghum on the liver of rats fed with it for 6 months. Thus the qualitative losses of food which are difficult to assess in economic terms, but adversely affect nutritional level and health of the people. These are of great consequence although they do not show up in the weight loss of the crop in storage. Damaged grains used in manufacture of other products carry forward or transfer these qualitative losses to items made from them without the knowledge of the consumer. There is a great potential to increase the level of nutrition by preventing such losses.

3.7 <u>Losses due to conversion of primary foods</u>

a) Conversion of primary foods into animal foods results in a very heavy loss. It becomes necessary to feed 6-9 kg to an animal to get a kg of edible meat from it. Borgstrom and others have calculated how much more an American or an Italian eats as compared to an Indian or a Mexican (Tables-13 and 14). As compared to an Indian, in terms of primary calories an American eats about six times more. It is said that the amount of grains Americans and Canadians fed to their animals in 1978 was enough to feed whole of India and China put together. Diets rich in animal foods are not necessarily good for human health. With doubling of meat consumption, it is said that artereosclorosis and cardiac disorders have gone up several times in affluent countries. Also Burkitt (Table-15) has pointed out that the difference in the faecal transit time of people in Europe is 2-3 times more as compared to Africans which is an indicative factor in the intestinal disorders of the former.

b) The loss of food due to conversion from primary to animal foods runs into millions of tonnes per year. If this can be reduced even to the extent of 50%, there will be more than twice as much food to go round. Table-16 also shows, in terms of calorie conversion, how uneconomical it is to produce animal products. Use of millions of tonnes of oilseed meals containing nearly 50% proteins for animal feed is also a great loss of food for humans. The oilseed meals should be used as direct food for humans to supplement their cereal diets and to provide milk analogs. India alone has 4 million tonnes of oilseed meals available, a substantial portion of which is exported to feed animals in rich countries to earn foreign exchange while the people starve and suffer from malnutrition. Of course it will be necessary to educate people and to overcome the brain washing and resistance of powerful lobbies of meat producers to control conversion of food into feed. As time goes, production of animal products will have to be increasingly restricted in developing countries to the use of agricultural and industrial by-products with some forage.

c) India has become nearly "self-sufficient" with production of 185 million tonnes of food grains for 800 million peoople while USSR with 250 million people and with a foodgrain production of nearly 170 million tonnes has to import food. Poland had political disturbances and food riots when meat rations were cut in the interest of self-sufficiency and public health. This was due to miseducation of people in the first place: A good example of indiscriminate copying the food patterns of the rich. More enlightened new policies and sounder programmes for better nutrition and health are needed urgently. It is fortunate that the developing countries have not been able to copy the rich North in this respect although the affluent segment of their population often tries to do so.

3.8 <u>Losses at distribution, marketing and consumption level</u>

a) Distribution of food grains in developing countries is normally done in jute bags of one quintal capacity which are easily emanable to rodent and insect infestation and are difficult to carry. Technologies to repel rodents and insects from the jute bags have been successfully developed and tried but much needs to be done to make their extensive use. Besides, the methods of handling the jute bags need a great deal of improvement. Normally steel hooks are used to lift them for loading and unloading which leave holes in them and the grain begins to flow out. Inspite of trials of alternative methods such as use of clamps, the success achieved has been very little. One can estimate with little hesitation that such losses are at least 2-5%.

b) At marketing level, where the retailers sell grain from the open bags by measure or weight in small quantities to the consumer, the losses can be quite high as the bags are often left open or inadequately closed and the rats and insects have a free run. Efforts have been made to encourage the retailers especially in urban areas to use metal bins but with limited success.

c) School lunches, where possible in fairly affluent countries often result in quite heavy losses estimated to be 20-40% in some cases. Even social problems of cast and religion prevent children from eating a mass produced meal. Often the losses between kitchen and the dinning table and from dinning table to overnight holding of the cooked foods are quite heavy. Few people in the developing countries can afford coolers or refrigerators. Traditional practices such as lactic fermentation of leftover foods like cooked rice with a small amount of yoghurt saves it and contributes to nutrition. Such methods need to be improved and used more extensively.

4. <u>Role of loss prevention in bringing about socio-economic transformation</u>

a) Organisation of an integrated effort as a major thurst to prevent losses in the agro-food system at each one of the stages, and their sub-stages can speed up the socio-economic progress much faster than is often realised. It can contribute to increasing and improving food supplies by at least 4-6 times even if the losses are reduced by 50%. Its impact on socio-cultural and techno-economic development of the third world nations and on their balance of payments could be more than all the development aid put together. Their GDP to the extent of 60-90% comes from agriculture and many of them are at present dependent upon import of food.

b) Based on the best possible information available, an attempt has been made in Table-17 to summarise the losses at various points in the agro-food system. This shows that the human efforts to produce 1000 kg of foodgrains ends-up only with barely 43 kgs. If the losses can be reduced even by half at each stage, the foodgrains made available for consumption would be about 210 kgs or nearly 5 times. Presuming that only half of this target can be achieved in the near future, 2-3 times more food can be made available to mankind. If this is the situation with durable foods, the losses which could be prevented in perishable foods would be greater.

c) Many questions can be raised regarding the "correctness"of the estimates (Table-17), their sources and the economic benefits that can be derived from prevention of losses at various stages. Table-18 shows the rise in the price of rice and wheat from 1975 to 1981 in India. These rises indicate that the expenditure which could have been considered uneconomical for prevention of losses ten or more ~~year~~ years ago may have become economic now and would be justified even more in the future. It is with this foresight that the subject of loss prevention should be examined and undertaken.

d) Prevention of only 25% of the losses at each stage can more than double the food supplioes and increase the income of the producers at least twice which many 5 year development plans of nations have not been able to achieve. Increase in the use of agricultural raw material to develop agro-food industries, which is not very large in developing countries at present, can raise industrial production at least 3-4 times within a period of of 4-5 years. In most of the developing countries, this will generate the largest amount of employment per unit of investment and have a multiplier effect on their social progress. Thus industrial development will be able to support agricultural development. It will even change their balance of trade. Availability of more food and creation of more employment around the agro-food sector will further reduce poverty, raise levels of nutrition and improve economic productivity per person. The agro-food system will accelerate development of several other sectors of economy whose products they will use. It will thus transform the subsistance agricultural economies of nearly a hundred nations into more balanced economies. Such development through prevention of losses would contribute to solution of other social problems such as prevention of migration to urban areas and consequent prevention of pollution, protection of environment and ecology.

e) The share of family expenditure on food will have to change in order to meet higher cost of production and protection of food if we are to feed more than 8300 million people on this earth by AD 2025 or a 1000 million people in a single country like India by AD 2000 without seriously damaging our environment and ecology, or without converting our small planet into a permanent desert by taking away more from it in the form of organic matter, subsoil water and other resources for intensive cultivation than our ability to replenish them. The impact of such policies on making food available endogenously and on sélf-reliance would be tremendous.

5. Research and development for prevention of losses in the agro-food system

Because of the limit placed on the size of the paper, it is not possible to go into details of how to create suitable structures and organisations for the development of well managed and coordinated programmes of multi-disciplinary and inter-institutional research with socio-scientific dimensions. It would suffice to state that -

a) A centre for information be created on technology, especially biotechnology of food losses, involving several institutions in agriculture, ecology, post-harvest technology and other related sciences to provide relevant inter-disciplinary knowledlge to its users for prevention of losses at each point or stage. In this effort, care must be taken to ensure that over-load of information should not result in its underuse as over 5000 words of scientific literature are being published every minute on this earth. The scientists and the users must not get drowned in it. Without sound information it is neither possible to take proper decisions nor to undertake research with clear focii and make effective use of the results obtained.

b) A programme of technology assessment for prevention of food losses should be organised. This will help to carefully select available technologies and adapt or modify them in relation to the actual identified need and ensure their purposeful transfer, absorption, and use in specific socio-cultural situations.

c) Technological research should be undetaken to develop appropriate new technologies with emphasis on improvement and development of traditional technologies which with the application of scientific knowledge can be modernised and made more viable and relevant to the situations in developing countries. Their absorption into the rural culture to make the desired impact is much easier. Most of such technologies use local materials, and can be handled by the common people with the least possible dependence on outside materials which are generally out of their reach. There are many good examples of this, such as the use of covered and paved irrigation canals of

Vijayanagar, and use of stabilised soil for canal lining which prevent water seepage loses, use of insecticidal clays containing meta-hydrogen halloysite for infestation control of seeds and stored food grains, use of tricalcium phosphate mixed with small amounts of pyridoxin and glucose to accelerate life cycle of insects for destroying them before they can do the damage and biological control of rodents by use of non-poisonous snakes and other means safe for humans. As for processing of foods, there are many traditional processed products based on grain legumes, oilseeds, and amaranth seeds provide excellent nutrition for weaned infants and others at low cost. Research and development work on improvement of technologies for making nutritive products of this nature must be intensified and given high priority rather than transplanting less relevant technoloigies from outside often based on imported materials. The new effort should concentrate on integration of traditional technologies with emerging scientific and technological knowledge to meet changing socio-cultural needs with clear development objectives.

d) Mission-oriented basic research must be undertaken with future perspectives to develop competence in building new relevant science-based technologies, especially biotechnoloiges, which would make new breakthrough in prevention of food losses as a long term measure.

e) Continuous research on (i) R&D itself, (ii) changing human resource needs (iii) policies and (iv) effective planning must be undertaken to forecast the need for timely course correction and to increase relevance to changing needs for faster progress. This will help to take advanced action to eliminate obsolescence before it can become obstruction to progress.

5.4 Human resource development

Right type of human resource capabilities are fundamental to creation of an infrastructure for research, development, technology assessment, and institutions. There is no alternative to building human resource through the right kind of training and education to fulfil these needs. Inadequacy of such training continues to be a serious obstacle to the meaningful progress of many developing countries who have largely copied indiscriminately their former colonisers and have often built foreign-oriented and less relevant system of advance training and education which does not meet their own needs. What the developing countries need first is a clear assessment of their own problems and then creation of a purposeful educational system to build human resources to deal with them, in this particular case for prevention of losses in the agro-food system through use of the best possible multi-disciplinary knowledge oriented to their needs.

b) The urgency is to build the agents of socio-scientific transformation who can accelerate the process of achieving a better quality of life and not just to train academic degree holders from abroad or from institutions built at home in the foreign image. Training is needed to create inter-disciplinary competence for dealing with problems which most often are multi-disciplinary like food

Training is needed to create inter-disciplinary competence for dealing with problems which most often are multi-disciplinary like food losses and to build well managed relevant institutions. Copying or indiscriminately adopting irrelevant curricula and teaching systems not only have held back progress but have even resulted in negative impact on training and has lead to increase in brain drain.

Summary and conclusion

- Solution of the food problem of nearly 80% of humankind requires a major socio-economic transformation that would increase and improve food supplies, generate employment and reduce poverty. Solution to the problems of food and poverty cannot be imported nor can nations survive on imported food; these solutions must be found by the countries themselves where the problems exist.

- Continuing overemphasis on agricultural production alone, especially through the increased use of high cost inputs is taking heavy toll of the earths non-renewable resources and putting mankind to great future risks. Cultivable land available on earth, fossil energy and water resources are depleting fast.

- It is high time an alternative means of improving food supplies based on self-purpetuating cycles and on reducing poverty for a better quality of life is found. An importent and promising means of this can be the total process of prevention of losses at all possible stages in an integrated manner.

- Prevention of losses, even to the extent of 25-50% can increase food supplies 3-5 times, raise farm incomes, build employment generating agro-food and related industries, and minimise poverty, especially in rural areas.

- The developing countries cannot achieve the above objectives by just copying the economic pattern of rich countries which use very large amount of fossil energy, chemical fertilisers, pesticides and costly equipment. Their development through careful adoptation and transfer of relevant technology through research rather than indiscriminate transplant can prove valuable.

- An integrated and relevant programme of collection and use of relevant scientific information, sound programmes of R&D, technology assessment and transfer, education and training are needed to build the desired capabilities for finding viable solutions to the problems of food loss. In this, the development of traditional technologies, integrarted with emerging technoloiges, must receive special attention. These technologies are more relevant, will be absorbed faster and will have the desired impact.

- What is needed most urgently in all countries is the recognition, especially at policy level, of the fact that food loss prevention is a key to self-reliant progress.

Based on this, polices, plans and programmes of action for food loss prevention, and agro-industry development must be formulated sparing no efforts on raising and mobilising adequate resources for the purpose.

- Development of agro-food industries and biotechnologies which form their vital components must receive priority attention. It is already well known that conservation and processing of agricultural produce adds 50 to 500% value to the raw materials. Development and manufacture of many more sophisticated products by these industries can lead to much greater value added. Several of these industries today use high-tech processes and can light the path for modern industrial development of the third world.

References

1. David Pimentel, Hurd, LE, Bellotti AC, Forster, MJ, Oka IN, Sholes OD, Whitman RJ. Food Production and the energy crisis, Science, Vo.182, pp.443-449, 2 Nove 1973

2. Steinhart JS, and Steinhart CE. Energy use in the US Food system. Science, vol.184, pp.307-315, 19 April 1974

3. Paul Neergaard. Seed Pathology, the MacMillan Press Ltd, 1973, pp. 20-21

4. Cramer HH. Plant protection and world crop production. Bayer Planzenschutz, Leverkusen, 1967

5. De Grazio JW et al. The J. of Willife Management, 35(3), 1971, 565-569

6 . De Grazio and Besser JF. 4th Vertebrate Pest Conference. West Sacramento, Calif, March 3-5, 1970

7. Dana RH. Vertebrate Pest Control. Divn of Plant Industry, Calif. Dept of Agric. Sep 1971, pp.15-17, 19,20

8 Deoras PJ. Studies on Bombay rats. Current Sci. 32, 1963, pp.163

9. Spillet JJ. The ecology of the lesser Bandicoot rat in Calcutta. The Bombay Natural History Society and the Johns Hopkins Univ. Centre for Medical Res and Training, Calcutta, 1968

10. Vertebrate damage control research in agriculture. Annual Report of Denver Wildlife Research Centre, US Agency for International Development, 1986

11. Nash MJ. Crop Conservation and Storage. Pergaman Press, Oxford, 1978

12. Parpia, HAB. Conservation and technological production, agricultural sciences and world food supply. Miscellaneous paper No.3, Landbounhoge School, Waganingen, The Netherlands, 1968

13. Parpia, HAB. Expectations of Asian and African Developing Countries in Food Science and Technology. Presented at the 28th Annual Conference of the Canadian Inst of Food Sci. and Tech. Toronto, Canada, 24-26 June 1985

14. Post-harvest food losses in Developing Countries. National Academy of Sciences, 1978

15. Mellor JW. Agriculture on the road to industrialisation. International Food Policy Research Institute, Washington, USA,1986

16. Parpia, HAB and Desikachar, HSR. Modern process for par-
boiling, modernisation of rice industry. Indian Inst of Management, Ahmedabad, 1969

17. Draft world-wide study on agro-industries: 1975-2000. UNIDO, Ottawa, 1977.

Table-1: Energy consumption (per capita in kg of oil equivalent) and fertiliser consumption (in hundreds of gms of plant nutrient per hectare of arable land) in some selected countries

	Energy		Fertiliser	
	1965	1984	1970	1983
Bangladesh	--	40	142	596
Brazil	286	753	169	307
China	178	485	418	1806
Columbia	413	758	310	563
Ethiopia	10	17	4	35
Germany (Fed. Rep)			4208	4211
India	100	187	114	394
Iraq	399	692	35	165
Japan	1474	3135	3849	4370
Mozombque	81	93	27	77
Nigeria	34	129	3	87
USA	6535	7302	800	1045
USSR	437	987	437	987
Zaire	67	77	8	14

Source:World Development Report,
The World Bank, 1986, pp. 190-195

Table-2: Developing countries' share of world GDP, global agricultural production and population

	1960	1970	1975	1990
Developing countries share of				
World GDP	18.0	17.4	19.5	23.2
Global agricultural production	37.2	39.3	40.8	-
Food supplies	40.7*	44.1	46.4	53.5
Population	67.7	70.3	71.7	75.9
Index number of per per capita GDP (1960=100)	100.0	128.9	156.7	277.9

Source: FAO, 1976
* Data refer to 1962

Table-3: Energy use in the United States food system
(all values are mu.tiplied by 10 Kcal)

Energy consumption by	1940	1950	1960	1970
On farm, including				
fuel, electricity, fertiliser, farm-steel, machinery and irrigation	124.5	303.4	373.9	526.1
Processing industry, including				
industry, machinery, packaging, containers (glass and metal), transport-fuel	285.8	453.5	571.5	841.9
Commercial and home including				
refrigeration and cooking, refrigeration machinery, home refrigeration and cooking	275.2	377.3	494.8	804.0
	685.5	1134.2	1440.2	2172.0

Source: John S Steinhart and Carol E Steinhart, Energy use in the U.S. Food System, Science, No.3 Special Series (Ed. Philip H Abelson), 1975, pp. 35

Table-4: Some estimates of food losses in different countries

Country	Material	Loss		
		*Per-cent	Value in millions	Reference
Nigeria	Sorghum, Cowpea	46 41		Colon.Res. Pub.(NSPRI) 1952,12,40
USA	Stored grain packed food All crops		$ 500 150 3500	Metcalf,RL., Destructive & useful insects, 1962,p.41-43
India	All grains Field Loss Storage Loss Handling and processing loss Other losses	 25 15 7 3		CFTRI, Res. & Ind.Conf. CSIR, New Delhi, 1965
Germany	Harvested grain		DM 77.4	Frey,W.F. Biol.Bundesanstalt, 1951, No.05, 8
Sierra Leone	Rice	41		Colon.Res. Stud.1959, No.28, 52
	Maize	14		Tech.Rep. W.Afr.Stores Prod.Res. Unit, 1962 No.13
Tropical Africa	All crops (Storage and handling)	30		FAO Informal work, Bull.24,1964

*These percentages refer to post-harvest losses unless otherwise stated. Although the figures refer to specific crops in most cases, they are sufficiently indicative to lay emphasis on the problem of food losses

Table-5: A conservative estimate of field losse of maize in Asia, excluding China (in 1000 tonnes)

Actual production	Potential production	Losses due to: Insect pests	Diseases	Weeds	Total
16,510	26,206	2,620 =10%	3,145 =12%	3,931 =15%	9,696 =37%

Source: HH Cramer. Plant Protection and World Crop Production. Bayer Pflanzenschutz, Leverkusen 1967

Table-6A: Summary of total annual world losses of cereal (Quantity losses in thousand tonnes)

	Actual production	Potential production	Losses due to Insect pests	Diseases	Weeds	Total
Wheat, Oats Barley, Rye	433,923	566,224	27,355	50,589	54,349	132,293
Rice, Millets and Sorghum	527,135	901,227	176,384	84,721	112,986	374,091
Maize	961,058	1467,451	203,739	135,310	167,335	506,384

Source: Cramer

Table-6B: Equivalent losses of value in million dollars

	Actual production	Potential production	Losses due to Insect pests	Diseases	Weeds	Total
Wheat, oats Barley, Rye	28,719	37,255	1,821 (4.9)	3,155 (8.5)	3,557 (9.5)	8,533 (22.9)
Rice, Millets and sorghums	35,178	60,743	12,545 (20.7)	5,600 (9.2)	7,420 (12.2)	25,565 (42.1)
Maize (14.7)	63,897 (8.9)	97,998 (11.2)	14,366 (34.8)	8,755	10,977	34,098

Figures in brackets indicate percentage
Source: Cramer

Table-7: Bushels of corn lost per acre to blackbirds in the 8-section test area during pretreatment and treatment years, Sand Lake Wildlife Refuge, Brown County, South Dakota

Year	Number of fields surveyed	Loss (Bushels acre)
1961	4	10.0
1962	9	5.4
1963	14	10.9
Average	9	8.8
1964*	27	2.7

Source: Grazio et al

Table-8: Effect of insect infestation on the yield on dehusking and splitting chickpeas

	% Kernel damaged	% dhal yield
Chickpea (uninfested)	2	82
ckpea (infested by insects)	15	65

Source: Nutritional improvement of food legumes by Breeding, PAG 1978, page 286

Table-9: Milling losses of grain legumes in India

	Yield by	
	Traditional Methods (%)	Improved* Method (%)
Chickpea (Cicer arietinum)	75	85
Pigeon pea (Cajanus cajan)	72	87
Green gram (Phaseolus radiatus)	65	85
Black gram (Phaseolus mungo)	71	85

* Bench-scale results

Source: CFTRI, Mysore, India

Table-10: Average milling yields of rice from paddy in conventional and modern mills

	Raw		Parboiled	
	Total rice %	Head rice %	Total rice %	Head rice %
Modern rubber roller mills	72.5	55	73.5	70
Conventional disc sheller type mills	71.0	50	73.0	68
Engelberg type 'Huller' mills	69.0	45	72.0	66

Source: CFTRI, Mysore, India

Table-11: Mean growth rate and protein efficiency ratio of rats fed on wheat and bengalgram dhal (dehusked split chickpea) with and without infestation

(Duration of expt: 4 weeks; 10 female rats per group; protein level: 10%)

Group	PER	PER corrected*
Wheat (uninfested)	2.09	1.86
Wheat (infested)	1.53	1.36
Bengal gram dhal (uninfested)	2.48	2.21
Bengal gram dhal (infested)	2.08	1.85

PER corrected taking the PER of SMP as 3.00

Source: Personal, with Dr M Swaminathan, CFTRI, Mysore, India

Table-12: Histological changes in the livers of rats fed on diets containing control and infested jowar (sorghum) (Duration of experiment: 6 months)

Group	Diet	Number of rats	Normal	Histological changes in livers				
				Cytoplasmic valcuolation (MILD)	Focal liver cell necrosis	Centrilobular fatty infiltration Moderate severe	Periportal fatty infiltration	Hepotic fibrosis
1	Control jowar (sorghum)	33	18	15	Nil	Nil	Nil	Nil
2	Control jowar+ Uric acid	33	13	28	Nil	Nil	Nil	Nil
3	Infested jowar	33	5	21	Nil	7	9	1

Source: Ann. Biochem. Exptl. Med., 20, 135, 1960

Table-13: Primary calories in energy balance per caput 1971-72

	Food primary calories per day (PP)	Food kg CE p.a.	Energy account kg CE p.a.	Primary food calories as energy account
India	2,634	140.6	186	75.6
Mexico	4,372	232.2	1,270	18.3
Italy	7,729	411.9	2,682	15.4
U.S.A.	11,886	623.3	11,244	5.5

Source: The Price of a tractor, George Borgstrom, page 16, Ceres, Nov-Dec. 1974

Table-14: Calories in food intake per person per day

	I Total calories (II+III)	II Plant calories	III Animal calories (fish)	IV Feed calories	V Total primary calories (II+IV)
USA	3,300	1,869	1,431	10,017	11,886
India	1,990	1,871	109	763	2,634
Difference	1,310				9,252
Mexico	2,615	2,321	293	2,051	4,372
Italy	2,995	2,206	789	5,523	7,729
Difference	381				3,357

Source: The price of a tractor, George Borgstrom, page 17, Ceres, Nov-Dec 1974

Table-15: Faecal transit times for different regions and types of diet (Mean time in hours)

Country	Race	Type of diet	Transit time
U K	White	Refined	83
India	Indian	Mixed	44
Uganda	African	Mixed	47
South Africa (Rural)	African	Unrefined	33

Table-16: Some examples of conversion factors

		MJ energy intake per MJ energy food	Protein intake per kg protein gain
Veal:	Meat animals	43	27
	Dairy herds	15	7
Beef:	Meat animals	26	22
	Dairy herds	18	13
Mutton		28	21
Pork		5	8
Poultry		17	4
Milk (per litre of milk)		5	2.5

Source: Mogens Jul. The role of milk in nutrition. Presentation at a Round Table between the Science Academies of Eastern European and the Nordic Countries, Uppasala, January 1981

Table-17: A conservative estimate of losses at various points in the agro-food system, and possible impact of their reduction by 50%

	Losses (%)	What happens to 1000kg at present (kg)	If loss reduced by 50% (kg)
Loss due to poor preparation of soil	20-40	700	850
Loss due to poor quality seed	20-50	470	570
Loss due to poor water management	20-30	340	500
Field loss due to avians	10-50	230	425
Field loss due to rodents	20-40	155	360
Loss due to microorganisms	10-20	105	315
Losses in the post-harvest handling and distribution	20-40	60	260
Loss in milling and processing	6-10	56	250
Losses in conversion of primary- to animal-foods*	30-60	50	230
By-product losses	10-20	43	210

*Not more than 20-25% of grain is converted into meat on an average

Table-18: All India index numbers of wholesale prices of food grains (1970-71 = 100)

Year	Rice	Wheat	Chickpea
1970-71	100	100	100
1976	154.9	150.6	147.1
1977	163.5	154.8	229.3
1978	175.3	158.8	227.9
1980	201.6	169.9	325.7
1981	220.2	189.9	404.4

Source: Agricultural Prices in India, 1975-82, Ministry of Agriculture, Govt. of India, 1982

SUPPLEMENTARY

Some basic facts of world cereal situation
(world stocks, export prices & ocean freight rates)

	1983-1984	1984-1985	1985-1986	1986-1987 estim.	1987-1988 forecast	Change 1987-88 over 1986-87
World stocks*	.... million tonnes...........					Percentage
Rice (milled)	49	55	55	50	32	- 36.0
Wheat	134	152	157	159	146	- 8.2
Coarse grains	98	130	204	233	218	- 6.4
All cereals	281	337	416	442	396	- 10.4
Developing countries	124	134	129	125	102	- 18.4
Developed countries	157	203	287	317	294	- 7.3
Stocks as % of world cereal consumption	.... Percentage..........					
	18	21	25	26	23	
Export prices**	.... US $/tonne					
Rice (Thai, 100%)	272	246	226	222	241#	+ 8.1@
Wheat (US No.1 Hard Winter)	153	147	128	109	108#	+ 4.8@
Maize (US No.2 2 Yellow)	146	123	105	73	74#	-@
Ocean freight rates**						
From US Gulf to Egypt	21.4	23.3	21.4	21.2	18.0#	- 13.5@

* Stock data are based on an aggregate of national carryover levels at the end of national crop years

** July/June

\# Average of quotations for July-September 1987

@ Change from corresponding period of previous year for which figures are not shown

Source: Food Outlook. FAO of the United Nations, Rome, No.6, 1987

Basic facts of the world cereal situation

Source: Food Outlook, FAO of the United Nations, Rome, No.6, 1987

	1983-1984	1984-1985	1985-1986	1986-1987 estim.	1987-1988 forecast	Change 1987-88 over 1986-87
	.... million tonnes				....	Percentage
Low income food-deficit countries*						
Roots & tubers production**	282	289	283	287	285	- 0.7
Pulses production**	25	25	24	26	27	+ 3.8
Cereal production**	665	687	677	696	672	- 3.4
Percaput production (kg)	252	256	247	249	236	- 5.2
Cereal imports***	48	46	40	45	52	+ 6.7
of which: Food aid	8.4	10.6	9.2	10.2	9.5	- 6.9
Proportion of cereal imports covered by food aid	.... percentage					
	18	23	23	23	18	
Value of commercial cereal imports****	.... US $					
	7800	6400	4900	4400		
Prices of selected major exports**	...........US $/tonne..........					
Coffee (ICO, 1979, daily price)	2822	3108	2942	3768	2359@	-41.3#
Cocoa (ICCO, daily price)	2117	2398	2241	2068	2028@	- 2.1#
Sugar (ISA, daily price)	187	115	90	133	149@	+ 4.2#
Jute (BWC, fob. C-Chaina)	340	541	613	326	367@	+ 9.6#
Tea (London, all tea)	2277	3500	2014	1930	1670@	-11.0#

* Includes all food deficit countries with per caput income below the level used by the World Bank to determine eligibility for IDA assistance (ie, US$ 790 in 1985)

** Data refer to the calender year of the first year shown

*** July/June except for rice for which the data refer to the calendar year of the second year shown

**** July/June

@ Average of quotations for Jan-July 1987

\# Change from corresponding period of previous year for which figures are not shown

Some basic facts of world cereal situation
(world production, imports & food aid)

	1983-1984	1984-1985	1985-1986	1986-1987 estim.	1987-1988 forecast	Change 1987-88 over 1986-88
World production*	......	million tonnes	....			Percentage
Rice (paddy)	452	469	472	472	456	- 3.4
Wheat	494	517	506	537	514	- 4.3
Coarse grains	496	818	865	852	812	- 4.7
All Cereals	1642	1804	1843	1861	1782	- 4.2
Developing countries	891	920	925	945	923	- 2.3
Developed countries	751	884	918	916	859	- 6.2
World Imports**						
Rice (milled)	12	11	12	11	11	-
Wheat	101	104	84	90	95	+ 5.5
Coarse grains	90	102	85	85	87	+ 2.4
All Cereals	203	217	181	186	193	+ 3.8
Developing countries	110	109	99	109	111	+ 1.8
Developed countries	93	108	82	77	82	+ 6.5
Food Aids in cereals***	9.8	12.5	10.8	11.9	11.2	- 5.9

* Data refer to the calender year of the first year shown

** July/June except for rice for which the data refer to the calendar year of the second year shown

*** July/June

Source: Food Outlook. FAO of the United Nations, Rome, No.6, 1987

Histological changes in the livers of rats fed on diets containing control and infested jowar (sorghum)
(Duration of experiment: 6 months)

Group	Diet	No.of rats	Normal	Histological changes in livers				
				Cytoplasmic valcuolation (MILD)	Focal liver cell necrosis	Centrilobular fatty infiltration Moderate severe	Periportal fatty infiltration	Hepotic fibrosis
1	Control jowar (sorghum)	33	18	15	Nil	Nil	Nil	Nil
2	Control jowar+ uric acid	33	13	28	Nil	Nil	Nil	Nil
3	Infested jowar	33	5	21	Nil	7	9	1

Source: Ann.Biochem.Exptl.Med.,28, 135, 1968

Post-harvest losses of fruits

Commodity	Production in LDC* ('000 tonnes)	Estimated loss (Percentage)	Remarks
Banana	36,898	20-80	Olorunda (1977)
Papaya	931	40-100	Olorunda (1977)
Avocado	1,020	43	Thompson, in Coursey (1971)
Peaches, apricots, nectarines	1,831	28	Steppe (1976)
Citrus	22,040	23-33 20-95	Steppe, Iran (1976) Olorunda, Nigeria (1977)
Grapes	12,720	27	Steppe (1976)
Raisins	475	20-95	Steppe (1976)
Apples	3,677	14	Steppe (1976)

*Less developed country figures taken from FAO, 1977

Source: Post-harvest losses in developing countries, National Academy of Sciences, Washington DC, 1978, pp.113

Post-harvest losses of vegetables

Commodity	Production in LDC* ('000 tonnes)	Estimated loss (Percentage)	Remarks
Onion	6,474	16-35	Thompson, in Coursey(1971); Steppe (1976)
Tomatoes	12,755	20-50 5-16	Thompson,in Coursey(1971); Steppe (1976); Olorunda (1977)
Plantain	18,301	35-100	In transport only, Rawnsley (1969)
Cabbage	3,036	37	Olorunda (1977)
Cauliflower	916	49	Thompson,in Coursey (1971)
Lettuce		62	Thompson,in Coursey (1971)

*Less DEveloped Country figures taken from FAO, 1977

Source: Post-harvest losses in developing countries, National Academy of Sciences, Washington DC, 1978, pp.113

Post-harvest losses of roots and tubers

Commodity	Production in LDC* ('000 tonnes)	Estimated loss (Percent)	Remarks
Carrot	557	44	Thompson, in Coursey (1971)
Potatoes	26,909	5-40	8% in cold store; 20-40% on farm (FAO,1977)
Sweet potatoes	17,630	35-95	Thompson, in Coursey (1971); Hall (1970)
Yams	20,000	10-60	FAO (1977); Olorunda (1977)
Cassava	103,486	10	Indonesia, Brazil, FAO (1977)

Source: Post-harvest losses in developing countries, National Academy of Sciences, Washington DC, 1978, pp.113

* Less Developed Country figures taken from FAO, 1977