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## ASPECTS OF FOOD SECURITY AND THE POST-HARVEST SUB-SECTOR IN TANZANIA

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### ABSTRACT

*This paper is all about post-harvest and food security in Tanzania, which are inter-related aspects. An overview of agricultural production, which is the major source of food, is briefly described. From the noble FAO definition of food security the issues of food supply stability, availability, accessibility, and the overall food supply chain in Tanzania are described. Also described is the way post-harvest processes mainly processing, storage, packaging and transportation influence food security directly and indirectly and recommendations for alleviating the observed problems given. Since food security is a proxy of poverty then strategies for agricultural development should also include tapping of marine and forest products and should be implemented in collaboration with other poverty reduction strategies, which are education, health, water and roads for sustainability. As such engineering interventions towards improving post-harvest and food security situations in the country should be implemented in collaboration with other stakeholders, again for sustainability.*

**KEYWORDS:** Food security, post-harvest, stability, availability, accessibility

### 1. INTRODUCTION

The population of Tanzania is estimated at 36 million people (National Sensors, 2002), with the major source of food and income being Agriculture, that also provides about 70% of the national labour force. Majority of Tanzanians (79%) live in the rural areas and are engaged in subsistence farming, with an average of 1.2 hectares per household (TARPII, 1998). The rest live in urban areas where they depend on food supplies mostly from these rural areas for their survival, although urban and peri-urban agriculture has some contribution in terms of food supply. Of the 43 million hectares of arable land available only about 7 million (16%) are cultivated (MAFS, 2001). By the year 2001, the agricultural sector contributed 50% of the GDP and more than 60% of the national foreign exchange. The crop sub-sector alone contributed 63% of the total agricultural GDP.

Due to the importance of agriculture, the government through the Ministry of Agriculture and Food Security (MAFS) has a vision that envisages “an agricultural sector that is highly competitive, diversified and sustainable that ensures food security, improved rural livelihood, strong private sector participation and economic growth to the nation by the year 2025” (MAFS, 2001). Here, the term food security refers to *physical and economic access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active healthy life* (<http://www.fao.org/spfs/>, 17/1/2005). This is a fundamental right to every human being (FAO, 1996a). Food security is dependent upon three factors: availability, stability and accessibility (FAO, 1996b; FAO, 1996c). Sustainable food security can only be achieved through facilitation of effective and efficient agricultural development in all sub-sectors in collaboration with all stakeholders. Additionally, social, political and economic environment should be good.

Food security is essentially a proxy for poverty (FAO, 1996a). Some years ago, the government priority has been to undertake policies and programmes destined to improve food security of the poor groups. This was among other things triggered by the fact that between 1996-98 more than 40% of Tanzanian’s population was undernourished (<http://www.fao.org/spfs/>, 17/1/2005). This may also imply that even those societies with reasonable wealth they might have been food insecure since they could probably not have been able to obtain the right food at the right time. In most of the previous agricultural programmes much emphasis was on the pre-harvest

phase including increased productivity and extension services. The post-harvest phase, which encompasses very important engineering activities received low priority except in a few programmes like the Carter Center's Global 2000 and the Sasakawa Africa Association project (<http://www.cartercenter.org/activities/country72.htm>, 2/1/2005) and the 1970s FAO Rural Structures project. However, the long-term sustainability of the technologies advanced by these projects and many others may still be questionable if the approach used excluded important food security facets in the initial plans.

## 2. FOOD SECURITY

### 2.1 Stability in Food Production

Although agricultural productivity does not always mean complete availability of food and accessibility to food, maintenance of stability in production or increase in production should be the first step toward sustainable food security. Shocks that can arise and cause reduced production, result in instability in both availability and accessibility. Such shocks may include drought, floods, outbreak of both field and post-harvest pests, civil strikes and political problems. In Tanzania, these problems except the last one have happened in some years and had significant contribution to food insecurity grossly and also in isolated cases.

Instability in food availability and accessibility resulting from shocks can be minimized through:

- i) Establishing more irrigation schemes from the available rivers
- ii) Establishing as many charcoal dams to attain efficient use of rainwater.
- iii) Establishing a proper mechanism for disseminating meteorological information on timing of rains and occurrence of floods so that farmers can timely plant annual crops
- iv) Establish efficient early warning systems in zones to monitor the outbreak of pests but in addition appropriate traps and baits should be designed in order to avoid use chemicals that are hazardous to the environment
- v) Harmonization of planned increase in production simultaneously with increased storage capacity that are capable of preventing attack by post-harvest pests.
- vi) Good governance at all levels to provide harmonious environment for increased agricultural production.

### 2.2 Food Productions and Availability

Tanzanian agriculture is mainly of the subsistence nature and it is to a large extent rain-fed. The government is determined to develop agriculture. This led to establishment of the Food Security Department (FSD) under MAFS, under which the 1991 Food Security Act was enacted. One of the responsibilities of FSD is to provide food production situation, and advice the government on the same. The crops used as indicators of the level of food security are mainly maize, rice, sorghum and millet, cassava, sweet potatoes, bananas, and grain legumes. These give only a gross partial indication of food availability in the country and not accessibility. The fact that fruits, vegetables, livestock and livestock products, and fish are often not considered in estimating food security level it implies that the national food security indicators are weakly correlated with food availability. Such correlations, however, may vary from one location to another since in some locations there may be plenty of livestock products or fruits and vegetables but no grains and vice versa. The lack of accurate food security indicators is further compounded by the fact that livestock products and fish, which are potential sources of food, are under the ministry of Livestock and Water and ministry of Tourism and Natural resources, respectively, which may result in weak coordination in data acquisition.

Though not sufficient, considering the crops used as food security indicators by MAFS and on the basis of the Self Sufficiency Ratio (SRR), that is percentage of food requirement that is met from domestic production, in 1996/97 for example, the national total food SSR was 88% and the cereal SSR was 72% (TARPII, 1998). Iringa, Rukwa and Ruvuma regions produced substantial surplus (SSR>100) while Mbeya and Shinyanga produced at self-sufficiency levels. The remaining regions produced less than 50% of the cereal regional requirements, which is a

great food deficit. These figures have kept on changing from time to time but the situation has not changed significantly. Food deficit calls for re-distribution of food from the surplus regions to the deficit regions in order to bridge the gap of food insecurity although this does not imply accessibility of the same by all in need of food. However, if other products specifically livestock products and fish were considered the SSR values shown above could have changed and therefore trigger different options of bridging food insecurity.

Food security indicators may reveal surplus production of cereals in the main production areas but the gross national population may still be in deficit (TARPII, 1998; MAFS, 2001). This can be more clarified when the indicators are compared with population growth (Table 1).

Table 1. Annual growth rate of production versus population growth (from 1981/82-1997/98)

Type of crop	Approximate production (Metric tones, 000)	Production growth (%)	Population growth (%)
Maize	1,400-3,000	2.95	2.8
Paddy	300-1,400	5.4	2.8
Cassava	1,400-2,000	1.8	2.8
Wheat	60-110	1.1	2.8
Sorghum and millet	1,000-1,200	5.2	2.8
Pulses/grain legumes	300-600	15.6	2.8

Source: MAFS (2001)

In the period of estimation (Table 1), production fluctuated but increased over the years. Since majority of Tanzanians feed on food derived from cereals as the main dish and perhaps pulses as relish, it suffices to say that food production growth rate was good provided that the base production level was sufficient. Whether there are enough surpluses in gross terms the main question remains to be whether the surpluses reached all the areas in need. Surplus food may fail to reach the needy due to a multitude of problems, most of which are due to the weak post-harvest sub-sector, that may include processing, storage, packaging, and transportation. For example, milk losses during the dry and wet seasons stand at 16% and 25%, respectively. These amounts to 59.5 million litres a year, which is equivalent to US\$14.3 million (<http://www.fao.org/ag/againfo/projects/en/pfl/home.html>, 2/1/2005). Another example is on fruits for which about 40-60% of the production are wasted due to lack of processing and preservation (PASS, 2002). URT and UNICEF (1990) concluded that in aggregate terms Tanzania does not suffer from food shortages; the problem is smooth transfer to deficit areas. However, in drought years availability may be very much lower than needs.

Food security is a very dynamic facet, not static (Milch, 1997). At the household level, food availability is determined by the traditional food crop production system, food storage facilities and the food marketing system (Wangara, 1988). These factors have been changing variably and therefore affect food availability differently. Perhaps what is also alarming nowadays is the high youth migration to urban areas, leaving mainly the old people to practice farming yet the production methods have not been sufficiently improved to register optimum yield per unit area. This rings an alarm for increased food insecurity.

Proposed strategies to alleviate problems of food production and availability include:

- (i) Modernizing or improving agriculture through use of appropriate production technologies (semi- or full-scale mechanization, irrigation, precision farming, etc)
- (ii) Improving extension services (government and private)
- (iii) Increasing the area under cultivation
- (iv) Improving the post-harvest sub-sector that encompasses processing, storage (including cold storage facilities), packaging and transportation, with the major aim being reduction of losses and maintenance of quality in the food supply and value adding chains.

- (v) Encouraging local production of post harvest equipment and tools through reduction or elimination of taxes on raw materials and parts
- (vi) Increasing capacity for processing locally grown food commodities into alternative shelf stable products; for example, milk into milk powder and UHT milk; cassava into dry chips or starch; fruits into juices and jams, etc..
- (vii) Establishing credit and insurance schemes for agriculture
- (viii) Improving the rural roads all over the country for smooth transportation from the food surplus areas to the food deficit areas
- (ix) Creating suitable environment for agricultural commodities merchandise, within and across borders
- (x) Establishing mechanism for improving food security indicators and food security patterns that will include all the major food groups, i.e., cereals, legumes, meat, milk, fruits and vegetables. This will assist in echoing re-direction of food surpluses or food imports. Relevant food security indicators may also provide useful information to investors in agriculture.

The above strategies have to be applied by all stakeholders in the government and the private sector. In particular the government is required to provide suitable environment for smooth and fair operation by the other stakeholders. However, where the government can have direct interception, e.g., opening up of more roads, mechanisms for sustaining such services should be established.

### 2.3 Food Accessibility

Food accessibility can be looked at in two levels: the national level and the household or individual level. At the national level, the key issue is whether every household can access the available food and whether it is enough and have the acceptable quality. When there is gross national shortage, food can be imported to offset the deficit but there is no mechanism in place to ensure equitable accessibility by all households. The situation is generally caused by the poor transportation infrastructure, untimely release of food stocks by middlemen traders and agents, and poverty as a whole. At the household level, the key issue is whether the food that has been accessed by a particular household and therefore become available is accessible to every household member in sufficient quantities and quality (FAO/WHO, 1992). Accessibility to food has a number of dimensions, as summarized below:

- (i) If food is available nearby, is the household liquid enough to purchase enough food from this source? Liquidity here implies possession of physical cash or items that can be disposed to obtain money to buy food. In most rural families liquidity is far below adequacy to access enough and quality food.
- (ii) If a household has enough income to buy food, do all family members share the food equally or proportionately depending on requirements? Do all the gender groups get the right share? In our society it is common for the household heads to spend a big chunk of family income to drink alcohol and eating out unnecessarily leaving very little for the rest of the family members.
- (iii) What may be used for food is mainly the starchy cereals and relish made from meat, beans or green vegetables. The importance of fruits and vegetables as part of every meal is mostly disregarded either deliberately or ignorantly. This may lead to food insecurity in terms of nutrition even in families with modest to high incomes due to bad eating behaviour.
- (iv) In some households, either due to social or economic circumstances the frequency of eating is below normal, i.e., less than three meals a day. In some areas this is often considered as a coping strategy to reduced food availability or accessibility. Such food insecurity situation may lead to energy and health retardation, which hamper both productive and reproductive activities.

The underlying reason for food insecurity at the household level is mainly poverty. This is caused by low agricultural productivity, which in turn cannot be improved if people entangled in it are poor. This is worse in a market-controlled economy where the government does not supply food unless there is serious famine crisis but rather sets conducive environment for

stakeholders to operate. Such disadvantaged households will remain in a vicious cycle of poverty and perpetually food insecure.

Strategies to improve food accessibility situation must include:

- (i) Implementing all the above proposed strategies for improving food availability
- (ii) Reducing poverty. As majority of Tanzanians are entangled in poverty cycle the strategies for individual and gross poverty reduction should be applied.
- (iii) Proper education on food security requirements and prioritisation at the household level

## **2.4 The Food Supply chain**

Several food supply systems exist in Tanzania but their modes of operation are very dynamic. During the state controlled economy, the government operated the so-called "Strategic Grain Reserves" (SGR) in major producing zones, from which during food deficit period the government released the stocks to food traders and sometimes free for making it available to the needy. Nowadays, free distribution of food is almost non-existent. The common food supply chain is the farmer-middlemen trader-retailers-consumers system. The characteristics of each system component are briefly discussed by considering cereal grains as an example.

### **The farmer level**

After harvesting the farmer can store the unprocessed crop to attain storage and in-storage drying and afterwards process the crop and either store the crop for own use or sell. It is apparent that farmers sell their crop when they are badly in need of cash and may release the crop in several lots with time as needs arise or at once leaving a small amount for the family, which sometimes may not last until the next harvest is due, thus rendering them food insecure. Since the schedule at which they release their crop is uncontrolled, supply to other areas is inconsistent, and in most cases controlled by market forces. However, farmers would wish to sell all their crop when the price is very high but due to the subsistent nature of their agriculture only a few can manage it. This is caused by a number of reasons, notably lack of alternative commercial crop, poor household planning, and problems associated with storage pests. All these situations lead to food insecurity on the part of the farmers.

### **The middle traders/crop-buying agents**

These are businessmen whose major aim is to make profit and not to alleviate food insecurity as such. They move searching for the commodity and the price they pay depends on the severity of the deficit in the deficit areas, cost of transport to the deficit areas, and overhead costs such as labour and temporary storage. Sometimes they may also hold the commodity for some time while waiting for the deficit to grow even bigger so that they can earn more money when they release their stocks. However, at this stage losses may be encountered, magnifying food insecurity even further if the food/crop is not kept well. Together with the importance of this group in linking producers/farmers with retailers/consumers, the environment in which the group operates is sometimes harsh, often leading to high commodity prices paid by the consumers. The current environment is characterized by insufficient permanent and improved selling centres in the major producing areas where farmers could store and auction their commodities, lack of paved roads including permanent bridges to some producing areas, low prices paid to farmers due to possible curtailing by these businessmen since the environment is also not suitable to farmers to look for alternative markets.

### **Retailers' level**

After buying a commodity from the middlemen retailers pass it to consumers at a profit. This is where all the costs right from production to this level are lumped. For poor societies the price of such food will normally be very high and they may not be able to acquire enough. Retailers are

usually many and each take only what he/she can sell at a particular time and the price may vary without notice to the consumer for maximization of profit so long as there is willingness to buy. At the retail stock, a commodity can be distributed to consumers or the consumers can follow it. It is also possible for sub-retailers to emerge, for example for maize and paddy where the grain is bought, processed into flour or rice and re-sold to consumers.

An exception to the above system is where buying agents and large-scale stockists or processors are involved. In this case the supply chain is that of the farmer-commodity buying agents-large-scale processors-processed food supply agents-retailers-consumers. The buying agents work as middlemen that link large stockists or processors with farmers. In this system processors/stockists may enter into an agreement with the buying agents, a scenario that denies the agents chances of withholding a commodity while waiting for price increase. There can also be an arrangement for contractual farming between the processor and farmers and therefore avoid using agents. With this system long series of value adding makes a U-turn of the same commodity in a processed form to the same farmers, but at a very high cost.

Although value adding through processing and preservation have good food security dimensions most of the poor consumers will feel insecure because they will not be able to have access to such foods. Considering the fact these farmers were the source of raw materials at a low price then a vicious cycle of poverty is further magnified.

An improved and sustainable food supply chain is required for enhanced food security. However, both the producers and consumers need to be treated fairly by establishing an enabling environment for all the stakeholders to operate. In such a case the following should be done:

- i) Introduction of alternative commercial crops to minimize quick selling of food crops by farmers immediately after harvesting
- ii) Improvement of both traditional and conventional storage methods and structures
- iii) Establishment of official crop auctioning centres
- iv) Continuous improvement of transport infrastructure
- v) Establishment of farmers associations or cooperatives where farmers have common interest
- vi) Establishment of village-level processing shops. This will minimize transport cost but will require good utility set-up and human capital
- vii) Eliminate taxes or impose very low taxes at various stages of the food supply chain for products whose commodities are grown in Tanzania.

### **3. POST-HARVEST OPERATIONS IN TANZANIA AND THEIR INFLUENCE ON FOOD SECURITY**

#### **3.1 General Overview**

The post-harvest phase is the period between harvesting and consumption, in which the benefits of agricultural production are realized. Such benefits include availability of food and feeds, availability of industrial raw materials, availability of seeds for the next season, and income generation. These benefits can be realized if produce is harvested at the right time and carefully to minimize losses at harvesting or due to untimely harvesting and if throughout the post-harvest operations losses are minimized. This requires adoption and implementation of Total Quality Management (TQM) procedures, which in the whole chain vary from one commodity to another, otherwise costs and efforts incurred in the pre-harvest and harvest phases will be wasted.

The important post-harvest activities include processing, storage, packaging and transportation. The sequence of operation of these activities may differ between commodities, and for a single commodity they may vary depending on the ultimate consumption point or form. Losses in these activities are very apparent but there is scarcity of data to indicate losses for all the important crops at each post-harvest stage. Almost all the data available refer to cereal grains and grain legumes, where overall losses are estimated at 30-35% (SACCAR/GTZ, 1994). It has been argued that losses in stored maize are the highest and for

paddy losses are due to processing (Schulten, 2005). For fruits, losses occur throughout the post-harvest phase with an overall estimate of 40-60% (PASS, 2000; SACCAR/GTZ, 1994). Data on losses of roots and tubers in Tanzania is scarce, but elsewhere Coursey (1984) gives a figure of about 30%. Apart from the lack of sufficient loss data the overall indication is that post-harvest losses are very high and are therefore the main contributors of food insecurity in Tanzania in addition to the vagaries of weather and poor farming practices.

### 3.2 Processing

Processing of agricultural crops can be categorized into primary and secondary processing. The first one is subjected to almost all the commodities and forms the beginning of the post-harvest food supply chain while the later may be just for specific requirements.

Primary processing is usually done on-farm where the methods and technologies used are very rudimentary. This includes such activities as shelling/threshing, cleaning, sorting, grading and surface treatment. These are done for good presentation or storage, preparation for further processes, preservation, value addition or direct consumption. Value addition at this stage is still low; hence direct selling of primarily processed products does not give good returns to the farmer. For example, shelling of maize is done using one of the following methods: use of bare hands, beating in bags, or beating on a rack. Use of mechanical shelling devices is expensive for peasant farmers and therefore rare. While use of bare hands produces clean and undamaged grains but at a very low output which cannot be relied on for big harvests the rest of the methods may result in shatter losses and/or grain damage although throughput is a little bit higher. The highest throughput can be achieved by using mechanical shelling devices, depending on designed throughput capacity. Grain damage is particularly high during beating or use of mechanical shelling machines when moisture content is high. In this context, increased agricultural productivity will need innovations to increase primary processing capacity necessary to minimize delays and eventual physical (e.g., shatter losses, spillage, etc) and/or qualitative (e.g., loss of viability, damage, blemishes, discolouration, etc) losses. However, data on processing losses for the major crops of Tanzania is scarce.

Processing after primary processing is referred to as "secondary processing", which is principally aimed at increasing the commodity value even further, imparting long shelf life, obtaining different forms of utilization and reducing bulkiness. Such products give good economic returns to the processor and the entire nation, which can trickle back to the growers directly or indirectly. However, the food processing industry in Tanzania is very weak, processing only about 1% of the available food raw materials. This compares very poorly with 40-50% in Thailand, 78% in the Philippines and 83% in Malaysia, which all fall under the category of developing countries (REDI, 2004). During secondary processing losses may occur due to commodity mishandling, personnel errors and equipment malfunction. Quantitative losses may be insignificant but significant losses due to quality degradation may occur in the subsequent stages, notably storage, transportation and on-shelf product display, hence a great care should be exercised to minimize such losses. Secondary processors usually obtain primarily processed or raw commodities from farmers. Experience shows that the price offered is often low and does not give enough empowerment to these farmers to have full access to other important food items for enhancing household food security.

Level of processing determines the commodity price and its ultimate accessibility. At the lower level, such as processing of cereals into flour and hulling of paddy into rice, it can be done on-farm by the farmers at an affordable cost. The processed commodities can also be traded with other families not in possession of the same commodity. If the same is done by businessmen/entrepreneurs who then sell back the processed commodities to the same farmers during the time of scarcity, then accessibility costs become high and some farmers may not afford. Further processing of a secondarily processed product often results in a very high value products such as cookies, confectionery products, and snacks, which are convenient foods and very easy to prepare. In some secondarily processed products, however, some important nutrients may be lost. Therefore, accessibility to such products may not suffice the nutrition and health requirements unless supplemented with other products or measures are taken to minimize such losses.

Table 2. Examples of secondary processed products

Commodity after primary processing	Secondary processed products
Maize	Flour, corn oil, glucose, gluten, starch, bran, corn flakes
Paddy	Brown rice, polished rice, rice beer
Cassava	Flour, starch
Soybean	Soy oil, soy sauce, soy milk, soy drink, infants food
Fruits	Juices, jams, marmalade, nectars
Vegetables	Diced vegetables, vegetable powders
Oils seeds	Oil, cake
Meat	Cut meat, minced meat, sausages
Milk	Pasteurised/sterilized milk, milk powder, yoghurt, sour milk, cheese, butter

On overall basis, processing offers a lot of social and economic advantages to the society. The issue of value adding gives better economic returns in terms of goods sold and in wages paid to people employed in the industry. For example, it has been argued that in a new venture in milk processing, transportation and processing of every 100 litres of milk will create up to five jobs (<http://www.fao.org/againfo/projects/en/pfl/home.html>, 1/2/2005). Similar scenarios may apply to other commodities, where the extra-generated income will increase capacity to access food.

The following should be done in order to improve commodity processing in Tanzania:

- (i) Promote local innovations and transfer of technology in order to manufacture suitable and appropriate primary and secondary processing machines and tools. One of the good examples is that of "Intermech Engineering Ltd" of Morogoro, which manufactures cassava processing machines ranging from manual chippers to engine driven machines that can be used in the rural areas in various set-ups (household, SMEs, and associations/cooperatives)
- (ii) Promote establishment of Small and Micro Enterprises (SMEs) for secondary processing in line with the governments SMEs Policy.
- (iii) Reduction or elimination of taxes for small engines destined for production of small and medium scale food processing equipment for establishing SMEs
- (iv) Improvement of the transport infrastructure to facilitate procurement of raw materials and other commodities for processing
- (v) Make available important utilities required for processing
- (vi) Improved social and human capital to encourage investment in processing of foods in the rural areas
- (vii) Ensure quality assurance of processed food products by observing the requirements of food regulatory bodies (e.g., Tanzania Food and Drug Authority).
- (viii) Training of post-harvest technologists at all levels (craftsmen, technicians, engineers)

### 3.3 Storage

Storage is practiced in all stages of the food supply chain as a means of holding a commodity or to avoid losses. Between harvesting and primary processing, storage is on-farm, and often for a short while. On-farm storage can be in the open field or in-house. Where it is done in the open the probability of deterioration is very high, and in some cases losses of up to 100% quality wise can be reached. Another form of storage is done in a manner that processing is only done when in need but often such commodities may succumb to pest attack and moreover large space will be required. The quality of on-farm storage depends on the conditions of the commodity itself and the prevailing ambient conditions.

After primary processing, the processed commodity can be stored in traditional storage structures and containers. Almost all the ethnic groupings in Tanzania are associated with certain traditional storage structures, for example *Kihenge* in the Southern Highlands and



*Ngoko* in Mahenge (ASPS, 2000) and *Ibelele* in Sukumaland (Silayo *et al.*, 1999). Some of the many traditional storage structures may be very appropriate but some have certain limitations, including inadequacy to protect the stored commodity against bad weather, theft and pest and inability to store big amounts of the commodity, hence the entire nation cannot rely solely on them. Where large conventional storage structures are used, for example the Strategic Grain Reserves (SGRs) in Iringa and Arusha such problems are minimum. However, with the growing population the SGRs capacity will need to be expanded and mode of operation changed because they were established before trade liberalization during which the population of Tanzania was small. The biggest storage problem encountered countrywide is attack by insect pests, particularly for cereal grains. Specifically, the attack by the Larger Grain Borer (*Prostephanus Truncatus*) can result in up to 100% losses while in the store unless effective pesticides were used. However, the efficacy of some of the popular pesticides is questionable as a lot of contraband pesticides are available in the market. This has forced farmers to use local herbs in uncontrolled concentrations with only slight successes but in other areas use of chemicals that are harmful to human beings have been reported (ASPS, 2000). Inability to control pests and use of contraband drugs reduce food security.

After secondary processing a product acquires a different form and has a relatively higher value. This necessitates good storage facilities either in bulk or packaged in suitable containers. Suitable storage conditions are those that provide adequate protection against harsh ambient weather, are properly ventilated, and the environment is clean. It is also important to set storage premises where there is enough security against theft and pests invasion to avoid reduced food security.

Processed commodities can succumb to qualitative and quantitative losses when they are moved and stored in other premises in the process of distribution and selling. In retail shops, for example, damage and eventual losses may arise due to storage or display in improper conditions, storage beyond the recommended shelf life caused by absence of buyers or overstocking, and unexpected calamities, e.g., fire, rain storms, etc. At home these losses are also possible.

Solutions to storage problems in Tanzania should involve:

- (i) Advocacy to improve the traditional storage structures and methods to accommodate more materials and for a longer time while keeping the quality at acceptable levels.
- (ii) Sensitisation of entrepreneurs to invest in suitable food storage buildings, including cold storage facilities for perishables
- (iii) Training of extension personnel to involve aspects of storing various food commodities
- (iv) Collaboration with other stakeholders to employ Integrated Pests Management (IPM) skills in order to minimize usage of chemicals, which may be a health hazard.

### **3.4 Packaging**

Packaging is the integral part of the whole post-harvest phase. It involves packing of food items in suitable packs for protection against environmental hazards. Such a package must be convenient for storage and movement, with provision for identification. However, packaged foodstuffs are still subjected to attack by insects with exception of canned foods (Mullen and Highland, 1984). Therefore, the type of packaging material to use depends on among other things nature and type of food material, type of environmental hazard to be expected, the expected shelf life, type of information to be embedded, and cost of the packaging material itself. Packaging is applied in all stages, and for a particular commodity the type of package may vary from stage to stage depending on the extent the food raw material has been transformed. For example, maize grain can be packaged in sisal/jute bags while maize flour will last longer when packaged in polypropylene bags or polythene laminated paper bags.

Whilst conserving and presenting the food, packaging adds on cost of accessing the food, but to a great extent benefits outweigh disadvantages if optimal packaging conditions are applied.

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With the increasing need for food, the scope and quality of packaging materials produced industrially have increased. Unfortunately some of these materials are not biodegradable and are disposed rather haphazardly. This is an environmental hazard, which may also have negative effects on food production and on health of human beings and grazing animals. A good example of this is the nuisance created by disposed polythene or nylon bags, popularly known as *Rambo* bags.

Use of packaging materials in Tanzania can be looked at as undeveloped for several reasons. They include use of inappropriate containers for transportation which cause significant damage and eventual losses of perishable commodities, lack of standard size containers for various products, bulk display and sale of unprotected food commodities, and lack of regulatory standards for packaging fresh and processed food products. This is also evident from the presence of very few package manufacturers available. However, underdevelopment of the packaging industry has been caused by the life of most Tanzanians. With the anticipated urbanization that might trigger use of fast foods, need for appropriate packages by food manufactures will increase.

Problems associated with packaging can be eliminated or minimized through:

- (i) Promotion of research on suitability of locally available materials for both short and long-term packaging
- (ii) Establishing and enforcing regulations for packaging of various foodstuffs for long distance transportation and on-shelf display
- (iii) Advocating establishment of small and medium scale packages manufacturing enterprises
- (iv) Establishing regulations and mechanisms for safe disposal of used packages or recycling

### 3.5 Transportation

In this context, transportation can be regarded as movement of materials from one area to another. This is encountered throughout the post-harvest phase, and the mode of operation may differ from one stage to another. For example, on-farm transportation will need different transport compared with transport from a farm to consumption points in urban areas, e.g., use of ox-carts instead of pick-up trucks. Whichever the case, appropriate and efficient transport system is required for reliability of supply from one point to another. In particular the carriageways should always be passable with minimum congestion and the carriages must be efficient and suitable for the type and nature of food to be transported otherwise food insecurity problems will occur. For example, unsuitable roads will cause delay due to slow moving of the vehicles and frequent breakdown of the vehicles. This will cause high operation costs, which are always compensated for by high pricing at the last destinations and affect its accessibility. Inefficient transport system reduces the number of vehicles plying to certain destinations to the extent that collection of goods from these destinations is slow, ultimately resulting in stockpiling. This is particularly worse for fruits and vegetables, which deteriorate within few days after harvesting. Unsuitability of transport vehicles is another problem. For example, there are no refrigerated trucks for transporting fruits and vegetables, fish, and meat. The few ones available for milk transportation are not enough either, considering the increasing population in need of milk and other perishable food commodities. These situations results into gross deterioration of these goods and therefore affect both their availability and accessibility, which are important components of food security.

In order to avert transport problems the following can be done:

- (i) Carrying regular maintenance of roads plying between food deficit areas and food surplus areas or inter-market movement.
- (ii) Opening up of more rural roads
- (iii) Establish and enforce transport regulations for specific commodities, particularly perishables such as meat, fish, milk, fruits and vegetables.

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#### 4. WAY FORWARD

Since food security is a proxy of poverty then sustainable food security can be attained if poverty will be eliminated as per the government vision that envisages eradicating poverty by the year 2025. This will require rigorous implementation of the strategies set to eradicate poverty that fall under the main sectors of education, health, water, roads, and agriculture though not exhaustive. These sectors are inter-related; therefore none of which can be isolated in the successful development of sustainable agriculture. However, food is the source of livelihood of mankind, thus it should be given the first priority otherwise the human capital that is responsible for operating in the other sectors will not function. This underscores need for developed agriculture including fishing and harvesting of forest products. Artificial fishponds and forests can also be established for the same.

Engineering led interventions are required to boost agricultural production including harvesting of marine and forest products. Much as their efforts are required to improve the pre-harvest phase including land preparation and agronomic practices and the harvesting stage, interventions in the post-harvest phase are equally important. With the fast change of post-harvest technologies and the increase in population, investment in this phase should be increased in order to sustain supply and accessibility under the auspice of the liberalized trade. The post-harvest phase requires engineering inputs at all stages mentioned and on the recommendations proposed although they may not be exhaustive. However, successful implementation can only be obtained if the necessary interventions are carried out in full collaboration with other stakeholders, both under the private sector and the government. This will certainly require stakeholders' analysis and participation before implementation of any strategy or recommendation. Adhering to these propositions will certainly lead to sustainable food security, which in turn will contribute to a robust engineering sector in Tanzania.

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