Food Reserve Stocks and Critical Food Shortages - a Proposal Based on the Needs of Sub-Saharan Africa

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Abstract

This working paper examines the food security policy, where food security means ensuring an adequate supply of food for hungry people. In particular, the recommendations of FAO are being used as a measuring rod against which food security policies are assessed. By means of FAO's database a statistical analysis of all Sub-Saharan Africa countries with respect to measuring the incidence and severity of critical food shortages are carried out. Stock policies seem to have been the answer when issues of ensuring adequate supplies have surfaced.

In the paper, an estimate of the costs of keeping stocks is provided, and the costs are quite staggering. Based on the statistical analysis an estimate of the number and volume of acute food shortages per year in Sub-Saharan Africa is achieved. Upon this number a much cheaper alternative to keeping stocks for security purposes is proposed.

It is proposed that a financial fund is set up with the sole purpose of purchasing grains on the open market when acute food shortages occur. In order for the fund to achieve its goals it must be completely independent of politics, and the financing and replenishing of the fund must be automatic. The advantages are that a lot of costs are saved which could be used to improve food security policies in developing countries. Furthermore, the supply of food aid is done via a global fund, and is not the result of political considerations in donor (big exporting) countries. The reservations voiced by some developing countries that further liberalisations in agricultural policies in the WTO round of negotiations could jeopardise food security is answered by this fund. Liberalisations of agricultural policies may lead to lower food stocks in the big exporting countries, but the proposed financial fund does not rely on such stocks. It is found that the purchases the fund would have to conduct only comprise a small fraction of the world trade in cereals.

Keywords: Food, stocks, shortages, uncertainty, Sub-Saharan Africa.

1. Introduction

This paper considers food stocks for security reasons as an insurance against shortages due to bad harvest, wars, etc. The ultimate purpose of the paper is to derive an "optimal" level of food stocks based on the uncertainty of food supply and demand, and the objective of keeping stocks. More specifically, the paper aims at deriving distributions describing the probability of critical food shortages and the scale of the shortage. Although the focus of stocks for food security purposes is of global relevance, the focus of the paper is on Sub-Saharan Africa. The developed countries are food secure, so they do not need to keep stocks for security purposes. The least developed countries, on the other hand, are food insecure and Sub-Saharan Africa constitutes a sizeable part of the latter group.

In this paper, instead of using the observed levels of stocks, which ever since WWII has been greatly affected by the prevailing protectionist agricultural policies, and instead of indirect measures of nutritional status, the basis for the analysis are the observed levels of calorie intake. In contrast to the level of stocks that may go up or down for a variety of reasons, calorie intake gives a more direct measure of food shortage, and, consequently, the potential need for reserve stocks. In relation to food intake other measures could be relevant such as the amount of protein, various nutrients, etc. However, these other measures are more related to the longer-term well being of the individual. Thus, these measures have to do with ensuring access to a steady, sufficient flow of proper diets, and have not so much to do with unexpected emergency situations. In the latter case, the important short-term (and long-term for that matter) objective is to ensure an adequate supply of calories.

2. Background

Storage of food for use in times of need has taken a more prominent position in the international food policy debate. The impetus for this debate is the ever-increasing liberalisation of the world economy and, in particular, liberalisation of agricultural policies. It is argued that with already implemented agricultural liberalisations and expected future liberalisations to follow, in particular due to the agreements from the last negotiation round as well as the ongoing WTO negotiations, use of food storage is declining thereby jeopardising food security. Previously, due to agricultural policies vast amounts of food were stored as a result of political wishes to keep farmers income at a desired level. Consequently, after the abandoning of some of these policies the use of stocks of various agricultural products generated by public interventions in times of low prices has decreased. In turn, therefore, FAO has raised some concern about the level of food stocks. In particular, the concern is that the levels of food stock under a regime of liberal agricultural policies may not be sufficient to cover the needs in case a major disaster erupts, FAO (1995).

Storage of food against hunger is an age-old policy. The first instance recorded in history is that of Josef's recommendation to the Egyptian pharaoh based on the pharaoh's dream around 2000 BC (Genesis 41). According to the story, cereals were stored during seven years with good harvests to be drawn upon during the following seven years with bad harvests. In principle this was not an insurance scheme, but a case of consumption smoothing over time. To be an insurance scheme, some degree of uncertainty has to play a role, but in this case the outcomes (bad harvests, good harvests) were known in advance though revelation. Storage of food as consumption smoothing must have been even older as people need to store food for consumption between harvests or hunting/fishing seasons.

Since the time of Josef ensuring an adequate supply of food has been a prime concern of political leaders. As the sentence *panem et circenses* (bread and circuses) by the roman poet Juvenal around 100 AD shows, the leaders of Rome were perfectly aware of the correlation between ensuring an

adequate supply of food and political power. Now, again skipping something like two thousand years, the common agricultural policy of the European Union is, among other concerns, founded on the objective to pursue an adequate supply of food within the union. At the time of the making of the common agricultural policy the degree of self-sufficiency of food products were at 85%, which was considered too low. Thus, the common agricultural policy was constructed with a primary aim of increasing the EU's supply of food, which has subsequently led to big surpluses.

Around 1970, the hitherto prevailing optimism about the state of the world was being questioned. The old hypothesis of Malthus (1798) that the growth of population will outstrip the growth of food production was being given new life, in particular, by the so-called Club of Rome (1972). This led to the world food conference in 1974. During this time unprecedented increases in world food prices were being observed as a result of large and unexpected purchases of grain from the Soviet Union. Simultaneously, the el nino effects made the fish off Chiles coast disappear whereby a substantial portion of the worlds protein supply failed. Added to that, bad harvests plagued the soybean producers in USA. From July 1972 to February 1974 the price in real terms displayed an alarming increase of 270%. The price remained at a high level the following years but eventually returned to its previous low levels towards the end of 1977.

One of the major results of the world food conference was to put the issue of food security on the international agenda. Thus, the UN organisation IFAD (International Fund for Agricultural Development) was established as a result of the conference. A more specific result was that the Committee on World Food Security was established in 1975. This committee has the "function of evaluating the adequacy of food stocks, especially cereals", FAO (1983), see also Sarris (1985).

To achieve the objectives of the committee an estimate of a minimum safe level of world cereal stocks were carried out by the FAO secretariat in 1974. Three methods were employed.

- The longer-term trends in area, yields and domestic production and consumption of cereals in exporting countries and trends in net imports during 1955/56 to 1972/73 were analysed to measure deviations from the trends in these variables; this analysis provided the range of deviations observed in the past to serve as a possible indication of reserves needed to maintain the long-term trend in consumption in a year of crop failure.

- The maximum single year shortfall in actual production below trends during the period 1955/56 to 1972/73 for each grain at the world level was measured as an indicator of the maximum level of stock that would have been required in the past to maintain consumption levels.

- An historical analysis of past ratios of actual carry-over[2] stocks to total disappearance (domestic consumption plus exports) in exporting countries, and to total domestic consumption in importing countries, was carried out for all countries for which stock data were available. The aim was to identify those ratios that in the past (1961-1974) were related to "normal" or "abnormal" situations in the grain economy. This analysis provided a measure of the level of working and reserve stocks.

All three of the methods used by FAO are based on maximum previously observed discrepancies between a supply and a demand measure. In the third method the level of working[3] stock is estimated. It is assumed simply to be the lowest level of stocks relative to demand. Thus, at this point

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[2] Carry-over stocks are stocks held from the end of one crop year to the beginning of the next. It is the same as ending stocks for a particular crop year.

[3] Working stocks are stocks required to assure the smooth and uninterrupted flow of supplies through the production and distribution lines.

(1973/74) all reserve[4] stocks and only reserve stocks are used up, it is assumed. The two first methods are used to estimate the combined level of stocks, which is working stocks plus reserve stock.

According to FAO (1983) the three methods yielded similar results. A minimum safe level of world carry-over stocks for all cereals should be within a range of 17-18% of world cereals consumption. The major part of this level consists of working stocks, whereas the reserve element amounts to 5-6% of world consumption.

The figure of 17-18% has FAO since maintained as a target level to assess the state of food security. Thus, after the trade liberalisations resulting from the Uruguay round some concern have been raised by FAO that the world food stocks may fall below the minimum safe level as so defined. Up until the Uruguay round agricultural policy often dictated intervention in the market through public purchases in order to diminish supply whereby agricultural prices could be maintained at a politically satisfactory level. Consequently, stocks of agricultural products increased and as a side effect FAO's safe level of stocks were more likely to be attained. In the post Uruguay round, however, because of the liberalisation of the agricultural markets, this mechanism is expected to decline implying lower levels of stocks overall.

The methods employed by the committee have a very ad hoc nature. For instance, why is it reserve stocks and only reserve stocks that have been used at the low point? No compelling argument can be found. It could very well be that some of the working stock had been used as well. Furthermore, the historical period under consideration 1955/56 to 1972/73 was at a time where widespread agricultural protectionist measures were being used. Thus, the actual stock levels may have had very little to do with the levels needed for keeping the production line running smoothly. Another point is that the level of working stocks needed may not necessarily be stationary over time. Stocks have in general quite a high upkeep providing incentive for reducing them. Indeed, terms such as "Just in Time", which has been popular for some time, gives some anecdotal evidence that working stocks may be reduced. The proliferation of new effective means of communication including internet, cellular phones and road – and railway building provide means by which reduction of working stocks may be made possible. Furthermore, the market situation could influence the level of stocks. Thus, in times of high prices working stocks may be substituted for income thereby decreasing the stock levels, and vice versa in times of low prices. Overall, the rule of thumb that 17-18% of the world s food consumption provide a minimum safe level of food stocks are not achieved via compelling irrefutable arguments. Moreover, working processes, organisational advances and technological improvements may have changed the need for keeping food stocks.

2.1 Regional considerations

The FAO requirement for a minimum safe level of food stocks applies to the entire world. In practice, however, some countries are immune, from a disaster point of view, to fluctuations in food supply, while others are highly vulnerable. As shown by Diaz-Bonilla, Thomas, Robinson and Cattaneo (2000) all developed countries in the world are food secure. That is, they have enough production capacity and/or sufficient resources to sustain periods of food shortages. On the other hand, all of the least developed countries are food insecure and, therefore, exposed to the fluctuations of food supply and world food prices. Other developing countries show much more heterogeneity and may or may not be food insecure.

This paper narrows the area of interest to Sub-Sahara Africa. African countries south of Sahara are of particular interest in the development literature. Other developing country areas such as South America and Asia have experienced important improvements in their standard of living and

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[4] Reserve stocks are stocks which can be drawn on to meet unexpected deficits and other emergency needs.

income in recent decades. Thus, in the 1950'ies several African countries had income and growth exceeding that of Asian countries. This has been reversed since then, and the Sub-Saharan countries in particular seem halted at a low income level, which is reflected in the average food consumption per capita. Many Sub-Saharan countries have a low level of calorie consumption per capita, and are thus exposed to risks of under nourishment and hunger. This exposure is exacerbated by the fact that many of these countries are net food importers. Domestic production is not sufficient to satisfy domestic demand and in order to import food the country is, therefore, dependent upon its foreign exchange resources, which are not in abundant supply. In fact, in case of disasters and emergencies Sub-Saharan countries are often not in a position to supply enough resources in a timely manner.

Therefore, the international system of disaster and emergency relief is required, which is operated through various organisations. The food aid needed in such circumstances is supplied by the major food exporting countries of the world where the European Union is an important contributor. Actually, one of the reasons stated for the Common Agricultural Policy is to provide a safe level of food supply although this presumably is directed towards the EU member countries. However, the EU has for a long period been a net food exporter and even though yields fluctuate according to the specific conditions within the harvest year this has not changed the net exporting position at any time during the last couple of decades. In fact, the EU has build up large stocks of food that in turn are drawn upon in times of need of the food deficit countries, primarily located in Sub-Saharan Africa.

Most studies of food security rely on indirect measures of nutritional status such as income per capita. However, such measures can be very misleading with respect to the nutritional status of the inhabitants.

4. Statistical analysis of critical food deficits

According to SOFI (1999) approximately 800 million people suffer from under nourishment. This is a consequence not so much from unexpected events in the form of disasters, conflicts and bad harvests around the globe, although such events occur on a regular basis, but a consequence of lack of access to stable food sources. In this study, chronical under nourishment is separated from disastrous events because stocks are modelled as an insurance policy. Providing adequate food supplies for 800 million people is not a "stock" issue. It would require a totally different policy comprising production, transportation, distribution, etc., which is beyond the scope of this study. Thus, only the temporary negative shocks to food supply are considered.

Certainly not all temporary negative shocks to food production pose a problem. On the contrary, such events are an integral part of food production that is exposed to several uncertain external factors. Thus, the amount and timing of rainfall varies from year to year, pests and diseases may attack the crops, and other detrimental events may occur, so any farmer experiences variation in production.

Thus, production uncertainty is inherent in food production. In affluent societies this uncertainty does not pose any difficulty in maintaining overall food supplies at an adequate level. Exports and/or imports function as buffers for overall food supply for the domestic population. Likewise in poor countries, however, large negative shocks may render the policy of adjusting exports and/or imports unfeasible.

Data

Data for consumption of food are obtained from FAO's database (http://apps.fao.org/). The database contains among other statistics, food balance sheets for practically every country in the world with annual data in the period 1961-1996. A food balance sheet is equivalent to an input-output ta-

ble in that it shows supply and demand of food in metric tons in a particular year for a particular country/region. Food is divided into a large number of food items (around 100). Supply is comprised of domestic production, imports, stock changes and exports. In FAO's terminology positive stock changes are positive supply and positive exports are negative supply. Thus total supply equals production + imports + stock changes – exports. Demand is comprised of feed, seed, processing, waste, other uses and food. Furthermore, in the food balance sheet per capita supply is shown, which is derived as demand for food in kilograms divided by population. Three nutrient specific variables are also shown in the food balance sheet, calories per capita per day, grams of proteins per capita per day and grams of fat per capita per day.

In this paper, focus is on calorie consumption as the paper is concerned with catastrophic events where food is for survival. On the longer term other nutrient features of food intake is of course of great concern, however, the contention is that this is not related to food storage as such, but has to do with longer term developments of food availability and accessibility.

Throughout the paper as well as in FAO's food balance sheets the term calorie is shorthand for kilocalories (1 calorie = 4.19 kilojoules). The supply of calories per capita per day is derived as the per capita supply of food in kg per year divided by 365 to obtain the per capita supply of food in kg per day. This is then divided by a conversion factor, which is the number of calories per kg of the particular food item. The result is the per capita supply of food in calories per day. For proteins per capita per day and fat per capita per day a similar calculation is done.

Sub-Saharan Africa, which is the focus of the study, consists according to FAO of 52 countries.[5] FAO have data for 46 of these countries in the years 1961-1996. The remaining countries are British Indian Ocean Territory, Equatorial Guinea, Mayotte, Reunion, Saint Helena and Western Sahara. However, these countries only have a small population of 3,200, 474,214, 155,911, 720,934, 7,212 and 244,943 people, respectively, according to http://www.odci.gov/cia/publications/factbook. The included countries have more than 500 million people, so the average results should not be too biased by the omission of these countries. For Peoples Democratic Republic of Ethiopia data for the period 1993-1996 are calculated by combining the data from Eritrea and Ethiopia. Thus, the two latter countries are not represented individually in the study. Thus, data consists of annual observations in the period 1961-1996 for 45 countries. In particular, observations on calories per capita per day and population are used. Figures on population are likewise obtained from FAOSTAT.

The definition on survival rates of energy intake is somewhat ambiguous. In FAO/WHO (1985) the survival requirement is defined as 1.27 times the basic metabolic rate (BMR)[6]. Thus, from the equation 1.27*BMR, in principle, it is possible to estimate survival energy consumption. However, the BMR changes according to weight, height, age and sex. Likewise other factors contribute to BMR, but these are of minor importance, like in the case of pregnancy the BMR is increased. In FAO/WHO (1985) BMR's for various combinations of the abovementioned characteristics are given.

In the present study it is chosen to use the figures for men, 18-30 years of age, 1.7m in height and weighing an average of 63.5 kg; and for women, 18-30 years of age, 1.6 m in height weighing an average of 54 kg. These figures are added and divided by 2. Hopefully, this crude method is not too

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[5] Actually, the table contains 53 country names. However, one country, Peoples Democratic Republic of Ethiopia, ceased to exist as it was split in two in 1993, hence Sub-Saharan Africa consists of 52 countries.

[6] The 1.27 is obtained as 1*1/3 + 1.4*2/3. The 1/3 is the average proportion of time spent on sleep and, hence, the 2/3 is the period awake. In the period awake, even though no activity as such is carried out still the acts of washing, dressing and short periods of standing raises the energy consumption to 1.4 BMR.

bad an approximation. My guess is that this method does not understate the need for energy, because the populations of Sub-Saharan Africa on average are quite young and contains a lot of children that has a lower BMR compared with adults. Dividing by two suggests that the number of males equal females. This is not exactly the case, but not far from the truth either. FAO/WHO (1985) figures for BMR in calorie requirements per day for the two groups are 1650 calories for men and 1290 calories for women. Thus, the average survival requirement for energy intake is calculated as 1,27*(1650+1290)/2 = 1867 calories per day. On average, this subsistence level is too high, because Sub-Saharan countries generally have a young population. Thus, a large share of the population is under 18 years of age, who have a lower BMR than adults.

Probability of food deficit

The problem of assessing the probability of a food deficit is twofold. First, what is the probability of an event occurring, that is, what is the probability of per capita consumption falling below the critical level? Second, in case of an event, what is the probability of the deficit being of a particular size?

   In both cases, the recorded events and sizes are approximated by an adequate probability distribution. The approximation is based on the statistical properties of data from Sub-Saharan Africa.

Probability of an event occurring

As outlined above the purpose of the study is to assess the need for keeping food stocks. Because supply of food follows an annual cycle the natural time period for the study is by year. Thus, the first step is to approximate the number of annual food deficits, where food stocks may be of use in meeting these demands. Again, because of data availability the number of food deficits is equal to the number of countries experiencing food deficits. Data are recorded in the period 1961-96 for 45 countries. This yields a total number of 1620 observations. With the critical level equal to subsistence level (1867 cal) 273 events are observed. (An event is an observation of calorie intake below the critical level). Thus, an average of 7.58 events per year are observed.

   The mode of these frequencies is 7, meaning that 7 events per year is the most frequent outcome. As they stand, the frequencies are not particularly useful for assessing the probability of a given number of outcomes per year. Certain outcomes such as 11 or 5 events per year have not been observed in the period under consideration. Thus, they would be assigned a probability of zero if based solely on the frequencies, which does not appear too satisfactory. Instead, a generalisation is needed in the form of a distribution, which assigns probabilities over the entire range of possible outcomes. Hence, the problem is to seek among distributions in order to find a satisfactory generalisation of the frequencies. A first requirement of potential distributions is given by the nature of the problem. Number of events per year can only take on discrete values, thus the seeking process is restricted to discrete distributions[7].

   One obvious candidate is a distribution that yields the probability of the number of events per time period known as the Poisson distribution, Stuart and Ord (1994). However, this result on the Poisson is based on certain assumptions, in particular, events are assumed independent. This may be questionable in the case under consideration as it is likely that the probability of observing a value below the critical level for a given country is higher if the value was below the critical level the previous year. Nevertheless, whether the Poisson is an adequate approximation must be left to empirical analyses.

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[7] A more formal way to say this is that the dominating measure is a counting measure on {0,1,2,…}.

The Poisson possesses a number of redeeming features. It is a known and relatively simple distribution that is fully described by only one parameter, and a maximum likelihood estimate of this parameter is easily derived. Hence, the contention is that the frequencies of the events can be described by T independently and identically Poisson distributed random variables X_t,

$$f(x \mid \lambda) = \frac{\lambda^{x_t}}{x_t!} \exp(-\lambda), \ t = 1, 2, \dots, T .$$

Thus, the joint density is of the form,

$$f(x_1, \dots, x_T \mid \lambda) = \prod_{i=1}^{T} \frac{\lambda^{x_t}}{x_t!} \exp(-\lambda) = \frac{\lambda^{\sum_{i=1}^{T} x_t}}{\prod_{i=1}^{T} x_t!} \exp(-T\lambda)$$

The ML-estimator[8], $\hat{\lambda}$, is,

$$\hat{\lambda} = \frac{1}{T} \sum_{t=1}^{T} x_t$$

The ML-estimator is given by the average number of events, 7.58, per year. Because the Poisson distribution only depends on the λ-parameter, it is fully described by the ML-estimate.

The Poisson distribution can be approximated by a normal distribution with mean and variance equal to the mean and variance of the Poisson distribution. Table 2 displays some tests for the approximation.

Table 2. Normality test

Test	Test value
Skewness	1.260
Excess kurtosis	1.447
Normality test, $\chi^2(2)$	0.415
95% critical value for $\chi^2(2)$	5.991

Note. Skewness is a measure of the symmetry of the distribution. If the distribution is symmetric skewness equals zero. The normal distribution is symmetric. Kurtosis is a measure of the thickness of the tails in the distribution. The normal distribution has kurtosis equal to three. Thus, excess kurtosis is defined as kurtosis minus three. A test for normality of the distribution can be derived from the two measures, skewness and excess kurtosis. The test is χ^2 distributed with two degrees of freedom.

Some skewness and excess kurtosis is observed, but according to the normality test these third and fourth moment measures are well inside the acceptable region. As seen the null-hypothesis of nor-

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[8] It is easy to derive,

$$\ln L(\lambda \mid x) = -T\lambda + \ln(\lambda) \sum_{t=1}^{T} x_t + \sum_{t=1}^{T} \ln(x_t!),$$

$$\frac{\partial \ln L(\lambda \mid x)}{\partial \lambda} = -T + \frac{1}{\lambda} \sum_{t=1}^{T} x_t = 0 \Rightarrow$$

$$\hat{\lambda} = \frac{1}{T} \sum_{t=1}^{T} x_t,$$

where $L(.)$ is the likelihood function.

mality is convincingly accepted. Therefore, the Poisson distribution appears to provide an adequate description of the frequencies.

Probability of the size of an event

When an event occurs the scale of the food deficit is of course of vital importance for any strategies aimed at alleviating food shortages. This time the data is not indexed by time but treated as one big sample. Except, only observations where an event occurs, that is, the per capita consumption falls below the critical value, are included. This happens in 273 cases. Thus, the sample consists of 273 observations. The time and place (country) where the event happens is of no concern in this analysis. It is assumed that the place (country) where disaster strikes is of no importance. That is, the benefactors and administrators of the food aid system are willing to help regardless. Therefore, in this analysis the purpose is to obtain a probability distribution for the size of events upon which the system for the entire region should be based.

When an event occurs, where the food consumption in calories per capita per day is below the critical value, the shortage is multiplied by the number of people in the country and the number of days in a year. The resulting number shows the annual food shortage in calories. These observations are ordered according to increasing size. Subsequently, the events are collected in intervals where the upper limit is 150 billion calories higher than the lower limit, and the number of events in each interval is derived.

Almost half the events fall into the first interval (0 - 150 billion calories) and the frequency of an event declines rapidly with increasing scale of the event. In contrast to the probability of an event occurring, in this case there are no prior hints as to what sort of probability distribution to look for. However, the configuration of the frequencies immediately excludes many possible candidates. Thus, the normal distribution is clearly inadequate in this case with the frequencies forming a highly asymmetrical shape. On the other hand, the rapid decline of the frequencies points to some sort of exponential feature. One candidate that is capable of producing such behaviour is the exponential distribution, Stuart and Ord (1994), where frequencies of food deficits are described by a random variable Y with density function,

$$f(y \mid \theta) = \theta \exp(-\theta y), \ y > 0.$$

The expected value of the exponential distribution is derived as,

$$E[f(y \mid \theta)] = \frac{1}{\theta},$$

and the variance as,

$$Var[f(y \mid \theta)] = \frac{1}{\theta^2}.$$

The exponential distribution is a continuous distribution as opposed to the Poisson distribution, which is a discrete distribution, in accordance with the nature of the two types of phenomena the respective distributions describe. Like the Poisson it is a well-known, simple distribution that only depends on one parameter, θ. A property of the exponential distribution is that it is invariant to scale changes. So, in principle, if the probability model for Sub-Saharan Africa is an adequate description elsewhere, it is easily applied thereto.

In case, the exponential description is an adequate approximation to the observed frequencies, F_j,

$$F_j \approx P_j = 1 - \exp(-\theta y_j),$$

a linear in parameters relationship is derived,

$$\log(1 - F_j) \approx -\theta y_j.$$

The parameter, θ, in the exponential distribution is derived from this relationship. An OLS regression of $\log(1-F_j)$ on y_j yields,

$$\log(1 - F_j) \approx -0.00127 y_j$$
$$(0.00005)$$

where the number in brackets is the standard deviation and R^2 is 0.77. Thus, the estimate of θ is 0.00127. In figure 7 the estimated exponential distribution is displayed.

   If the estimated exponential distribution is an adequate approximation to the observed frequencies, the latter should be dispersed more or less randomly around the straight line in figure 7. In figure 8 the observed frequencies are shown together with the estimated exponential distribution.

   Admittedly, the observed frequencies display signs of systematic deviations from the estimated exponential distribution. Thus, for lower values of Y the corresponding estimated probabilities are lower than the observed frequencies ($\log(1-Hj) < \log(1-Pj) \Rightarrow Pj < Hj$). Nevertheless, overall the deviations are small as some 77% of the variation in the observed frequencies is explained. Accordingly, the approximation in form of the estimated exponential distribution is considered adequate for the present purpose.

   The mean of the exponential distribution is derived as,

$$E[Y] = \frac{1}{\theta},$$

where the estimate of $è$ is 0.00127. Thus, the expected value or mean of the size of calorie deficits is 789.65 billion calories.

Summary of statistical analysis

From the Poisson distribution an average of 7.58 events of food deficits occur every year. Multiplying this number with the average size of a food deficit obtained from the exponential distribution yields 7.58*789.65 = 5,989.55 bill. calories. Consequently, according to the statistical analysis, approximately 6 trillion calories is needed annually on average to cover the most basic nutritional requirements.

   In it self this number may not be particularly informing since calories *per se* are not stored or traded. Instead, the calorie equivalent of food stocks can put some perspective on the numbers. The most stored, in particularly in EU, food item is wheat. Therefore, wheat is used as a reference point in the subsequent calculations. Furthermore, wheat is traded and consumed world wide although the amount of wheat in daily diets vary across regions and cultures. Also, it is in comparison with other food items relatively easy to transport and distribute, it does not require e.g. cooling vehicles or –ships.

   The average calorie content of wheat is derived from FAO's food balance sheets. The total supply in the world of wheat in calories per capita per day and total food supply of wheat is used to derive the number of calories per kilogram wheat. This is done for all the years in FAO's food balance

sheets and the average is calculated. It should be mentioned that the figure does not change much over the time period. The resulting figure is 2827 calories per kilogram wheat. Using this to convert the average food deficit per year in calories yields 1,000,000*5,989.55/2827 = 2,117,278 metric tons of wheat.

A new question arises. Is this figure big or small? In figure 9 is shown the European Unions ending stocks of wheat for the period 1970/71 to 1999/00. Ending stocks are the stocks at

FIGURE 9. **Ending stocks of wheat in European Union in million metric tons**
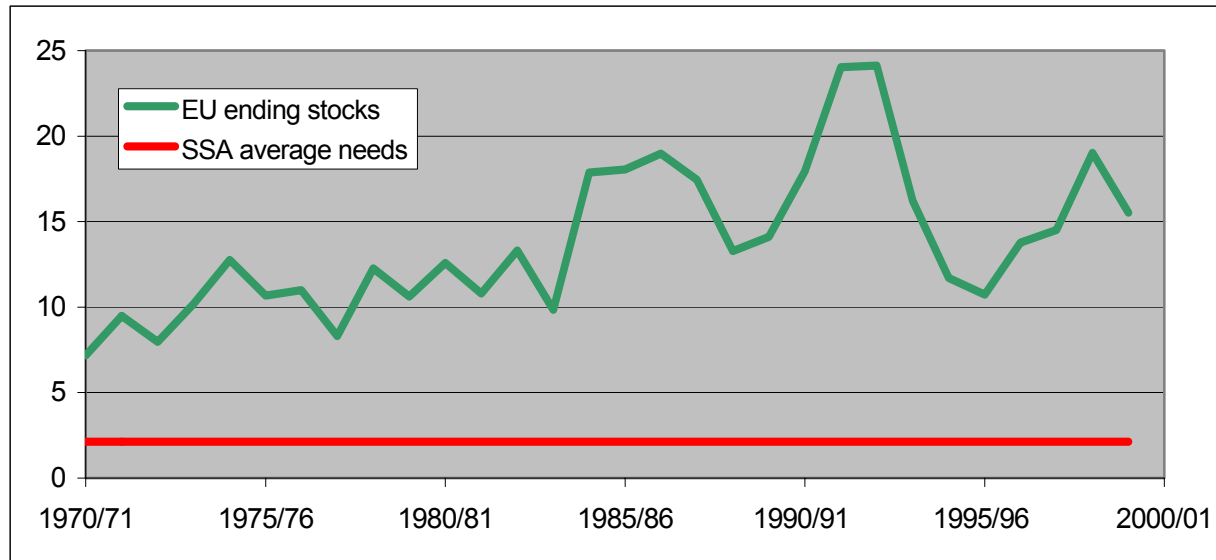
the end of the harvest year, which is around August 1. At this point the stocks are assumed to be at their lowest during the harvest year, and will soon be replenished with the new harvest. In figure 9 is also shown a line corresponding to the average food deficit in Sub-Saharan Africa calculated above. Evidently, the wheat stocks of the European Union are more than sufficient to cover the average needs. Furthermore, figure 9 only shows the wheat stocks, but besides that the European Union also keep stocks of other grains not to mention various other food items such as beef, butter, other dairy products, etc.

5. Interpretation of results and perspectives

The upkeep and maintenance costs of perishable food products are quite high, in particular, if the product is meat. Meat needs refrigeration which is energy consuming and thereby costly to maintain. But, even with grains costs run to considerable numbers. Despite the numerous studies that have been conducted concerning the stock issue, few seems to consider the magnitude of the costs. Implicitly, however, some measurements can be deduced. The Common Agricultural Policy of the European Union was and to a certain degree still is heavily dependent on stocks to regulate prices received by farmers. To this effect, EU pay farmers to stock up agricultural products by paying them sum to cover the expenses at private stocks.

One study made by Dhar (1993) makes an attempt to quantify the costs. Based on the operations of the Food Corporation in India it is estimated that the maintenance costs of the (buffer) stock of grains is around 15% of the price of the grain, or rather they should be. The current costs of maintaining the stock is more than 30% of the price of the grain according to Dhar (1993). Now, if only wheat is considered, in 2000 approximately 600,000,000 MT of wheat were consumed in the world. This leads to a required stock according to FAO's 17% rule of around 100,000,000 MT of wheat.

The maintenance costs of this stock runs in more than one billion dollar. Considering only the part of FAO's requirement that refers directly to emergency needs, which is one third of the 17%, the upkeep on these stocks still runs into several hundred million dollars. According to the calculation from the statistical analysis an amount of 2,117,278 metric tons of wheat are needed on average every year to supply the needs of Sub-Saharan Africa. Admittedly, the rest of the world is neglected in the statistical analysis, however, the FAO requirement do seem quite an expensive way to ensure food security.

From the perspective of available resources the amount of wheat traded in the world was at more than 100,000,000 MT in 2000. In wheat equivalents, the amount traded in the crop year 1999/00 was 104.3 million MT of wheat, 29.3 million MT of rice and 101.4 million MT of coarse grains, totalling 235.0 million MT of wheat equivalents. Furthermore, the figures based on USDA data exclude intra-EU trade. Thus, removing a couple of million MT or even twice that amount from the world market through purchases does not seem so big a deal. The drawback of this strategy is that available resources must be ready before a crisis emerges. It is evident that if sufficient resources can only be made available through a complicated political process involving disputes over who is to pay then such a strategy is doomed to fail. The much and urgently needed food aid would be delayed with potential devastating implications. Instead, an international fund could be established with the sole purpose of functioning as financier of buys on the world market in case certain emergency criteria are met. This fund must be financed and replenished continuously through a set of agreements among donor countries. The advantage of this strategy is that it is much cheaper than providing emergency aid through stocks. Stocks are as shown above very expensive to maintain. The advantage of relying on stocks is that the available resources are already at disposal. This in no way implies that they are in the right locations. On the contrary, stocks are primarily kept by big exporting countries that do not need them for security purposes. Thus, all the problems involved in the logistics and distribution of the emergency aid are present. The alternative strategy of having an international financing fund would also start the emergency aid from much the same place as under the stock strategy. When the fund buys up grain at the world market they would get the grain at much the same places as they were kept under the stock strategy, namely in the ports of the big exporting countries.

The concern over the future of the world's disaster aid capabilities arose because of the liberalisations agreed upon during the Uruguay Round of GATT negotiations. In order to pre-empt anxieties, also for other reasons voiced in particular by developing countries over even further liberalisations, the matter of emergency aid could be a negotiating topic during the ongoing WTO trade negotiations. The key interest in a formal emergency aid fund would lie at the developing countries and in particular at the least developed countries since they stand to benefit. But these countries also have bargaining power as the Seattle incident revealed. Thus, the developed world who probably stand to win the most by further liberalisations need the consent of the developing countries to push further. Therefore, part of the price for the consent of the least developed countries could be the establishment of such a fund along with binding agreements and commitments to the funds continuation.

The fund needs to be able to conduct its business totally independent. One argument against such a fund could be that in times of worldwide short supply and therefore high prices, the developed countries would be reluctant in allowing major buy ups from the market. Thus, if the operations of the fund are under political control, emergency aid could be impeded or delayed intolerably. It may be true that in particular years the costs of providing emergency aid will be high as in the years of worldwide short supply. But in the longer perspective it is much cheaper to operate through buy ups as opposed to spending millions of dollars every year on maintenance costs. Furthermore, in case of the stock strategy besides the maintenance costs the stocks have to be replenished when drawn upon for emergency aid. It is conceivable that the costs of replenishing the stocks could be lower

than the costs of making the buy ups in times of need. However, these conceivably lower costs are hardly millions of dollars cheaper. Moreover, in case of a financial fund the fund would be earning interests on its capital. Admittedly, the funds would have to be in a highly liquid form but still the fund would get a positive rate of return. In case of a stock strategy the capital is tied up in buildings and the grain stored, which earns no interests. On the contrary, the rate of return is negative because both buildings and grain depreciates over time and needs to be maintained.

Based on the 15% maintenance costs in 2000 the costs of keeping the EU wheat stocks amounted to approximately 12$ per metric ton. Thus, EU's wheat stocks had an upkeep of approximately 200 million US$ based on the estimate of maintenance costs by Dhar (1993). Another estimate is indirectly provided by the EU itself through the workings of the CAP. Thus, the CAP stipulates an intervention price for the supported products, which includes wheat. That intervention price is valid in the first month of the crop year. If the farmer postpones his sale to the EU through intervention then he receives an addition to the stipulated intervention price for every month after the first harvest month he has postponed the sale. This monthly addition is granted because the farmer incurs the costs of keeping his grain in stocks. Thus, this monthly addition is in essence an estimate of the costs of keeping stocks. In 2000 this addition was set at 1€/MT according to Landbrugsraadet (2000), which is equivalent to 0.92$/MT in 2000 prices. A crude calculation yields the annual costs of keeping one metric ton of wheat as 12*1€ = 12€ = 11.1$, which is actually surprisingly close to the estimate based on Dhar (1993)

According to FAOSTAT the average citizen of the world consumed 2791.84 calories of food per day in 1998. With 5,901,054,000 inhabitants according to FAOSTAT a total of approximately 6,013,301 billion calories were consumed in 1998 in the world. In wheat equivalents this amounts to approximately 2 billion MT. FAO's 17% requirement therefore prescribes 362 million MT to be stored in large inventories at a yearly cost of no less than 4 billion US$, according to the indirect measure of EU costs of storage derived above, just for keeping this amount at the inventories.

This paper, however, argues that most countries in the world are food secure so they do not need to store food in large inventories in order to insure themselves against bad harvests, etc. This function can readily be left to the market, where the demand and supply situation of course mirrors the situation and events in the individual countries, and therefore prices increase if decreasing supplies is a widespread phenomenon. However, paying an "over-normal" price for a temporary phenomenon will in the long run be cheaper than incurring the very sizeable costs a stock strategy entails. Nevertheless, this form of "insurance" provided by the market excludes countries that do not have ready access to foreign exchange. In particular, poor countries as most of the Sub-Saharan Africa region face grave disasters now and in the future. Therefore, an insurance system has to be set up for such countries. Again the contention is that stockholding is too expensive a strategy. Instead, a financial fund with short-term highly liquid assets should be established. This fund should have no other purpose than to provide food in kind when needed. Thus, when a country faces serious food shortages the fund should buy up food on the open market and put it at the disposal of proper authorities. Whether the fund should also be involved in transportation and distribution aspects of providing food aid is not an issue here, only the actual acquisition of the food.

One drawback of the proposal is the financing of the fund. Not that the fund needs to be very large. The estimate for Sub-Saharan Africa suggests a yearly average of 2,1 million MT of wheat which amounts to approximately 189 million US$ per year using a price of 90$/MT of wheat. This is not very much considering the costs of other UN organisation for instance. However, the fund needs to be bigger than this figure since it is based on the average because some years widespread disasters happen whereas other years are much calmer. The 90% quantile based on the estimated stochastic processes yields around 15 million MT, so in order to be able to counter 90% of all events with this fund it needs to have approximately 1,323 million US$.

Another prerequisite for this fund is that it should be continuously replenished. Thus, an automatic refinancing structure needs to be implemented. This is not an easy task as the controversies surrounding financing of the UN reveals. However, the sizeable stockholding costs that can be saved if this fund is set up should provide an economic incentive for choosing such a strategy. Thus, approximately 4 billion $ is being spent on stockholding each year if FAO's 17% requirement is followed according to the calculations above. One third of the 17% stockholding is for reserve purposes. If these reserve stocks can be saved more than 1 billion $ is saved each year. Of course, some administrative costs would be incurred by the financing fund but hardly at the scale of stock maintenance costs.

The fund would on average have to act 7.5 times per year according to the statistical analysis. Thus, the fund would need to be replenished at least every two months. Naturally, the fund would be inoperable if political compromises and dealings would have to be undertaken each time. Instead an automatic system for replenishing the fund needs to be implemented, perhaps a system be based on countries relative income or following the UN contributions.

Furthermore, the activities of the fund need to be conducted independently of any political process. Thus, the suggestion is that a set of criteria is set up by the UN or relevant political organisations. Henceforth, the fund is obligated to act if a country in need meets these criteria. These criteria could be based upon the UN definition of an LDC (Least Developed country).

6. Concluding remarks

6.1 FAO's recommendations

Table 3 summarises different policy options dealt with in this paper. FAO's recommended food stock policies as described in FAO (1983) are displayed in column one and three. Column one shows the recommendation for the entire world. It is surprising how close the recommendation for total grain stocks is to the actual grain stocks in the world as displayed in column two. Then again, FAO's recommendation is derived from the actual behaviour of food stocks, and apparently this behaviour has not changed much since the recommendations were calculated based on numbers from the 1960'ies and 1970'ies. The cost of keeping these stocks runs in more than five billion US$ per year both according to FAO's recommendation. Most of these stocks, however, are not for insuring against hunger. According to FAO approximately two thirds are working stocks that are kept to ensure the smooth and uninterrupted flow of food and foodstuffs both in the production and the distribution process. In reality, however, large parts of these stocks have been acquired as a result of the agricultural policies in the exporting countries. Thus, in periods of low demand and/or "too" high supply EU and US policies call for interventions in the markets often by purchasing grains and subsequently placing it in storage buildings. Therefore, large parts of the actual stock level may have little to do with production processes or supply security.

FAO's recommendation for a safe level of food stocks applies to the entire world. Nevertheless, in column three the recommendations are used for the Sub-Saharan Africa region. This region is much more prone to famines and disasters than most if not all other regions in the world. Average calorie consumption is at a low level, therefore, it does not take very big catastrophes to put dietary needs in jeopardy. Furthermore, natural catastrophes such as droughts and floods are common in the region; as are manmade disasters such as civil war. For these reasons, FAO's recommendations for stock levels made for the entire world should be increased significantly if applied to the Sub-Saharan Africa region. In column four, however, the numbers are calculated without increasing the recommendation. Thus, these numbers provide a minimum for the FAO stock levels in Sub-Saharan Africa.

According to the FAO recommendation at least 9.2 million metric tons of wheat equivalents need to be stored as reserves. Apart from purchasing this grain at a cost of 787.1 million US $ in 1999, an annual cost of 129.7 million US$ is induced by the reserve stock. It must be assumed that the grain used to alleviate famines and hunger is not sold on the market but donated to people in want. Thus, the reserve stock does not provide funds for itself and depends upon adequate and timely donations for replenishing and financial assistance in order to maintain the reserves. However, no information exists regarding the operations of these stocks. Information on size and timeliness of withdrawals and replenishments from the reserve stocks are needed to get a precise estimate of the costs of the operation. Likewise, the criteria for donating food supplies would be required in order to assess the likely scale of operations.

6.2 Statistical analysis

Since none of this information is available, the statistical analysis based on the minimum calorie criteria is used to evaluate the FAO policy. Column six displays the figures based on the statistical analysis. On average, to achieve at least the minimum requirement of calorie intake, 2.1 million metric tons per year is required. This number is only about one fourth of the amount given by the FAO recommendation. A reserve stock of this size would, naturally, also cost only about one fourth of the FAO recommendation. However, the figure from the statistical analysis is an average, thus, in some years only small or no food donations are needed to alleviate sudden food crises, whereas in other years the wants will be much higher. In the examined period 1961 to1996 the highest deficit in wheat equivalents were in 1993 where just below 3 million metric tons were needed to cover the basic calorie requirements. In 1993 prices, 119.5 $/MT, this would have required around 350 million $. Still, the quantity of the highest deficit is only about one third of the FAO recommendation.

6.3 The proposal

It appears that quite substantial amounts of money are used just for maintaining large stocks, money that could be used much more productively elsewhere. However, discarding the use of stocks for reserve purposes would put a lot of people in jeopardy. Furthermore, the present talks of liberalising the international trade regime, in particular, liberalising production and trade of agricultural products has raised concerns about food supply security issues. Many developing countries fear that opening their markets for agricultural products could imply lower self sufficiency of food, and thereby they would to some extent be at the mercy of the big exporting countries if the supply situation deteriorates. In particular, the concern is that in times of low global food supply the big exporters, who are primarily OECD members, would be more concerned with their own countries than providing adequate food for suffering developing countries. Therefore, the question of food supply security is one of the impediments in the WTO round that has to be addressed.

One solution to the problem could be to assist the developing countries in building storage capacity and supply the necessary stocks of food. Or, the buffer stocks of the big exporting countries, where the bulk of the worlds grain stocks are located, could be expanded. Such a policy, however, is expensive both in terms of investments as well as in terms of maintenance. Instead, to address the legitimate concerns of the developing countries a financial fund is proposed; a fund with the sole purpose of providing financial means for alleviating sudden food crises. For the fund to be trustworthy it would have to operate independently of the political arena and instead base its decisions on a set of strict criteria. It is imperative that the fund is politically independent. One of the arguments in favour of stocks is that the food is already at hand, whereas if purchases has to be made on the markets then politicians from the donor countries may not be as willing to provide the necessary

means if prices are very high because of global supply problems. Furthermore, the political process in itself even without global supply problems can be lengthy and drawn out resulting in delayed arrival of necessary food supplies. Thus, the decision making of the fund must be independent of political skirmishes.

The argument in favour of strict criteria to be met before the fund takes action is to counter the problems of moral hazard that can arise. Thus, the fund would induce a positive incentive for countries or regions to declare themselves in a sudden emergency. Undoubtedly, in many countries and regions in Sub-Saharan Africa perennial problems of malnutrition exists, and as such they qualify for assistance. It is important, however, to emphasise that the fund is to be regarded as an insurance against suddenly arisen emergencies, not as a general organisation to combat malnutrition. The latter kind of organisations already exists, and provides assistance to address the more chronic problems. On the other hand, the decision making in the fund has to be flexible so as to enable a quickly and timely assistance. Obviously, the exact charter of the fund therefore must reflect both of these opposing considerations.

Another argument in favour of stocks is that as mentioned above the food is already at hand and, thus, time is saved in the distribution process. However, the bulk of the worlds grain stocks are kept in and by the big exporting countries, and are therefore not located in the countries where they would be most likely to be needed. Furthermore, if grain is purchased on the world market the location of the purchased food is where they are stored by the vendors, primarily in the silos of the ports of the big exporting countries. That is, the purchased food grains would be located much the same place as a reserve stock.

All of the above considerations concerning a financial fund whose purpose it is to purchase and donate food in times of sudden needs are only meaningful if enough food is available on the market. Thus, if very large parts of the global trade in grains would have to be directed towards this purpose the proposed strategy may not be feasible. Thus, one of the concerns of developing countries is that if purchases of food for emergencies increase the world price significantly, the developed countries in times of low global food supply may not be particularly willing to donate funds for this purpose as this policy could harm their own consumers. This is of course an argument for why the fund must be politically independent, but the question arises as to how much of the global grain trade this policy would commandeer.

According to USDA in 1999 global grain trade comprised 102 million MT of wheat, 25 million MT of rice and 91 million MT of corn. These figures are even without the trade among the EU countries themselves. Thus, in wheat equivalents a total of 230 million MT were exported (and, of course, the same amount was imported). Out of this amount an average of 2.1 million MT would be needed for Sub-Saharan Africa, and even considering the largest deficit experienced (3 million MT) only slightly more than one percent of the global grain trade is needed. Therefore, it is concluded that the amount of grain needed to be purchased relative to the global markets does not provide an impediment to the suggested policy. Even if the purchases do impact the world markets this would be a short term phenomenon, and should not be the cause of concern.

The advantages of the suggested financial fund is threefold:
- It is much cheaper to operate
- It is independent of political or other control over reserve stocks
- It can be replenished quickly

The first point is exemplified by Sub-Saharan Africa figures in table 3, which suggests that 129.7 million $ can be saved annually in maintenance costs. Thus, financial capital does not deteriorate as does physical capital such as storage buildings, as well as degradation of the perishable food items. However, the capital of the fund would have to be held in a highly liquid form in order to ensure the speediness of necessary purchasing operations. This is not to say that the capital is to be held in

cash, rather that the capital should be held in short-term but interest bearing assets. Therefore, the main cost here would be given by the term structure of interest, that is the difference in rates between short-term and long-term interest bearing assets.

The second point is largely addressed above. The present reserve stocks is owned and governed largely by the major exporting countries. Therefore, any operations involving these reserves need the approval of these countries. A fund such as the proposed operates independently of political considerations, thereby circumventing potentially political conflict areas, which may impede the timeliness and execution of emergency assistance.

The third point is concerned with the continuity of operations. After an emergency operation has been carried out the reserve stocks under the present regime needs to be replenished. This is done independently and uncoordinated by the stockholding agents, no overall coordinating role is allocated to anyone. Thus, the replenishment or not of the reserve stocks is to some extent a result of chance behaviour. On the contrary, a financial fund would have a set of criteria that has to be reached and maintained such as the level of finances in order to achieve an established level of security. Furthermore, the replenishment of the fund after execution of emergency assistance should follow a pre established process. It could be backed in its finances by e.g. the World Bank and /or IMF who would be committed to maintain the funds finances at the pre established level. In this respect the fund may never be in short supply of resources since a replenishment of financial capital can be carried out almost instantaneously.

Finally, the establishment of a food security fund may facilitate the current WTO negotiations. In many proposals posed by countries or groups of countries the need for exemptions from general agricultural liberalisations due to food security concerns is underlined. A dedicated fund to this purpose could meet some of these concerns, and thereby diminish the need for special rules, which are always open to differing interpretations.

TABLE 3. **Stock policies**

	Based on FAO's recommendation World	Actual stocks World	Based on FAO's recommendation Sub-Saharan Africa	Required stocks Sub-Saharan Africa	Proposal Sub-Saharan Africa
1. Food consumption in weq[1], mMT	2,159.4		167.2		
2. Total grain stocks in weq[2], mMT	377.9	376.9	29.3		
3. Reserve stocks in weq[3], mMT	118.8		9.2	2.1	0.0
4. World price of wheat[4], $/MT	93.7	93.7	93.7	93.7	93.7
5. Maintenance costs of wheat stocks[5], $/MT/year	14.1	14.1	14.1	14.1	14.1
6. Costs of maintenance of total stocks[6], million $/year	5,328.4	5,314.3	412.5		
7. Cost of maintenance of reserve stocks[7], million $/year	1,674.6		129.7	29.6	0.0
8. Cost of purchasing the total grain stocks[8], million $	34,397.3	35,315.5	2,661.1		
9. Cost of purchasing the reserve grain stocks[9], million $	10,119.6		787.1	196.8	196.8

mMT is million metric tons, weq is wheat equivalents. All quantities are in wheat equivalents.

1) In 1999, 5,956,286,000 people in the world consumed an average of 2808 cal/cap/day according to FAOSTAT, Thus, the number of calories consumed per year can be calculated and dividing this number with the number of calories per kg wheat (2827) the quantity of food consumption in the world in wheat equivalents is obtained. For Sub-Saharan Africa in 1999, 589,140,000 people consumed an average of 2198 cal/cap/day according to FAOSTAT.
2) FAO's recommendation that 17-18% of total food consumption should be stored, is used to calculate total recommended food stocks. Hence, 1. is multiplied by 0.175 to obtain FAO's recommended total grain stocks. The actual stocks are ending stocks for 1998/99, that is the stock level in mid 1999. According to USDA the quantity stored for wheat was 135.6 mMT, for rice 60.0 mMT and for coarse grains 155.3 mMT. The calorie content in these grains are derived using FAOSTAT data yielding 2,827, 3,649 and 2,982 calories per kg for wheat, rice and corn, respectively. Thus, the actual grain stocks in wheat equivalents yields, 135.6, 77.4 and 163.8 mMT respectively, amounting to 376.9 mMT.
3) FAO recommends that 5-6% of total food consumption should be stored, which is used to calculate total recommended reserve stocks. Hence, 1. is multiplied by 0.055.
4) Average price for wheat in 1999. Source: USDA.
5) According to Dhar (1993) maintenance costs of storing amounts to 15% of the price per year. Thus, maintenance costs per MT is obtained by multiplying 4. with 0.15.
6) 6. = 2. * 5.
7) 7. = 3. * 5.
8) 8. = 2. * 4.
9) 9. = 3. * 4.

References

Club of Rome (1972): 'The limits to growth', by D.L. Meadows et al, New York, Universe Books.

Dhar, U.R. (1993): 'Managerial issues in public-inventory holding: the experience of the Food Corporation in India', in *Food Security and Food Inventories in Developing Countries* edited by P. Berck and D. Bigman, CAB International.

FAO (1983): 'Approaches to world food security', *FAO economic and social development paper*, 32, Food and Agriculture Organization of the United Nations, Rome.

FAO (1995): 'World agriculture: towards 2010', *an FAO study* ed. by N. Alexandratos, John Wiley and Sons, Chichester.

Konandreas, P. (2000): 'Trade and food security: options for developing countries', module 10 in *Multilateral trade negotiations on agriculture – a resource manual*, vol. II, FAO.

Landbrugsraadet (2000): *Raadsnyt om EU*, no. 4.

Pal, S.P. and J.P. Singh (1986): 'Food security and food stocks in India', *Margin, Quarterly Journal of NCAER*, 19(1), 30-41.

Sarris, A. (1985), 'Safe Levels of Global Grain Carryover Stocks for World Food Security', report prepared for FAO Commodities Division, September.

Stuart, A. and J.K. Ord (1994), 'Kendall's Advanced Theory of Statistics - volume 1: Distribution Theory', Edward Arnold.

WHO (1985): 'Energy and protein requirements', Report of a Joint FAO/WHO/UNU Expert Consultation. *WHO Technical Report Series No. 724.*