Ranking Food Security Planning Objectives in Tanzania Using the Analytic Hierarchy Process

Christian B. Alphonce

Abstract

This paper proposes a systematic methodology for ranking of the multiple often conflicting food security planning objectives in Tanzania a typical low income food deficit developing country. First, a hierarchy of food security planning objectives is developed from an extensive literature survey of food security in low income food deficit developing countries. Then, Analytic Hierarchy Process is employed to analyse the preference judgements elicited from experts in food security planning. Finally, a priority structure is established reflecting the perceived importance of these food security planning objectives. This methodology can assist food security planners and decision makers in low income food deficit developing countries in formulating effective and efficient plans consistent with national objectives.

1. Introduction

Food security, which is usually defined as *the ability of a country (or community) to ensure access by all people at all times to the food needed for a healthy life*, has been an elusive goal for most low income food deficit (LIFD) developing countries (Chisholm, 1996). This is in spite of many years of concerted efforts to achieve national food self sufficiency.

The problem is compounded by the fact that these countries are characterised by poor performing economies, agricultural stagnation, heavy external debt service burden and lack of appropriate technology. Their exports are mainly unprocessed agricultural products which continue to sell at perpetually decreasing world prices. A large part of the poor population is still rural and dependent on agriculture for food and income.

Effective food security planning remains the main hope of most LIFD developing countries for ultimately alleviating the food security problems. It is accepted as an essential and pivotal means of guiding food security developments in most LIFD developing countries (Reutliger and Pellekaan, 1986). The need and importance of food security planning at national level have been emphasised in the literature (El-Sherbin, 1979; Bigman and Reutlinger, 1979 and Tabucanon, 1993).

Food security planning in LIFD developing countries is often characterised by multiple objectives which are in most cases not commensurate and often in conflict with each other. It has been observed by Stern (1974) that, as the level of development of a developing country rise, conflicts between different sets of objectives increase. He further advocates a careful and systematic analysis of national priorities and a more comprehensive view of how the interests of various segments of the population fit into the national system.

Effective food security planning in a LIFD developing country, therefore, requires *a priori* the articulation and ranking of the multiple food security objectives and goals in line with the national development needs. This paper describes a systematic approach for use by food security planners and decision makers to articulate and prioritise multiple food security planning objectives in a typical LIFD developing country.

Mathematics Department, University of Dar es salaam, P. O. Box 35062, Dar es salaam, Tanzania.

2. Identification of Food Security Planning Objectives in LIFD Developing Countries.

There is a close resemblance between food security planning objectives and agricultural planning objectives in a LIFD developing country. The only major difference is that food security objectives place emphasis on the key basic needs of the poorest and most vulnerable groups within a country while agricultural planning objectives emphasize profit maximisation. Food security planning objectives ensures that the needs of disadvantaged groups are not neglected in policy formulation. A number of authors have identified these objectives for a typical LIFD developing country. (Bigman and Berk, 1993; Tabucanon, 1993; Lele, 1989; Shuttleworth et al, 1988; Barbara, 1990; and Martin, 1989).

From the surveyed literature above it is noted that food security planning objectives in LIFD developing countries are almost identical. These objectives falls basically under four broad categories; namely physical, political, economic, and social/cultural objectives.

Physical objectives consist of policies aimed at satisfying basic individual human needs. Since these are part of basic human rights it is important to optimise them in the context of a LIFD developing country. Major physical objectives are:

(i) meeting minimum nutritionally adequate food needs of all people, and

(ii) conservation of environment.

Political objectives are policies concerned with political stability that a country is able to command. Major political objectives include

(i) achieving a pre - set level of food self sufficiency and

(ii) stabilising food supplies.

Economic objectives are policy statements on how scarce resources should be allocated among different activities in order to attain a targeted rate of economic growth over a given period of time. The most prominent economic objectives are:

(i) optimising inputs usage,

(ii) optimising energy usage,

(iii) optimising individual income,

(iv) optimising government income and

(v) minimising distribution costs.

Social/Cultural objectives are those policy initiatives that bring about social/cultural benefits to the society as a whole rather than to private individuals. It is always desirable in the context of LIFD developing countries to optimise the social/cultural benefits in light of the resource limitations. The most prominent social/cultural objectives are:

(i) satisfying people's food habits, and

(ii) maximising employment opportunities.

The analytic hierarchy process (Saaty, 1990 and 1991; and Vargas, 1990) was used as a prescriptive mechanism to prioritise the food security objectives a LIFD developing country should pursue to attain a desired food security level. The problem analysis involved decomposition of the food security problem in a LIFD developing country into a mission statement, the possible scenarios of the food security, participants who have the ability to influence the desired level of food security and policy objectives which a country intends to pursue to attain a desired outcome.

These components form the levels of a hierarchical (pictorial) representation of the food security problem of a LIFD developing country. The hierarchical structure illustrates the link between various levels. The mission statement together with the levels of the hierarchy are discussed below.

a) **Mission statement**: The mission statement establishes the focus of food security planning in a LIFD developing country. The mission statement identifies the desired food security level. The desired food security level of a developing country is characterised by the ability to provide access to nutritionally adequate food for all its population at all times.The first level of the hierarchy list the possible scenarios through which a LIFD developing country can attain the desired food security level.

b) **Possible Scenarios**: The desired food security level in a developing country can be attained through the following scenarios.

i) **Food Self - Sufficiency**: This involves meeting domestic food demands through production and stockholding. Surplus food produced together with cash crops are exported to generate foreign exchange needed to import agricultural inputs and pay for other development activities.

ii) **Food Self - Reliance**: This means meeting a country's food requirements through a combination of production, stocks and trade, with the mix depending on the relative costs of procurement from each source.

c) **Second Level**: Participants: This level contains the most influential participants whose actions affect the desired food security level of a developing country. Since the term food security covers such aspects as trends in production, marketing, aid flows, food prices, fluctuations in food supply etc. (Rukuni and Eicher, 1987), the following participants have been identified:

i) **Government**: Food security activities of this participant include encouraging and advising farmers on how to produce enough food and cash crops to achieve the following:

- ensure that agriculture remains a potential source of employment and income,
- ensure that the fluctuations in food supply and income are ,
- ensure the availability of agricultural inputs and extension services to farmers at the right time and place,
- co-ordinate the marketing and distribution of agricultural outputs,
- co-ordinate the availability of services such as credit to farmers,
- co-ordinate environmental conservation measures,
- build and maintain infrastructure, and
- co-ordinate distribution of food aid and other emergency measures.

ii) **Farmer**: This participant assists in attaining the desired food security level through the following activities:

- producing enough food to meet a large proportion of the family needs without degrading the environment,
- generating income needed to purchase complementing food and basic consumption goods,
- ensuring that fluctuations in family food supplies and income are minimized, and
- ensuring equal distribution of food within a family.

iii) **Private Trader:** Food security actions of this participant are:

- efficient marketing and distribution of agricultural inputs and outputs, and
- providing services such as credit to farmers.

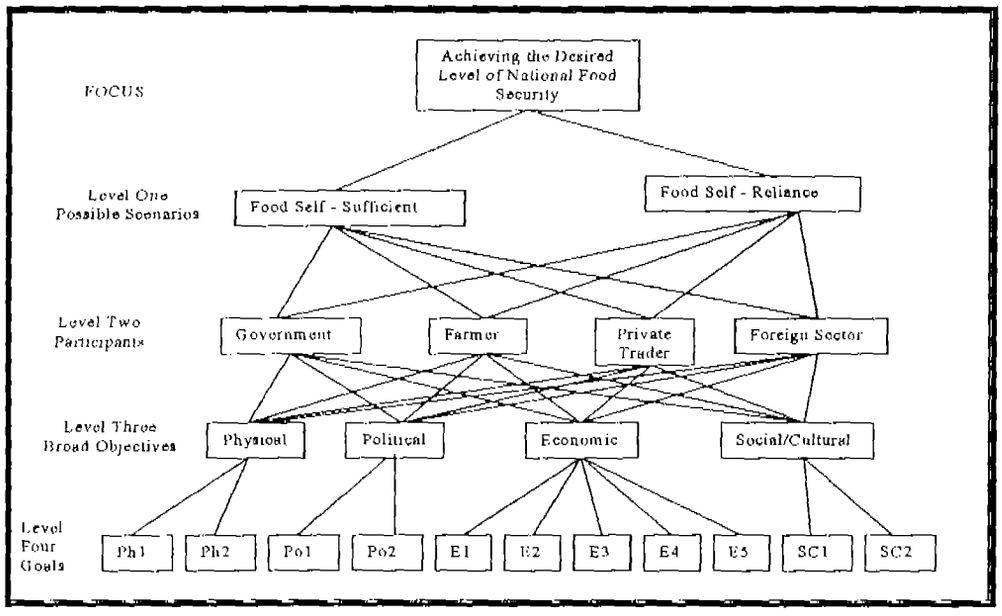
vi) **Foreign Sector**: This group of participants (World Bank, FAO, European Community, etc.) are involved in the following food security activities:

- provision of food aid and other emergence relief services,
- advising the government on best ways of tackling the food security problem,
- providing and co-ordinating necessary assistance needed to accelerate the country's agricultural growth in a sustainable manner, and
- assisting in establishing income generating activities for the vulnerable groups such as women, disabled, etc.

d) **Third Level: Broad Objectives**: In this level of the hierarchy is a list of the broad objectives which are expected to play a major role in determining the future course of food security planning in a developing country. The broad objectives which have been identified are Physical, Political, Economic and Social/Cultural.

e) **Fourth Level: Goals**: A breakdown of the broad objectives of Level Three is given in this level. This breakdown provides more specific goals for the food security planning objectives identified through the intensive literature survey mentioned above. The prominent goals under each broad objective are used for this purpose. The resulting hierarchy structure for this problem is shown in Figure 1 below:

Figure 1: An Analytic Hierarchy of the Food Security Problem of a Developing Country
Legend:



Ph1 – Meeting minimum nutritionally adequate food requirements of all people; Ph2 – Conservation of environment; Po1 – Achieving a pre - set level of food self - sufficiency; Po1 – Stabilise food supplies; E1 – Optimising inputs usage; E2 – Optimising energy usage; E3 – Optimising individual income; E4 – Optimising government income; E5 – Minimising distribution costs; SC1 – Satisfying all people's food habits; SC2 – Maximising employment opportunities.

3. Study Methodology

The questionnaire survey method was employed to determine the priority and relative weights of food security planning objectives in a developing countries with focus on Tanzania. The survey instrument was constructed in a way which would enable the elicited preference judgements from experts in food security planning to be analysed using the Analytic Hierarchy Process (AHP) technique.

3.1 The Analytic Hierarchy Process: A Review

The Analytic Hierarchy Process (AHP) developed by Thomas Saaty (Saaty, 1990) is a multicriteria decision making technique which decomposes a complex problem into a hierarchy, in which each level is composed of specific elements. The overall objective of the decision lies at the top of the hierarchy, and the criteria, sub criteria and decision alternatives are on descending levels of this hierarchy. The hierarchy does not need to be complete, i.e., an element in a given level does not have to function as a criteria for all the elements in the level below. Thus a hierarchy can be divided into sub hierarchies sharing only a common topmost element.

Once the hierarchical model has been structured for the problem, the participating decision makers provide pairwise comparisons for each level of the hierarchy in order to obtain the weight factor of each element on that level with respect to one element in the next higher level. This weight factor provides a measure of the relative importance of this element for the decision maker.

To compute the weight factors of n elements, the input consists of comparing each pair of the elements using a scale set of

$$s = \left\{\frac{1}{9}, \frac{1}{8}, \frac{1}{7}, \frac{1}{6}, \frac{1}{5}, \frac{1}{4}, \frac{1}{3}, \frac{1}{2}, 1, 2, 3, 4, 5, 6, 7, 8, 9\right\}$$

The pairwise comparison of element i with element j is placed in the position of aij of the pairwise comparison matrix A as shown below:

$$A = \begin{bmatrix} a_{11} & a_{12} \cdots & a_{1n} \\ a_{21} & a_{22} \cdots & a_{2n} \\ . & . & . \\ . & . & . \\ a_{n1} & a_{n2} \cdots & a_{nn} \end{bmatrix}$$

The reciprocal value of this comparison is placed in the position aji of A in order to preserve consistency of judgement. Thus, given n elements, the participating decision maker compares the relative importance of one element with respect to a second element, using the 9-point scale shown in Table 1 below:

Table 1: The 9-point scale for pairwise comparisons

Importance	Definition	Explanation
1	Equal importance	Two elements contribute identically to the objective
3	Weak dominance	Experience or judgement slightly favours one element over another.
5	Strong dominance	Experience or judgement strongly favours one element over another.
7	Demonstrated dominance	An element's dominance is demonstrated in practice.
9	Absolute dominance	The evidence favouring an element over another is affirmed to the highest possible order.
2,4,6,8	Intermediate values	Further subdivision or compromise is needed.

Hence, if element one was strongly favoured over element two, for example, then $a_{12} = 5$. If the converse was true, element two was strongly favoured over element one, a_{12} is the reciprocal value 1/5. The pairwise comparison matrix is called a reciprocal matrix for obvious reasons.

The AHP technique was adopted because apart from enabling rank ordering of the objectives under consideration, it also provides relative weighting of the objectives through a priority vector. The priority vector ranks a given set of objectives together with the degree to which the objectives are preferred. Another advantage of the AHP technique is that it provides a direct measure of inconsistency of judgements provided by each respondent. The main weakness of the AHP technique is that the 9 point scale with its associated verbal descriptions may confuse the decision makers.

The questionnaire was designed in two parts. The first part requested an ordinal ranking of elements in a given level. Given the ranking, the second part conducted a set of pairwise comparisons on the elements in line with rankings provided in the first part.

3.2 Administering the Survey Questionnaire

After extensive pre testing, the survey questionnaire was administered to experts in food security planning in Tanzania, one of the LIFD developing countries, to get expert judgement on ranking and weighting of food security planning objectives. The chosen group consisted of students, academicians, business persons as well as politicians. It was envisaged that the above spectrum would give a generalisable opinion. Thirty questionnaires were distributed, of which twenty were returned.

3.3 Prioritisation

The response from each respondent was analysed using a specially written computer program. This program utilises the multiplicatively normalised geometric means AHP method as follows. To obtain the priority structure of the food security planning objectives, elements in each level of the hierarchy in Figure 1 were pairwise compared in the AHP fashion. The pairwise comparison was done with reference to their relative importance (effect) on an element in the next higher level (the governing element), by experts in food security planning in Tanzania using the AHP's 9 point scale. This generated a judgement matrix $A = (a_{ij})$ in which $aij = \frac{1}{a_{ji}}$ and $a_{ij} = 1$. A_{ij} is the degree of importance (effect) of element i relative to element j in the level with respect to the governing element. **A** is accepted or rejected depending on whether or not it satisfies the consistency measure. (Alphonce, 1997b)

The degree of importance of element i relative to all elements in the level with respect to a governing element k is given by w_{ik} which is obtained as follows (Barzilai et al, 1987):

$$w_{ik} = \left[\prod_{j=1}^{n} aji\right]^{\frac{1}{n}}, \quad \prod_{i=1}^{n} w_{ik} = 1 \qquad (1)$$

where n is the number of elements in the level governed by element k.

The overall degree of importance of element i in a level relative to all elements in that level with respect to the overall goal is given by w_i which is computed as (Barzilai et al, 1992):

$$wi = \prod_{k=1}^{m} (w_{ik})^{w_k} \qquad (2)$$

where w_k is the overall degree of importance of the governing element k.

The w_i's of the elements in the lower level of the hierarchy in Figure 1 gave the priority structure of the food security planning objectives as perceived by individual experts in food security planning in

Tanzania which took into considerations all factors involved in the food security of a LIFD developing country.

3.4 Amalgamation of Group Rankings

The group responses were aggregated using two different analyses. First, the statistical agreement among members was calculated. This determined the extent to which the respondents applied similar criteria in completing the questionnaire. It is also a test of content validity of the questioning device.

The null hypothesis was that there is no statistically significant difference in the rankings of objectives among the group members. If the null hypothesis is not rejected (i.e. there is statistically significant agreement between respondent) the aggregate group ranking is then determined using the geometric means of individual judgements. These analyses are discussed below.

3.5 Statistical Agreement Among Respondents:

To test for the existence of significant agreement in ranking of the elements at each level of the food security planning problem hierarchy (See Fig. 1) Kendall's coefficient of concordance was used (Shannon, 1968). In short this test is as follows:

Suppose m experts are ranking n items, let r_{ij} be the rank of item j provided by expert i. If there are ties then the tied items are given the mid point of the ranks which they tie. The sum of all ranks given to item j by all experts is

$$Rj = \sum_{i=1}^{n} r_{ij}, \tag{3}$$

the average of rank sums of all items is

$$\bar{R} = \frac{1}{n} \sum_{j=1}^{n} R_j. \tag{4}$$

and the sum of square deviations of item rank sums from the average of rank sums of all items is given by

$$S = \sum_{j=1}^{n} \left(Rj - \bar{R}\right)^2 \tag{5}$$

In the absence of ties the Kendall's coefficient of concordance is defined as

$$C = \frac{12S}{m^2 (n^3 - n)} \tag{6}$$

This gives a number between 0 and 1 where C = 0 implies perfect disagreement and C = 1 implies perfect agreement.

If ties are present then a correction factor has to be introduced in the value of C as follows. Let t be the number of items in expert i's rankings which tied for a given rank, the correction term from expert i's rankings is

$$Ti = \frac{\sum (t3 - t)}{12} \tag{7}$$

the summation is over all tied groups within i's rankings. Taking into consideration all experts with ties leads to the following formula for C

$$C = \frac{12S}{m^2(n^3 - n) - 12m\sum_{i=1}^{m} T_i} \qquad (8)$$

When n ≥8, Staticians have shown that the statistic m(n-1)C follows χ^2 distribution with n - 1 degrees of freedom (Bowen and Starr, 1982). Hence we can test for existence of significant agreement among experts in ranking the items by testing whether or not the computed m(n - 1)C value is greater or less than the critical χ^2 value.

For n < 8 we test the computed value of S against critical values of S using tables such as Table 6 in Kendall, 1970 (Kendall, 1970).

3.6 *Determination of Consensus Group Rankings*

Once the statistical agreement among respondents was established, aggregate group rankings were established as follows: Suppose

is the judgement of the relative importance of element i to j supplied by the k^{th} expert for k = 1, 2, ...N and N is the number of experts involved in the comparisons.

The group consensus on the relative importance of element i to j was determined as:

$$a_{ij}^{G} = \left[\prod_{k=1}^{N} a_{ij}^{k}\right]^{\frac{1}{N}} \qquad (9)$$

The matrix $A = \left[a_{ij}^{G}\right]$ was then considered to be the decision makers' consensus judgement matrix. From this matrix the consensus rankings and the consensus overall weights of the food security planning objectives was synthesised using the multiplicatively normalised geometric means of AHP method as follows:

Local weights for each element i in the hierarchy with respect to criterion k was computed as:

$$wik = \left[\prod_{j=1}^{n} a_{ij}^{G}\right]^{\frac{1}{n}}, with \prod_{i=1}^{n} w_{ik} = 1 \qquad (10)$$

For the case in which an element i in the hierarchy is influenced by more than one element in the immediate higher level the global weight of that element was computed as follows:

$$wi^{*} = \left[\prod_{k=1}^{n_i} w_{ik}^{wk^{*}}\right]^{\left[\sum_{k=1}^{n_i} w_k^{*}\right]}, with \prod_{i=1}^{n} w_i^{*} \qquad (11)$$

where n_i is the number of elements in the immediate higher level influencing element i.

When element i is influenced by only one element k in the immediate higher level the global weight of i was computed as:

$$w_i^{*} = w_{ik} * w_k^{\frac{1}{n}}, with \prod_{i=1}^{l} w_i^{*} = 1 \qquad (12)$$

where n is the number of elements influenced by element k and l is the number of elements in the hierarchy level of which i is a member.

4. Results and Discussion

There were 50 paired comparisons derived from the four level incomplete hierarchic structure of the food security planning objectives.

4.1 First Level - Scenarios

At this level two scenarios for the food security future of a LIFD developing country identified are National Food Self Reliance (NFSR) and National Food Self Sufficiency (NFSS). The group consensus ranking and global weights of these scenarios obtained from the experts in food security planning in Tanzania's responses are given in Table 2

Table 2: Group consensus rankings and global weights for elements in Level One

	NFSR	NFSS
Rank	1	2
Weight	1.003	0.997

Table 2 shows that experts in food security planning in Tanzania do not differentiate much between achieving National food security through self reliance or through self sufficiency. The two are almost equally weighted. For these rankings the computed S value is 0 and Kendall's coefficient of concordance is 0. This indicates a strong statistical disagreement among respondents in ranking the elements in this level.

When there is a strong statistical disagreement among respondents in ranking elements of a particular level in an AHP hierarchy, the exercise should be repeated. If this is not possible then all elements in that level should be assigned equal weights. This is basically the same as removing them from consideration as they will not influence the elements in the level immediately below them. This is what the group consensus synthesis in Table 2 did.

4.2 Second Level - Participants

In level two the identified participants whose actions affect the future of a nation's food security are Government(GOVT), Farmers(FARM), Private Traders (PTRD) and International Community (ICOM). Group consensus rankings and global weights of elements in this level are given in Table 3

Table 3: Group consensus rankings and global weights for elements in Level Two

	FARM	GOVT	PTRD	ICOM
Rank	1	2	3	4
Weight	2.099	1.483	0.659	0.487

According to results in Table 3, it seems that experts in food security planning in Tanzania place more emphasis on farmers needs and requirements when planning the nation's food security future. This is followed by priorities on government, traders, and international community interests in that order.

The computed S value for rankings of elements in level two is 1082 and Kendall's coefficient of concordance is 0.54. The critical S value for 20 experts ranking 4 elements from Table 6 in Kendall, 1970 is 258. Since the computed S value is greater than the critical S value the conclusion is that there is a strong statistically significant agreement among experts in ranking elements in this level.

4.3 Level Three - Broad Objective

Level three of the food security planning problem Hierarchy is made up of four broad objectives namely, Physical (PHYS), Political (POLI), Economic (ECON) and Social/Cultural (SOCU).

Consensus rankings and global weights for the broad objectives by the entire group of experts is given in Table 4.

Table 4: Group consensus rankings and global weights for elements in Level Three

	ECON	PHYS	SOCU	POLI
Rank	1	2	3	4
Weight	1.408	0.934	0.881	0.863

Results in Table 4 show that experts in food security planning in Tanzania give economic objectives greater weight in planning the nation's food security. This is followed by physical, social/cultural and political objectives respectively.

4.4 Level Four - Measurable Goals

The fourth and final level of the food security planning problem hierarchy consists of measurable goals of the broad objectives. Table 5 gives the group consensus rankings and global weights for the measurable goals under economic broad objective.

Table 5: Group consensus rankings and global weights for measurable goals under economic objective

	EC1	EC5	EC2	EC3	EC4
Rank	1	2	3	4	5
Weight	1.772	1.120	1.063	0.899	0.743

Results in Table 5 show that in doing food security planning in Tanzania much weight is given to of inputs usage. This is followed by minimisation of food distribution costs, optimisation of energy usage, maximisation of individual incomes and finally maximisation of government income.

For the rankings of measurable goals under economic objective, the computed S value was 530.7 and Kendall's coefficient of concordance was 0.265. The critical S value for 20 experts ranking 5 objects is 468.5. Since the computed S value is greater than the critical S value the conclusion is that there is a statistically significant agreement among experts in food security planning in Tanzania on the ranking of measurable goals under economic objective.

Consensus group rankings and global weights for the measurable goals under the physical broad objective by the entire group of experts is given in Table 6.

Table 6: Group consensus rankings and global weights for measurable goals under the Physical broad objective.

	PHY1	PHY2
Rank	1	2
Weight	1.245	0.750

Table 6 indicate that meeting minimum nutritionally adequate food requirements of all people is a more important physical measurable goal than environmental conservation in planning Tanzania's food security.

The computed S value for the individual experts ranking measurable goals under the physical broad objective was 72 and Kendall's coefficient of concordance was 0.36. Although Table 6 in Kendall, 1970 does not provide critical S value for ranking of 2 items, the computed Kendall's

coefficient of concordance suggest existence of statistically significant agreement among respondents in ranking measurable goals under the physical broad objective.

Consensus rankings and global weights of measurable goals under the social cultural broad objectives as supplied by experts in food security planning in Tanzania are given in Table 7.

Table 7 shows that in planning Tanzania's food security, priority in social cultural objective is given to the maximisation of employment opportunities followed by satisfaction of all people's food habits.

Table 7: Group consensus rankings and global weights for measurable goals under the social cultural broad objective

	SC2	SC1
Rank	1	2
Weight	1.075	0.819

The computed S value and Kendall's coefficient of concordance for the individual experts ranking measurable goals under the social cultural broad objective were 4.5 and 0.023 respectively. These values indicate a slight statistical agreement among respondents in ranking measurable goals under the social cultural broad objective.

Consensus rankings and global weights of measurable goals under the political broad objectives as supplied by experts in food security planning in Tanzania are given in Table 8. Results in Table 8 show that experts in food security planning in Tanzania accord more weight, in the political broad objective, to stabilising food supplies than in achieving a pre - set level of food self sufficiency.

Table 8: Group consensus rankings and global weights for measurable goals under the political broad objective

	PO2	PO1
Rank	1	2
Weight	1.107	0.779

The computed S value and Kendall's coefficient of concordance for the individual experts ranking elements in table 8 were 8 and 0.04 respectively. These values indicate an existence of some statistically significant agreement among respondents in ranking measurable goals under the political broad objective.

5. Internal Consistency of Judgement

The individual experts consistency as well as the overall group consistency were measured by the method developed by Alphonce (1997b). Consistencies are an indication of the extent to which inconsistencies exist among the pairwise comparisons conducted in the questionnaire.

Among the 20 respondents 12 were consistent in their judgements and the overall group judgement was consistent. These consistencies indicate that in general experts in food security planning in Tanzania were consistent in weighting and ranking food security planning objectives in Tanzania.

6. Conclusion

This paper has illustrated the potential of using AHP technique as the basis for a systematic approach to the identification and prioritisation of food security planning objectives in LIFD developing countries. As pointed out by Alphonce (1997a), with the exception of a few cases, this qualitative decision-making technique has not been used extensively in agricultural decisions in developing countries.

The ranking and degree of importance of these objectives were from the preference judgements elicited from experts in food security planning in Tanzania one of the LIFD developing countries. Analysis of the responses indicated that economic food security planning objectives are the most important in food security planning in LIFD developing countries.

The results obtained from the AHP analysis provide the priority structure and weighting factors (preference of planners and or decision makers) for the food security planning objectives and goals. These priorities and global weights can be used in formulating an effective and efficient national food security plan and in advising producers and consumers on what to produce or buy when and where.

References

Alphonce C. B. (1997a) Application of the Analytic Hierarchy Process in Agriculture in Developing Countries, *Agricultural Systems*, vol. **53**, pp. 97-112

Alphonce, C. B. (1997b) A Measure of Consistency in the analytic hierarchy process: An extension of Golden and Wang method *Uhandisi Journal*, Vol. **21** no. 2, pp. 72 - 84

Barbara, H. (1990) FAO's Overall Approach and Methodology for Formulating National Food Security Programmes in Developing Countries. *IDS Bulletin*, vol. **21** no. 3, pp. 72 - 80.

Barzilai, J.; Cook, W. D. and Golany, B. (1987) Consistent Weights for Judgements Matrices of the Relative Importance of Alternatives *Operations Research Letters*, vol. **6**, no. 3, pp. 131 - 134.

Barzilai, J.; Cook, W. D. and Golany, B. (1992) The Analytic Hierarchy Process: Structure of the Problem and its Solutions in Systems and Management Science by Extremal Methods, pp. 361 - 371, Phillips, F. Y. and Rousseau, J. J. (eds.), Kluwer Academic Publishers.

Bigman, D. And Berck, P. (1993) The multiple Dimensions of the world food problem *Food Security and Food Inventories in Developing countries*, pp 1 - 33, by Bigman D. and Berck P. (eds.), CAB International, United Kingdom

Bigman, D. And Reutlinger, S. (1979) National and International policies toward food security and price stabilization. American Economic Review, Vol. 69, pp. 159-163.

Bowen, E. K. and Starr, M. K. (1982) Basic Statistics for Business and Economics., MacGraw-Hill Book Company, London.

Chishonlm, N. (1996) Irish Aid Involvement in Sustainable Agriculture, *Rural Development and Food Security*, Report prepared for the Irish Aid Advisory Committee, Dublin.

El-Sherbin, A.A. (1979) Food Security Issues in the Arab Near East, Pergaon Press, Oxford.

Kendall, M.G. (1970) Rank Correlation Methods. , Griffin Publishing Company, London.

Lele, U. (1989) Sources of Growth in East African Agriculture. The World Bank Economic Review, vol. 3 no. 1, pp. 119 - 114.

Martin, F. P. (1989) Food Security and Comparative Advantage in Senegal: A Micro-Macro Approach. *Unpublished Ph.D. thesis*, Michigan State University, Michigan.

Reutliger, S. and Pellekaan, (1986) Poverty and Hunger. World Bank Policy Study, World Bank, Washington D. C.

Rukuni, M. and Eicher, C. K. (1987) Food Security for Southern Africa. UZ/MSU Food Security Project, University of Zimbabwe, Harare.

Saaty T. L. (1991) Decision Making for Leaders: The Analytic Hierarchy Process for Decisions in a Complex World. RWS Publications, Pittsburgh.

Saaty, T. L. (1990) Decision Making: The Analytic Hierarchy Process. RWS Publications, Pittsburgh.

Shannon, R.E. (1968) Amalgamation of Group opinions or Evaluations., *The Journal of Industrial Engineering*, vol. 19 number 6, pg. 18 -20.

Shuttleworth, G.; Bull, R. and Hdgkinson, (1998) Food Security Through Seasonal Stabilisation: The case of Madagascar. Food Policy, vol. 13 no 2, pg. 140-153

Stern, E. (1974) Foreign Aid and National Priorities. *Omega*, vol. 2 number 1 pg. 97 - 104

Tabucanon, M. T. (1993) Application of Multiple Decision making Methodology in Food Policy Analysis. In Food Security and Food Inventories in Developing countries, pp 151 - 174 by Bigman D. and Berck P. (eds.), CAB International, United Kingdom.

Vargas, L. G. (1990) An Overview of the Analytic Hierarchy Process and its Applications. *European Journal of Operational. Research.*, Vol. **48**, pp. 2-8.