A Multiple Criteria Analysis for Choosing between Indigenous and Traditional Food Crops to Promote Food Security in South Africa

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Abstract

Despite all the favourable indicators, strong government commitment and South Africa's national food secure status, a large proportion of all households, especially in the rural regions, are still regarded as food insecure. Consequently, rural agricultural development, focusing on cash crops such as sunflower and maize, has been prioritised by government as a way to address food security. However, this did not yield the desired outcomes. On the contrary, the success of indigenous and traditional food crops in the rest of Africa made it an attractive alternative to consider. Hence a great potential exists for increasing the use of indigenous and traditional food crops in the fight against food insecurity. Therefore the aim of the paper is to determine which indigenous and traditional food is likely to make the biggest contribution towards food security.

Key words: Food security; Traditional and Indigenous Foods; Multiple Criteria Analysis; Rural Agricultural Development

1. Introduction

Koch (2011) stated that: *"South Africa is unlikely to feature at the top of the agenda at any international dialogue on food security. The country is a net exporter of agricultural commodities and has a high per capita income, even for an emerging economy. There are no tight foreign-exchange constraints, and the country is not landlocked. The innovative constitution entrenches the right to adequate nutrition, and this is the basis of the national Integrated Food Security Strategy (IFSS). Taking these features into account, one could easily conclude that food ought to be available and accessible in South Africa at all times".*

The confusing reality is that despite all the favourable indicators and South Africa's national "food-secure" status, between 14% and 52% of the households, depending on the source, are regarded as food insecure (HSRC, 2004; Labadarios *et al*., 2008 and StatsSA, 2009; Koch, 2011). It is thus clear that despite strong government commitment, tremendous disparities in food security persist (HSRC, 2008). Statistics suggest that food insecurity is most severe in rural areas, where an estimated 70% of South Africa's poor reside (Koch, 2011). Moreover, rural agricultural development has been prioritised by government as a way of eradicating poverty and ensuring food security in these rural regions. The focus of rural agricultural development is primarily on the redistribution of commercial agricultural land and the production of high-value market crops, i.e. maize, wheat, sunflower etc. and their products. However, similar to other programs and policies, this has not yielded the desired outcome, with the failure being ascribed to the lack of adequate skills and knowledge, inefficient training etc. (Eicher, 1999; Magingxa and Kamara, 2003; Poulton, Kydd and Dorward, 2006; Magingxa, Alemu, and Van Schalkwyk,2009).

This raises the question why the production of indigenous and traditional food crops (ITFCs) have been ignored for so long in governmental policies and programs. Considering the rest of Africa, although mostly produced on a substance level, the important role ITFCs played in ensuring food security is well documented (Yiridoe and Anchirinah, 2005; Modi *et al.,* 2006; Van Vuuren, 2006; Friston *et al*.,2010). The success of and its contribution towards food security in the rest of Africa is ascribed to amongst others the level of traditional knowledge, expertise, skills and practices relating to the production of ITFCs (FAO, 2009). Although being neglected in South Africa, it is unlikely that the traditional knowledge, expertise, skills and practices relating to the production of ITFCs in the rural regions are lost.

This is evident from the fact that ITFCs are still consumed in both rural and urban regions of South Africa. Cloete *et al.,* (2011) informs that consumers in rural regions are consuming ITFCs without knowing that the crops they consume are classified as ITFCs. Moreover, the authors suggest that affordability is one of the reasons why ITFCs are consumed. They conclude by arguing that great potential exists for increasing the use of ITFCs in the fight against food insecurity.

With the afore-mentioned in mind, the paper strives to build on the work by Cloete *et al*., (2011). Therefore the aim of this paper is not to determine why ITFCs are excluded from previous policies and programs, it is rather to inform on which ITFCs are likely to make the biggest contribution towards food security in the North West Province (NWP) of South Africa should it be considered to be an alternative to high-value market crops in policies and programs adopted by governments in its fight against poverty and food security.

2. Study area

The NWP in South Africa is a medium-sized province, covering 11.6 million hectares or 9.7% of the total surface of South Africa. This province was created in 1994 by the merger of Bophuthatswana, one of the former homelands, and the western part of Transvaal, one of the four former South African provinces. The province is mostly rural in nature and is regarded as one of the poorest in the country, with areas that are characterized by high levels of food insecurity and poverty.

The rural regions of the NWP in South Africa accommodate approximately 65% of its inhabitants and the majority of these people are faced with severe economic and socio-economic challenges. Cloete, Van Schalkwyk and Carstens, (2009) reported that 41 out of every 100 people in the province are economically dependent on social funding from government. However, the rural nature and diverse natural resource base of the province provide significant opportunities for agricultural development, which can assist in improving the economic hardship experienced by many in the province.

3. Objectives

As mentioned, the article builds on the work of Cloete *et al*., (2011). Therefore, the overall objective is to determine which of the most consumed ITFCs in the NWP will make the biggest contribution towards the fight against food insecurity. To achieve the primary objective, the following secondary objectives need to be reached:

- Determine the main consumed ITFCs in the NWP;

- Determine the criteria which will be used to rank the different crops in terms of their potential contribution towards food security in the NWP;
- Develop a multiple criteria model that could be used to rank the different ITFCs consumed.

4. Methodology

When choosing between alternatives, a number of conflicting factors need to be considered. Hajkowicz (2006) highlighted that when considering conflict analysis, mainly four economic evaluation frameworks are available, which include: the cost benefit analysis (CBA), cost effectiveness analysis (CEA), cost utility analysis (CUA) as well as the multiple criteria analysis (MCA).

According to Hajkowicz (2006), MCA is likely to be the most suitable framework if there is no monetary cost data available to rank decision upon. Marinoni, Higgins and Hajkowicz (2008) are of the same view, arguing that MCA is an evaluation framework which can be used to rank or score the performance of decision options, e.g. policies, projects, locations etc. against multiple objectives in different units. Therefore, based on this, a MCA model will be developed to rank the importance of ITFCs in terms of their potential contribution towards food security in the NWP.

The first step in the development of an MCA model is to determine the criteria according to which the alternatives will be ranked. The following section will provide a brief overview of the criteria followed by a discussion on the model framework.

Criteria development

The contribution of different ITFCs towards food security will be ranked according to the different aspects in the definition of food security. In other words, the selected criteria will be based on the definition of food security. Several definitions for food security exist. However, for purposes of this study, the definition of the Food and Agricultural Organisation (FAO) will be used. According to the FAO (2006), the definition of food security states that "*it is a human right* *for all people to have access to affordable, safe and nutritional food at all times"*. With this in mind, the criteria that will be used to rank the alternative ITFCs includes: (i) the current market conditions; (ii) the potential market conditions; and (iii) the nutritional values of the specific ITFCs. Data to calculate current market conditions and potential market conditions were obtained from a survey conducted in the NWP which collected data concerning the consumption and production of ITFCs in the region.

The first criterion (current market conditions) was computed by determining through survey data the current production levels of different ITFCs. The second criterion (potential market status) combine three factors, namely (i) the distance to markets, (ii) evolution of the market, and (iii) most preferred ITFCs, which was also obtained from the survey. In other words, the above-mentioned criteria serve as proxies for availability and affordability of food as portrayed in the FAO (2006) definition for food security. The third and final criterion (nutritional values of the specific ITFCs) was used to rank the crops according to their respective nutritional values. Nutritional values for each of the ITFCs were obtained from South African food composition tables (Wolmarans *et al.*, 2010) and serve as a proxy for safety and nutrition as included in the FAO's definition for food security. Originally the 10 most consumed ITFCs in the NWP of South Africa were included in the analysis. However, limited nutritional composition data was available for these 10 ITFCs and as a result, only 6 ITFCs were included in the final analysis. USDA food composition data was also considered, and compared to the available South African data. Vast differences in this comparison resulted in the utilisation of only South African food composition data. Iron, vitamin A, and zinc deficiencies are three of the most prevalent nutrient deficiencies in South Africa (Faber *et al.*, 2007). The nutritional composition of the 6 most consumed ITFCs have therefore been evaluated on their iron, vitamin A and zinc content.

Selection Criteria Model

A wide variety of MCA methods can be used to obtain the final ranking or scoring of the decision option. A comprehensive review of all the possible MCA methods that could be used to rank decision options can be found in Figueira, Salvatore, and Ehrgott (2005). However, Hajkowicz (2006) suggests that the most common MCA methods are the Analytic Hierarchy

Process (AHP), weighted summation, ELECTRE, PROMETHEE, ORESTE and Compromise Programming.

In an attempt to bridge the gap between the different MCA methods, Van Huylenbroeck (1995) combined the principles of the ELECTRE, PROMETHEE and ORESTE. This combined method is known as the conflict analysis method (CAM) and bridges the gap between the different MCA approaches by combining all the strengths and eliminating most of their individual weaknesses. Therefore the CAM approach could be regarded as the most appropriate method to apply when solving conflict decisions.

In order to conduct the CAM, preference indicators have to be calculated for each pair of alternatives. Assuming alternatives *a* and *b*, let $e_j(a)$ and $e_j(b)$ be the preference scores for alternative *a* and *b* respectively. This can be defined as follows in its general form:

$$\mathbf{P}(\mathbf{a},\mathbf{b}) = \frac{\mathbf{1}}{\boldsymbol{n}}\sum_{j=1}^{n} \mathbf{g}_j[\mathbf{e}_j(\mathbf{a},\mathbf{b})] \tag{1}$$

With:

$$e_j(a,b) = e_j(a) - e_j(b) \quad if \quad e_j(a) > e_j(b)$$
$$= 0 \quad if \quad e_j(a) \leq e_j(b)$$

g_j = Weight factor for criteria j

n = Total number of criteria

The preference indicator P(a,b) measures the degree of dominance of *a* over *b* and likewise P(b,a) measures the degree of dominance of *b* over *a*. The degree of dominance *P(a,b)* is a function of both the difference in the evaluation score and the relative importance of the criteria for which *a* is judged to be better than *b*. The two initial scenarios of this study will, however, only consider the difference in evaluation score, as the three criteria developed for this study are regarded as equally important and thus awarded a similar weight. The last scenario, namely the sensitivity test, will be awarded a proportionally heavier weight for the nutritional content of each ITFC. This will test the sensitivity of the model towards weights as well as determine the ITFCs that would be preferred if nutritional values are considered to be of a higher preference.

Ultimately, only two CAM approaches, namely (i) the 0-1 and (ii) multilevel criteria, will be used to determine the preference rankings. The 0-1 criterion is the method usually used in the PROMETHEE approach. This criterion is characterised by an infinite discriminating power. Any difference in score immediately implies a total preference. The multilevel criterion is an extension of the pseudo criterion (Roy, 1985). The level of dominance in the pseudo criterion depends on the interval in which the difference in evaluation scores is situated (Van Huylenbroeck, 1995).

The comparison of both preference indicators makes it possible to determine the degree of conflict between the two alternatives. However, in order to determine the exact relationship between the two alternatives, a PIR test is introduced. The PIR test incorporates indifference and incomparability threshold in order to distinguish between preferences. A schematic presentation of the PIR sensitivity test can be found in Van Huylenbroeck, (1995).

5. Results

Scenario 1: Multilevel preference function with equal weights

Table 1 (see Appendix) illustrates the multilevel preference indicators as used in the conflict analysis. These values are used in the PIR sensitivity test to determine the exact relationship between two alternatives.

Table 2 (see Appendix) reflects on the results from the PIR-sensitivity test and therefore shows the exact relationship between two alternatives using the multilevel comparison method. In other words, Table 2 illustrates the preference of each ITFC in relation to the other ITFCs with: '!' that reflect on indifference, R on incomparability, >/^ on a weak preference and >>>/^^^ which reflect a strong preference.

The ITFCs included in the preliminary analysis can be seen in Table 1. For example, a weak preference for sorghum is reported compared to sweet potatoes. Furthermore, a strong preference for sorghum is reported when compared to cowpea leaves etc. In other words, given the set criteria, calabash is unlikely to make a bigger contribution than sorghum. However, sweet potatoes are likely to make a bigger contribution towards food security than cowpea leaves. Therefore, should government consider ITFCs in the fight against food insecurity, better results will be obtained by promoting the production of sorghum than of cowpea leaves, for example.

Scenario 2: 0-1 criterion function

Similar to the previous section, Table 3 (see Appendix) illustrates the 0-1 preference indicators as used in the conflict analysis. Values obtained in Table 3 form the first step in determining the relationship between two alternatives. The following step will be to use these values in the PIR sensitivity test and to determine the exact relationship between two alternatives. The exact relationship between two alternatives is depicted in Table 4. In other words, Table 4 illustrates the preference of each ITFC in relation to the other ITFCs.

Scenario 3: Multilevel preference function with different weights

This scenario uses the same conflict analysis method as the first scenario, namely the multilevel preference function. However, to test the sensitivity, this scenario alters the weights of the three criteria. In the first scenario all criteria had the same weight. However, this scenario alters the weights so that nutritional value is awarded a 50 percent weight and current market status and potential market status each is awarded a weight of 25 percent. Results for scenario 3 are displayed in Tables 5 and 6. Table 5 displays the preference intensity indicators while Table 6 is concerned with the results of the conflict analysis.

Results shows that sorghum is no longer the most preferred ITFC. Sweet potatoes are now considered to be the best ITFC to address malnutrition while also still considering potential and current market status. This is followed by amaranth leaves, sorghum, pumpkin leaves, calabash and cowpea leaves in order of preference. In other words, the preference order for scenario 3 identifies the ITFCs that are most likely to address malnutrition in the rural areas of the NWP, while also considering potential and current market status, although to a lesser extent.

However, results from this scenario are not recommended if food security in the NWP of South Africa is successfully addressed through the production of ITFCs.

Summary of results

Figure 1 reflects the ranking order obtained by using the multilevel criterion function and the 0-1 criterion function. See Table 2 for a schematic representation of the multilevel criterion function scenario and Table 4 for the schematic representation of the 0-1 criterion function scenario. According to multilevel criterion function scenario (scenario 1) sorghum was ranked as the best ITFC to address food security in the NWP of South Africa. This is followed by sweet potatoes, amaranth leaves, pumpkin leaves, calabash and cowpea leaves in order of preference. Thus, based on the ranking, capital investments in sorghum, sweet potatoes and amaranth are likely to yield the highest returns in terms of the set criteria. However, to confirm the results from the multilevel preference function, the 0-1 criterion function was also applied.

The 0-1 criterion function scenario (scenario 2) used the same criteria as was used for the multilevel preference function analysis. Thus the sensitivity of changes in the preference functions was tested by changing the multilevel preference function to the 0-1 preference function. The change in preference functions resulted in similar results, with sorghum, sweet potatoes and amaranth leaves still ranked as the best ITFCs to promote food security in the NWP of South Africa. The only change was cowpea leaves that ranked 5th and not 6th as was the case with the multilevel criterion function scenario. In the 0-1 criterion function, calabash is considered to be the worst choice in terms of the set criteria.

Results from scenario 3 (multilevel preference function with different weights) shows that sweet potatoes is regarded as the best ITFC to address malnutrition while also considering potential and current market conditions. Sorghum is considered to be the 3rd best ITFC, while calabash is still considered to be the worst (see Figure 1, scenario 3).

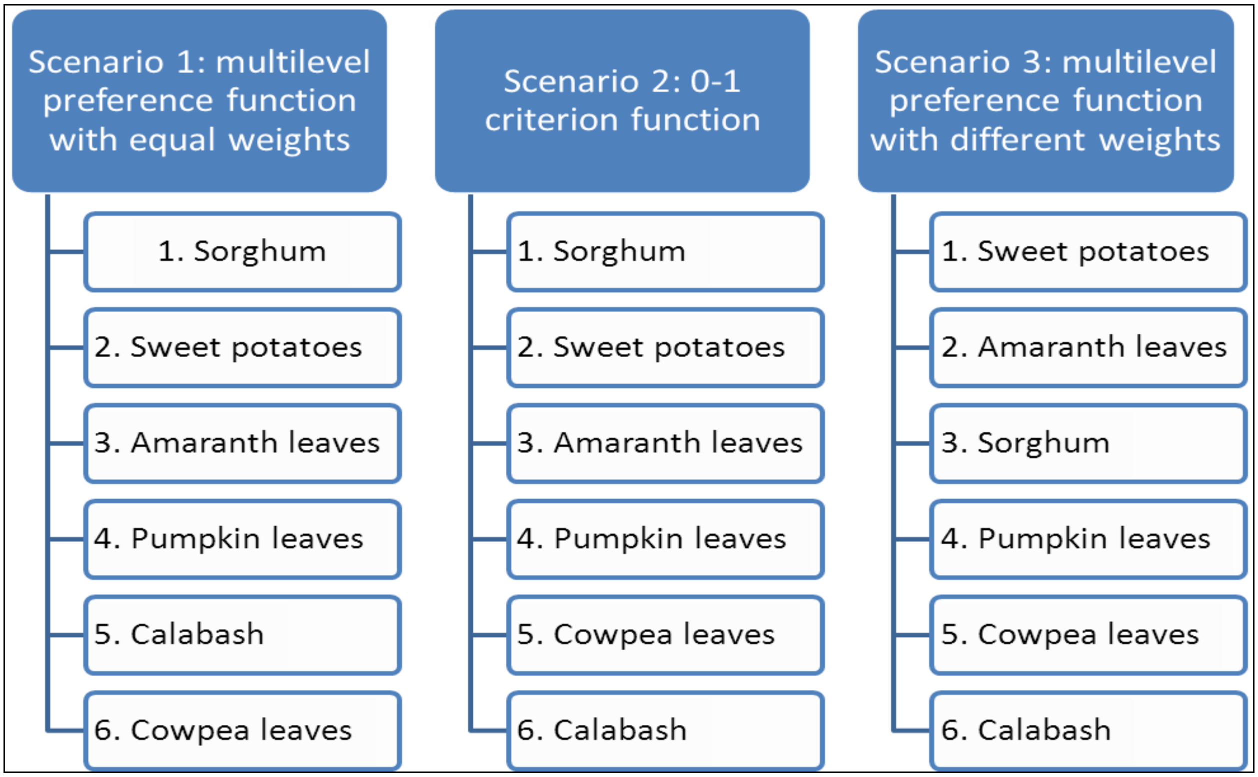

Figure 1: Summarised results of the conflict analysis

6. Conclusion

As mentioned, the high level of food insecurity in South Africa is of concern, especially considering that most of the policies and programs aimed at addressing the issue have not yielded the expected returns. In contrast to South Africa, the role of ITFCs in the fight against food security is well documented in the rest of Africa. This raises the question as to why ITFCs have been ignored for so long in South Africa. However, the aim of this paper is not to determine why ITFCs have been ignored; it is rather to inform on which ITFCs are likely to make the biggest contribution towards food security in the NWP of South Africa, should it be seen as an alternative to high-value market crops in policies and programs adopted by governments in its fight against poverty and food security.

From the results, it is clear that given the set criteria, certain ITFCs are likely to make a bigger contribution than others. From the results, sorghum is considered to be the ITFC that will make the biggest contribution in the fight against food insecurity and poverty. This is followed by sweet potatoes, amaranth leaves, pumpkin leaves, cowpea leaves and calabash. No distinction could be drawn between cowpea leaves and calabash and both are therefore considered to be the worst ITFCs to promote food security and eradicate poverty in the NWP of South Africa. However, if the focus should shift more towards addressing malnutrition in these rural regions while also considering potential and current market status, the best ITFC to consider will be sweet potatoes. In this case, sorghum will rank 3rd most important with calabash still considered to be the worst ITFC according to the set criterion. This article therefore serves as a guideline for government upon which they can base development decisions that relate to the production and contribution of ITFCs towards food security.

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Appendix

Table 1: Multilevel preference intensity indicators (equal weights)

Multilevel compare		P(b,a)					
		Cowpea leaves	Sorghum	Sweet potatoes	Amaranth leaves	Calabash	Pumpkin leaves
P(a,b)	Cowpea leaves	0	1.430126178	0	0	2.655199342	1.110430908
	Sorghum	21.41925957	0	7.366189238	19.83585786	22.64433273	21.14512634
	Sweet potatoes	14.83870445	2.215760297	0	12.46966862	17.49390379	15.67500213
	Amaranth leaves	5.596597638	5.44332211	3.227561813	0	8.25179698	6.432895321
	Calabash	0	0	0	0	0	0
	Pumpkin leaves	0.274133225	0.319695269	0	0	1.818901658	0

Table 2: Results of the conflict analysis for the multilevel compare function with equal weights

Multilevel compare		P(b,a)					
		Cowpea leaves	Sorghum	Sweet potatoes	Amaranth leaves	Calabash	Pumpkin leaves
P(a,b)	Cowpea leaves	!	^^^	^^^	^^^	R	R
	Sorghum	<<<	!	<	<	<	<
	Sweet potatoes	<<<	^	!	<	<	<
	Amaranth leaves	<<<	^	^	!	<	<
	Calabash	R	^	^	^	!	R
	Pumpkin leaves	R	^	^	^	R	!

Table 3: 0-1 preference intensity indicators

0-1 criterion		P(b,a)					
		Cowpea leaves	Sorghum	Sweet potatoes	Amaranth leaves	Calabash	Pumpkin leaves
P(a,b)	Cowpea leaves	0	3.333333333	0	0	10	3.333333333
	Sorghum	6.666666667	0	6.666666667	6.666666667	10	6.666666667
	Sweet potatoes	10	3.333333333	0	6.666666667	10	10
	Amaranth leaves	10	3.333333333	3.333333333	0	10	10
	Calabash	0	0	0	0	0	0
	Pumpkin leaves	6.666666667	3.333333333	0	0	10	0

Table 4: Results of the conflict analysis for the 0-1 criterion function

0-1 criterion		P(b,a)					
		Cowpea leaves	Sorghum	Sweet potatoes	Amaranth leaves	Calabash	Pumpkin leaves
P(a,b)	Cowpea leaves	!	^	^	^	<	^
	Sorghum	<	!	<	<	<	<
	Sweet potatoes	<	^	!	<	<	<
	Amaranth leaves	<	^	^	!	<	<
	Calabash	^	^	^	^	!	^
	Pumpkin leaves	<	^	^	^	<	!

Table 5: Multilevel preference intensity indicators (different weights)

		P(b,a)					
	Multilevel compare	Cowpea leaves	Sorghum	Sweet potatoes	Amaranth leaves	Calabash	Pumpkin leaves
P(a,b)	Cowpea leaves	0	3.2177839	0	0	5.318733285	2.498469544
	Sorghum	12.04833351	0	4.143481446	11.15767005	14.14928289	11.89413357
	Sweet potatoes	9.672528827	4.985460667	0	7.0141886	14.99126211	12.01679843
	Amaranth leaves	9.920354307	12.24747475	7.26201408	0	15.23908759	12.26462391
	Calabash	0	0	0	0	0	0
	Pumpkin leaves	0.154199939	0.719314356	0	0	2.97446368	0

Table 6: Results of the conflict analysis for the multilevel compare function with different weights

		P(b,a)					
	Multilevel compare	Cowpea leaves	Sorghum	Sweet potatoes	Amaranth leaves	Calabash	Pumpkin leaves
P(a,b)	Cowpea leaves	!	^^^	^^^	^^^	<	R
	Sorghum	<<<	!	!	R	<	<
	Sweet potatoes	<<<	!	!	R	<	<
	Amaranth leaves	<<<	R	R	!	<	<
	Calabash	^	^	^	^	!	!
	Pumpkin leaves	R	^	^	^	!	!