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Full Length Research Paper

Choosing between agricultural development projects in the North West Province of South Africa: A multiple criteria analysis

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In the light of past development failures, coupled with the pressure on government to deliver on their promises made towards agricultural development, a need was developed for a framework to assist government in choosing between agricultural development projects in the North West Province, consequently assisting government with their budget allocation towards agricultural development. Consequently, detailed agricultural development plans were drafted with the intent to provide a framework or roadmap that will enable small-scale farmers to be more successful over the long term. With a government that is often faced with strict budget constraints, budget allocations to agricultural development initiatives should be done in a way that will yield the highest economic, social and environmental returns. Hence, a decision support system that will guide budget allocation for agricultural development initiatives is sorely needed. This article provides a framework on how multiple criteria analysis can be used as a decision support tool that will ensure optimal budget allocation for agricultural development. Findings from the study concluded that the beef production (based on a joint venture business concept and linked to the Western Frontier Beef Beneficiation program) is one of the most viable and sustainable agricultural projects in the North West Province. Following beef production is vegetable production which makes use of the contract grower concept, goat meat (Public Private Partnership), grain (joint venture), veldt management and the Taung Irrigation Scheme which employs contract farming.

Key words: Agriculture, development, multiple criteria analysis.

INTRODUCTION

Large amounts of taxpayers' money have been invested in agricultural development initiatives in South Africa; but unfortunately, most of them have not been successful. This has increased pressure on government departments to deliver on their promises made, as more and more productive agricultural land has been virtually taken out of production. Besides, most of the past development initiatives have simply become poverty traps, which has added to the economic hardship already experienced by most people in the rural regions of the country (Cloete, 2010). Several authors including Eicher (1999), Magingxa and Kamara (2003), Poulton et al. (2006), as well as, Magingxa et al. (2009) suggested that a lack of adequate skills and knowledge, access to inputs and market information, credit availability, inadequate extension services and insufficient training can be held responsible for past development failures.

In addition to this, Nel and Davies (1999) considered droughts, lack of access to land, shortage of funds, and limited access to external markets, failure to penetrate established markets and insufficient marketing as restraining factors towards the success of agricultural development in South Africa. Thus, one might conclude that the failure of past agricultural development initiatives

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revolve around human, institutional, infrastructure and natural resource endowments, with most of these factors being interrelated. Munro (1999) was of the same view, suggesting that most factors that inhibit agricultural development are integrated. The United Nations (2002) suggested that in order to address interrelated factors that inhibit development, a co-ordinated response that draws on the strength of all stakeholders is needed. This requires putting in place a framework that incorporates appropriate policies, institutions and the mobilising of resources at the national, provincial and regional levels (United Nations, 2002).

According to Magingxa (2006), the formulation of workabledevelopment plans/ projects can serve as a means to address the interrelated factors that inhibit agricultural development. In other words, the formulation of development plans can provide a guideline that will incorporate policies, institutions and mobilise resources to a degree that will improve the success of agricultural development. The AgMRC (2010) made a similar observation, suggesting that development plans could improve the success of agricultural development if it provides a "blueprint" on how to create a viable business enterprise. Magingxa (2006) elaborated on this by arguing that development projects will ensure better governance and monitoring, which will consequently result in higher levels of success. However, workable development plans can only address the factors inhibiting agricultural development once they are implemented. This conveys another dimension of agricultural development, with a government that is often faced with strict budget constraints. For example, only 3.66% of the total budget available to the relevant study area is destined for agricultural development (DARD, 2010).

Therefore, with respect to a government that is already under pressure to deliver on its promises made, budget allocations to agricultural development initiatives should be done in a way that will yield the highest economic, social and environmental returns. Such decisions can become extremely complicated, especially, when in search of optimal allocation of limited resources.

With the afore-mentioned in mind, a decision support system that will guide budget allocation for agricultural development initiatives is sorely needed. This article will provide a framework on how multiple criteria analysis can be used as a decision support tool that will ensure optimal budget allocation for agricultural development. The North West Province (NWP) is used as a case study to illustrate the potential of the model.

In order to illustrate how multiple criteria analysis could be used by government to ensure optimal budget allocation, the article will start with a background, that is, the region and the development of agricultural development plans for the selected region.

This will be followed by a discussion on the model framework, algorithms and criteria development, subsequently, followed by the result. The article will conclude with a summary of the results whereupon recommendations will be made.

BACKGROUND TO THE CASE STUDY

The rural regions of the NWP accommodate approximately 65% of its inhabitants and majority of these people are faced with severe economic and socio-economic challenges. Cloete et al. (2009) reported that 41 out of every 100 people in the province are economically dependent. However, the rural nature and diverse natural resource base of the province provides significant opportunities for agricultural development, which can assist in improving the economic hardship experienced by many in the province. Based on this, the North-west government has emphasised the importance of successful rural agricultural development as a mechanism to improve the welfare of the province. In an attempt to co-ordinate agricultural development efforts, the Agricultural Master Plan (AMP) for the NWP was developed and part of the AMP entails the identification of agricultural production opportunities as well as, detailed development plans to guide and assist new entrants and small-scale farmers in the province to exploit these opportunities. The plans identified and developed as part of the AMP provides a framework or roadmap that will enable small-scale farmers to be more successful in the long run. In order to identify potential workable development plans for the NWP, the AMP made use of an integrated spatial agricultural system that was developed as part of the AMP. The integrated spatial agricultural system provided valuable information on the resource status, climate, environment, infrastructure, socio-economic status and current agricultural practices in the province. This information formed the basis for identifying potential development opportunities in the province. In addition, stakeholder workshops were held in each of the local municipalities. This was done to obtain a better perspective of the potential opportunities as well as, factors inhibiting agricultural development in the province.

A total of twenty one workshops were held throughout the province. These workshops were structured in the form of panel discussions for all role-players in the private/commercial agricultural sector, followed by workshops for role-players from the public sector. In general, the workshops were attended by representatives from organised agriculture, farmer's unions, co-operatives, input suppliers, banks, government officials, NGO's, commercial and small-scale farmers, etc. The sessions were guided by a discussion leader who orchestrated the discussion according to the SWOT methodology. Following the identification of potential opportunities, detailed plans were drafted as part of the AMP to provide a framework or roadmap for small-scale farmers to successfully explore each of the identified

opportunities.

Based on the aforementioned, the development plans identified and developed for the different regions of the NWP include:

1. A goat hotel: This business plan is based on a 'co-operative arrangement'/ joint venture between goat owners (farmers) and a dairy parlour, that is, farmers leasing their stock (goats) to the milk parlour.
2. A milk cow hotel: Similar to the goat hotel, this business plan is based on a 'cooperative arrangement' between dairy cattle owners (farmers) and a dairy parlour, that is, farmers leasing their stock to the milk parlour. The concept provides a blueprint whereby both production and income can be increased for the parties involved.
3. Goat meat production: The goat meat business plan revolves around the establishment of a commercial goat farm that can produce large quantities of goat meat, that is, economies of scale. The main aim of the proposed plan is to help small-scale goat meat producers to manage their existing stock under the supervision of an established and knowledgeable commercial producer.
4. Beef production: Similar to the goat meat production plan, the focus is on incorporation of small-scale beef producers into the formal red meat supply chain through the establishment of beef production units/ farms.
5. Broilers: The business plan focuses on vertical integration through contract farming. In other words, it provides a blue print for small-scale poultry producers to enter the formal market by partnering with large-scale producers.
6. Animal feed: Similar to the broiler plan, the focus is on contract farming with the establishment of a feed mill as the main market for small-scale grain producers as well as, the main supplier of inputs to broiler producers and feedlots in the region.
7. Eco-tourism: The business plan focuses on the link between agriculture and tourism for the benefit of the local communities.
8. Grain production: The business plan focuses on the transformation of small-scale grain producers to commercial farmers through producer alignments or joint ventures.
9. Vegetable Production: This business plan focuses on the unlocking of vegetable production opportunities through contract farming principles.
10. Perennial crops: The business plan is based on a public private partnership (PPP) due to the extensive capital and knowledge requirements that accompany perennial crop production.
11. Taung irrigation scheme: The business plan focuses on contract farming between small-scale irrigated producers and SAB (South African Breweries). The contract agreements involve small-scale farmers obtaining contracts to produce barley and maize under irrigation for SAB.
12. Veldt management: Similar to perennial crops, the veldt management plan makes provision for a PPP to improve the level of land degradation through the eradication of bush encroachment, clearing of road reserves and establishment of fire belts.

METHODOLOGY

When choosing between alternatives, a number of conflicting factors need to be considered. Hajkowicz (2006) highlighted that when considering conflict analysis, four main 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), the process of selecting the most appropriate framework will depend largely on the valuation of benefits. If benefits are adequately measured in monetary units, then, BCA provides an appropriate framework and if not, the analyst will need to contemplate CUA or non-market valuations (NMV). MCA is likely to be the most suitable framework if there is no monetary cost data available on which to rank decision (Hajkowicz, 2006). Marinoni et al. (2008) were of the same view, arguing that MCA is an evaluation framework which can be used to rank or score the performance of decision options for example, policies, projects and locations etc against multiple objectives in different units. Therefore, based on this, a MCA model was developed to rank the identified development plans for the NWP.

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 et al. (2005). However, Hajkowicz (2006) suggested that the most common MCA methods are the Analytic Hierarchy Process (AHP), weighted summation, ELECTRE, PROMETHEE, ORESTE and Compromise Programming. Moreover, the studies by Gershon and Duckstein (1983); Ozelkan and Duckstein (1996); Eder et al. (1997); Raju et al. (2000) as cited by Hajkowicz (2006), revealed that changes in the method can change the result, although, the differences are usually minor. However, in an attempt to bridge the gap between the different MCA methods, Van Huylenbroeck (1995) combined the principles of the ELECTRE, PROMETHEE and ORESTE. Van Huylenbroeck (1995) referred to this new MCA method as the Conflict Analysis Method (CAM). The CAM is based on a more general formulation, combining the basic notions of indifference, incomparability and strong preference from the ELECTRE, the different types of preference functions from the PROMETHEE and the PIR-test from the ORESTE approach. As a result, Van Huylenbroeck (1995) bridges the gap between the different MCA approaches by combining the strengths and eliminating their 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:

$$\mathbf{P(a,b)} = \frac{\mathbf{1}}{\boldsymbol{n}} \sum_{j=1}^{n} \mathbf{g_j[e_j(a,b)]}$$

With:

e_j (a, b) = e_j (a) – e_j (b) if e_j (a) > e_j (b) = 0 if e_j (a) ≤ 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 preference score for a criterion is measured along a preference curve, transforming the difference in evaluation scores into a preference between 0 and 1. According to Van Huylenbroeck (1995), six different kinds of preference functions can be used depending on the available data. These are:

i. 0-1 criterion: This is the true criterion function applied in the "ELECTRE" 2 approach or the usual criteria in PROMETHEE, which is characterised by an infinite discriminating power. In this case, a difference in the preference function between alternatives immediately implies a total preference.
ii. 0-1 criterion with indifference area: The same is true for this preference function, but here, an indifference threshold to allow a margin of error is considered.
iii. Multilevel criterion: This criterion is an extension of what Roy (1985) is calling a pseudo criterion. The level of dominance depends on the interval in which the difference in evaluation scores is situated.
iv. Linear criterion: This is probably the most common type of preference function and the one applied in the weighted summation technique. The slope of the preference function depends on the value of the total preference threshold.
v. Rank order criterion: This is a discontinuous type of preference function that only makes use of the ranking of the objects for each criterion.
vi. Gaussian criterion: In this preference function, the preference score changes continuously with the difference in evaluation scores.

This study will only make use of the multilevel criterion and the 0-1 criterion. The reason for using the 0-1 and the multilevel criteria is that, the 0-1 criterion is characterized by an infinite discriminating power while the multilevel criterion depends on the difference in evaluation scores and is sufficient to accomplish the desired goals. However, essential in the calculation process of the preference function is the establishment of weights for the relevant criteria. Specified criteria have different levels of importance and subsequently cannot be directly compared with each other. This problem can be overcome with the establishment of weights for each criterion which makes it possible to compare criteria with different levels of importance with each other. After the weights have been established for each criterion, each business plan will be weighed using the preference functions discussed earlier. 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).

Establishment of weights

While all the preference scores are calculated, they have to be weighted according to their relative importance. The conflict analysis method (CAM) information on the hierarchy of the criteria can be introduced and obtained in three ways depending on the type of data available, namely: (a) The decision maker is able to give quantitative weights: These are rescaled between 1 and 100.
(b) The decision maker may not be able to give a priority order: In this case, the decision maker is asked to compare the criteria two by two, and the weights are derived from the eigenvector of the pairwise comparison matrix.
(c) The decision maker is only able to give a ranking order: In this case the expected value of the weights is calculated.

If the decision maker is only able to give quantitative weights, as in this case, Van Huylenbroeck (1995) states that two approaches are possible. The first approach is applied in the "ORESTE" method where the ranking order information of the priorities is combined with the information on the criterion scores in a distance function. However, this is a rather complicated and arbitrary method. Van Huylenbroeck (1995) further explains that the estimation of the expected average value of the g_j -factor is a more theoretically sound way. On the basis of a uniform distribution of weights, it can be proved that the expected average value of the weights fulfilling the conditions imposed by the ordinal rank is given by the following equation:

$$g_j = \sum_{i=k}^{n} \left(\frac{1}{i}\right)$$

With:
k = priority level or ranking of criterion j (with k = 1 for the most important and k = n for the least important criterion).

Modifications to this formula makes it possible to handle ranking orders with ties (by multiplying the weight factor of order *k* by the number of times this ranking order occurs) or with a degree of difference (Van Huylenbroeck, 1995). Based on this, the weights of each sub-criterion are calculated according to their priority ranking. Stakeholders were consulted in an attempt to determine this priority list (Table 1). For example, job creation was identified as a high level priority criterion and was subsequently included as a priority level 1 criterion with a weight of 0.1493. On the other hand, the use of existing state assets were identified as a low priority level criterion and was included as a priority level 5 criterion with a weight of 0.0299 (Table 2). Weights calculated by using their priority levels will subsequently be used in the equation discussed in the model in order to determine the preference function that will indicate the preference of a over b and b over a.

Development of criteria

Balyamujura (1995) suggested that the basic aim of the multiple criteria analysis is to rank the actions that can be taken to solve a problem to which several alternatives but conflicting choices exist. The ranking is based on a set of goals or criteria. Moreover, Fischer et al. (2010) suggested that when evaluating the performance of alternative choices (that is, development plans), often the specification of a single objective function does not adequately reflect the preferences of decision makers. Fischer et al. (2010) suggested that when decision makers deal with practical resource complexities, their preferences are normally of a multi-objective nature; therefore, all factors impacting on agricultural development in the NWP need to be considered when developing a multi-objective MCA model. Considering the preferences of decision makers in the NWP to improve sustainable agricultural development, that is, improve welfare of the community and at the same time, conserve the province for future use, a MCA model was developed that depicted a trade-off between economic, environmental and social factors. Within the background of budget constraints, it is of utmost importance for the government that agricultural development should be conducted in a sustainable

Table 1. Rank order of goals or criteria (level of importance).

Goals or criteria	Rank (Scenario 1)	Rank (Scenario 2)
Job creation	1	1
Income generation	1	2
Economic sustainability	1	2
Social sustainability	2	2
Environmental sustainability	2	2
Adaptability to change	2	3
Use of local resources	2	3
Contribution to GGP	3	1
Potential for replication	3	4
Degree of institutional support	3	3
Economic growth potential	4	1
Use of external resources	4	4
Use of existing state assets	5	5

manner if they are to deliver on their promises made. The Chair in International Agricultural Marketing and Development (CIAMD, 2001) reported that in order to determine the optimal trade-off between the economic, environmental and social objectives, the following criteria need be considered:

(a) Economic benefits to the province: This can be analysed in terms of the number of jobs created, income generated, and the contribution of the specific plan to the geographical product.
(b) The Long-term sustainability of the project in terms of its economic, environmental and social sustainability.
(c) The future prospects of each plan, taking into account its economic growth potential, potential for future replication and adaptability to change.
(d) The degree of local resource utilisation, considering the use of existing state assets, use of local resources, use of external resources and degree of institutional self-reliance.

The afore-mentioned criteria, which are to be optimised in order to attain an increase in welfare, are listed in Table 1. The respective ranking order illustrating the priority level of each criterion is also included in Table 1. The listed criteria were used to evaluate the different alternatives and to determine the best development plan under the set objectives, that is, improved welfare and conservation of the province for future use.

RESULTS

The basic information used to compare the different business plans in terms of a set criterion was obtained from a study done in the Eastern Cape. The criterion was modified according to the inputs from a series of SWOT workshops held throughout the NWP. Important information was acquired from these workshops which ultimately assisted in determining the values of each business plan in terms of the respective criteria (Table 2). Values were awarded depending on the priorities of decision makers, which in this case, reflect on the improvement of the welfare of the communities and the conservation of the province for future use. For instance, each business plan was awarded a value in terms of the potential employment opportunities created. This value was transformed into a percentage value in order to compare the business plans with each other. The business plans generating the highest value in terms of a criterion were awarded a percentage value of 100 while the remaining, received values accordingly. The ranking order may differ, depending on the priorities of the decision maker at a specific time (Table 2). However, before the business plans can be ranked, weights need to be assigned to the identified criteria (Table 2). These weights have been calculated based on the equation described in the establishment of weights. Results obtained can be sensitive to modifications to either the criterion scores, ranking of the criteria or nature of preference function used. Subsequently, sensitivity of modifications can be illustrated by using the following:

(a) Changing the preference function from the multilevel criteria to the 0-1 criteria and
(b) By changing the ranking order (weights) of the criteria (Table 7).

The results of the sensitivity test can be seen in Figures 2 and 3 respectively. In the CAM, a value of 3.5 is applied for β, 7.5 for C* and values of 5 and 1 for $u1$ and $u2$ respectively.

Conflict analysis: Multilevel preference function (base scenario)

Table 3 illustrates the multilevel preference indicators as used in the conflict analysis. These values already incorporate the relative weights of the criteria and are a fair reflection of the preference of each business plan. These values are used in the PIR sensitivity test to determine the exact relationship between two alternatives. Table 3 depicts the values gained from

Table 2. Data for comparison of the different business plans.

Parameter	Weight	Priority ranking	GH	MCH	GM	B	BP	AF	ET	VM	TIS	VP	GP	PC
Job creation	0.1493	1	20.0	19.0	28.6	19.0	48.6	19.5	2.4	47.6	81.0	100.0	95.2	19.0
Income generation	0.1493	1	71.4	71.4	71.4	63.4	71.4	71.4	100.0	71.4	52.7	56.7	83.7	94.2
Contribution to GGP	0.0498	3	12.1	30.2	52.1	7.9	32.6	41.4	0.7	0.4	100.0	41.7	45.2	7.0
Economic sustainability	0.1493	1	60.0	80.0	100.0	80.0	100.0	60.0	60.0	80.0	60.0	80.0	40.0	40.0
Social sustainability	0.0746	2	42.9	57.1	71.4	100.0	85.7	71.4	85.7	71.4	85.7	85.7	100.0	85.7
Environmental sustainability	0.0746	2	75.0	75.0	100.0	60.0	60.0	20.0	100.0	75.0	27.3	21.4	20.0	20.0
Economic growth potential	0.0372	4	75.0	75.0	100.0	75.0	100.0	75.0	100.0	100.0	100.0	100.0	75.0	75.0
Potential for replication	0.0498	3	57.1	57.1	100.0	71.4	85.7	57.1	57.1	100.0	57.1	85.7	57.1	57.1
Adaptability to change	0.0746	2	66.7	66.7	100.0	50.0	100.0	100.0	50.0	100.0	66.7	100.0	100.0	100.0
Use of existing state assets	0.0299	5	20.0	20.0	10.0	10.0	10.0	20.0	10.0	30.0	100.0	40.0	20.0	20.0
Use of local resources	0.0746	2	85.7	85.7	100.0	85.7	100.0	100.0	71.4	100.0	85.7	100.0	100.0	100.0
Use of external resources	0.0372	4	75.0	75.0	75.0	62.5	87.5	62.5	100.0	62.5	75.0	87.5	62.5	62.5
Degree of institutional support	0.0498	3	2.5	1.0	0.6	3.8	0.9	0.7	48.5	100.0	0.3	0.7	0.7	4.4

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = perennial crops.

Table 3. Multilevel preference intensity indicators.

Parameter	GH	MCH	GM	B	BP	AF	ET	VM	TIS	VP	GP	PC
GH	0.00	0.17	0.30	3.60	1.15	3.64	4.47	0.81	4.97	4.84	5.88	6.12
MCH	3.81	0.00	0.25	4.18	1.09	5.82	7.34	1.50	7.21	4.78	8.12	8.99
GM	15.27	11.58	0.00	14.16	3.59	13.35	15.72	6.07	15.30	9.45	14.46	17.02
B	6.17	3.12	1.76	0.00	0.93	6.90	6.67	1.93	6.90	3.92	7.56	8.29
BP	16.02	12.32	3.49	13.22	0.00	13.58	16.72	5.17	12.83	6.21	11.72	16.08
AF	5.50	4.04	0.24	6.18	0.57	0.00	8.27	1.57	4.89	1.69	2.30	3.67
ET	10.37	9.61	6.65	10.00	7.76	12.31	0.00	6.62	12.16	11.67	12.38	11.04
VM	16.16	13.21	6.46	14.71	5.66	15.07	16.07	0.00	15.38	9.12	14.14	17.28
TIS	15.38	13.98	10.74	14.74	8.37	13.45	16.67	10.43	0.00	3.95	7.73	16.30
VP	20.44	16.74	10.08	16.95	6.95	15.44	21.37	9.36	9.14	0.00	8.21	18.29
GP	17.33	15.93	10.94	16.43	8.30	11.89	17.93	10.24	8.76	4.06	0.00	11.03
PC	7.88	7.11	3.81	7.48	2.97	3.57	6.89	3.69	7.65	4.45	1.34	0.00

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = perennial crops.

Table 4. Results of the conflict analysis for the multilevel criterion function.

First action P (a, b)	Second action P (b, a)											
	GH	MCH	GM	B	BP	AF	ET	VM	TIS	VP	GP	PC
GH	!	<	<	!	<	!	<	<	<	<	<	<
MCH	>	!	<	!	<	!	<	<	<	<	<	>
GM	>	>	!	>	!	>>>	>>>	!	>	R	>	>>>
B	!	!	<	!	<	!	<	<	<	<	<	R
BP	>	>	!	>	!	>>>	>>>	!	>	!	>	>>>
AF	!	!	<<<	!	<<<	!	<	<	<	<	<	!
ET	>	>	<<<	>	<<<	>	!	<	<	<	<	>
VM	>	>	!	>	!	>	>	!	>	R	>	>>>
TIS	>	>	<	>	<	>	>	<	!	<	R	>>>
VP	>	>	R	>	!	>	>	R	>	!	>>>	>>>
GP	>	>	<	>	<	>	>	<	R	<<<	!	>
PC	>	<	<<<	R	<<<	!	<	<<<	<<<	<<<	<	!

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = Perennial crops.

Table 5. 0-1 preference intensity indicators.

First action P (a, b)	Second action P (b/a)											
	GH	MCH	GM	B	BP	AF	ET	VM	TIS	VP	GP	PC
GH	0.00	19.91	7.97	56.47	15.43	31.09	42.81	18.65	19.90	19.90	23.62	48.50
MCH	29.85	0.00	7.97	41.54	15.43	23.62	50.27	18.65	27.36	19.90	23.62	33.57
GM	80.85	80.85	0.00	84.57	26.11	67.15	51.00	33.57	41.04	41.03	52.22	67.15
B	23.62	16.16	12.44	0.00	12.44	31.08	53.48	22.39	38.54	27.36	23.62	41.03
BP	77.11	77.11	31.09	77.11	0.00	64.66	51.00	48.50	44.76	27.36	42.27	67.15
AF	32.35	47.28	7.97	50.27	17.92	0.00	42.81	14.93	22.40	12.44	12.44	37.32
ET	46.01	46.01	23.62	38.55	23.62	46.01	0.00	41.03	23.62	23.62	46.01	46.01
VM	66.43	58.97	22.90	66.43	19.15	56.47	44.04	0.00	41.04	23.62	41.54	56.47
TIS	55.24	55.24	40.31	56.48	32.85	66.42	42.81	44.03	0.00	25.38	51.49	66.42
VP	80.10	72.64	34.08	65.18	32.85	77.60	53.99	44.03	52.23	0.00	60.19	70.14
GP	54.74	54.74	37.82	50.27	47.77	44.78	50.27	44.78	44.79	29.85	0.00	37.32
PC	29.86	29.86	22.89	25.39	15.43	19.90	42.81	29.85	22.40	12.44	12.44	0.00

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = perennial crops.

analysing the values in Table 2 with the conflict analysis method (CAM). The goal of the CAM is to determine the relationship between two alternatives, and the values in Table 3 were the first steps in achieving this goal. The following step is to determine the exact relationship between the two alternatives. This step entails using the PIR-sensitivity test. Table 4 reflects on the results from the PIR sensitivity test and therefore, shows the exact relationship between the two alternatives. In other words, Table 4 illustrates the preference of each business plan in relation to the other business plans with: '!' that reflects on indifference between the plans, R on incomparability, > on a weak preference and >>> which reflects a strong preference. For example, from the results, GH is reportedly indifferent compared to B. Furthermore, VP and GM are reported to be incomparable with MCH, with MCH that is likely to yield higher returns than GH and a strong preference for BP is reported when compared to AF etc.

Conflict analysis: 0-1 criterion function (sensitivity test)

Similar to just concluded topic, Table 5 illustrates the 0-1 preference indicators as used in the conflict analysis.

Table 6. Results of the conflict analysis for the 0-1 criterion function.

First action P (a, b)	Second action P (b/a)											
	GH	**MCH**	**GM**	**B**	**BP**	**AF**	**ET**	**VM**	**TIS**	**VP**	**GP**	**PC**
GH	!	<	<	>	<	R	R	<	R	<	<	R
MCH	>	!	<	>>>	<	<	>	<	>	<	<	<
GM	>	>	!	>>>	<	>>>	>	>	>>>	>	R	>
B	<	<<<	<<<	!	<	<	>	<	>	<	<	R
BP	>	>	>	>	!	>>>	>	>>>	>>>	>	<	>>>
AF	R	>	<<<	>	<<<	!	R	<	<	<	<	>
ET	R	<	<	<	<	R	!	<	R	<	R	R
VM	>	>	<	>	<<<	>	>	!	>	R	R	>
TIS	R	<	<<<	<	<<<	>	R	<	!	<	<	>
VP	>	>	<	>	<	>	>	R	>	!	>	>>>
GP	>	>	R	>	>	>	R	R	>	<	!	>
PC	R	>	<	R	<<<	<	R	<	<	<<<	<	!

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = perennial crops.

These values already incorporate the relative weights of the criteria and are a fair reflection of the preference of each business plan. Values obtained in Table 5 were the first steps 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 business plans. The exact relationship between two business plans is depicted in Table 6. In other words, Table 6 illustrates the preference of each business plan in relation to the other business plans. A description of the abbreviations in Table 6 can be subsequently found in conflict analysis: Multilevel preference function with a different priority ranking order of the criteria (sensitivity test).

Conflict analysis: Multilevel preference function with a different priority ranking order of the criteria (sensitivity test)

In order to illustrate the sensitivity with regard to a change in the ranking order of the criteria, different priority levels of criteria were identified (Table 7). This was done by consulting additional stakeholders and is merely an attempt to illustrate the sensitivity of a change in the priority levels of the criteria and to get another perspective on the ranking preferences. Additionally, the inclusion of this scenario in determining the final ranking order gives a better representation of the preferences of all the stakeholders in the province. A preference function similar to that used in the base scenario (that is, multilevel preference function), the change in results is due to the change in the ranking order of the criteria. The new weights awarded to each criterion are as a result of a change in their priority ranking order (Table 7). The changed priority ranking orders are illustrated in Table 7 and this shows a change in the following criteria: income generation (from 2 to 1), contribution to GGP (from 1 to 3), economic sustainability (from 2 to 1), economic growth potential (from 1 to 4), potential for replication (from 4 to 3), adaptability to change (from 3 to 2) and the use of local resources (from 3 to 2). Table 8 shows the preference indicators of the multilevel criteria function with a different criterion. To determine the exact relationship between two alternatives, the preference indicators are incorporated into the PIR sensitivity test (Table 9). A description of the abbreviations with examples on how to interpret the results in Table 9 can be found in the conflict analysis: multilevel preference function (base scenario).

Figure 1 reflects the ranking order that was obtained using the multilevel criterion function (base scenario) (Table 4) for a schematic representation of the scenario. According to Figure 1, vegetable production, veldt management, beef production and goat meat are ranked as the best alternatives, with grain production and the taung irrigation scheme ranked as second best. Although, the remaining six alternatives are on the same level, eco-tourism, broilers and the milk cow hotel concept is preferred over perennial crops, animal feed and the goat hotel plan. Thus, based on the ranking, capital investments into vegetable, beef and goat meat production as well as, improved veldt management are likely to yield the highest returns in terms of the set criteria. However, the preference function combined with the criteria is not sufficient to give a clear representation of which business plans are more preferred when compared to the others. This is evident from the fact that no clear distinction can be drawn between the four best alternatives. Consequently, the 0-1 criterion function was

Table 7. New weights awarded to each sub criteria.

Parameter	Weight	Changed priority ranking order	Previous priority ranking order
Job creation	0.1493	1	1
Income generation	0.0746	2	1
Contribution to GGP	0.1493	1	3
Economic sustainability	0.0746	2	1
Social sustainability	0.0746	2	2
Environmental sustainability	0.0746	2	2
Economic growth potential	0.1493	1	4
Potential for replication	0.0372	4	3
Adaptability to change	0.0498	3	2
Use of existing state assets	0.0299	5	5
Use of local resources	0.0498	3	2
Use of external resources	0.0372	4	4
Degree of institutional support	0.0498	3	3

Table 8. Multilevel preference intensity indicators with a different priority ranking order of the criteria.

First action (a, b)	Second action (b, a)											
	GH	MCH	GM	B	BP	AF	ET	VM	TIS	VP	GP	PC
GH	0.00	0.17	0.30	3.14	1.15	3.64	4.75	1.70	3.90	3.99	4.73	5.36
MCH	4.04	0.00	0.25	5.11	1.09	4.67	7.86	3.78	4.99	3.93	5.82	8.47
GM	16.87	12.94	0.00	16.59	4.95	13.61	15.44	8.88	10.60	8.11	13.28	18.76
B	4.89	2.98	1.76	0.00	0.93	5.61	5.66	2.50	5.00	3.54	5.12	5.92
BP	16.25	12.32	3.49	14.29	0.00	13.16	15.08	6.49	8.27	4.22	10.15	16.47
AF	6.83	3.99	0.24	7.06	1.25	0.00	9.88	4.71	2.91	0.85	1.15	5.15
ET	10.88	10.12	5.01	10.05	6.12	12.83	0.00	5.01	9.45	9.18	12.45	11.71
VM	15.85	14.05	6.46	14.90	5.52	15.66	13.01	0.00	11.83	8.13	13.58	16.72
TIS	24.26	21.48	14.41	23.62	13.53	20.09	23.68	18.06	0.00	8.41	12.93	24.42
VP	22.52	18.59	10.08	20.33	7.64	16.19	21.58	12.52	6.58	0.00	7.79	20.52
GP	18.25	15.47	10.23	16.89	8.57	11.47	19.83	12.96	6.08	2.77	0.00	13.95
PC	5.66	4.90	2.50	4.48	1.67	2.26	5.88	2.89	4.36	2.29	0.74	0.00

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = perennial crops.

also applied and considered.

Figure 2 is a schematic representation of the ranking order obtained by using the 0-1 preference function (Table 6 for a schematic representation of the scenario). The scenario used the same criteria as was used for the multilevel preference function analysis. Hence, 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 better results, with beef production reportedly being the best opportunity to pursue under the set criteria. This is followed by goat meat, vegetable production and veldt management being ranked 2nd, 3rd and 4th respectively. Eco-tourism is believed to be the worst alternative in this scenario. Figure 3 illustrates the results obtained using the multilevel preference function with different priority rankings for the set criteria (Table 7 for the change in priority rankings). New priority levels were identified for each criterion and weights were calculated accordingly. When comparing Figure 3 with the previous scenarios (Figures 1 and 2), it becomes evident that a change in the priority ranking of the criteria has a significant impact on the results. For example, in the previous scenarios, the taung irrigation scheme concept was not one of the preferred plans. However, with the changed priority ranks, results revealed that the plan is the most likely to achieve the set objective. The ranking order could be attributed to the fact that the taung irrigation scheme has high values in criteria such as the contribution to GGP and economic growth potential.

However, this scenario is merely an indication of the sensitivity of the preference order and due to a

Table 9. Results of the conflict analysis for the multilevel criterion function with a different priority ranking order of the criteria.

First action (a, b)	Second action (b, a)											
	GH	**MCH**	**GM**	**B**	**BP**	**AF**	**ET**	**VM**	**TIS**	**VP**	**GP**	**PC**
GH	!	<	<	!	<	<	<	<	<	<	<	<
MCH	>	!	<	!	<	!	<	<	<	<	<	R
GM	>	>	!	>>>	!	>>>	>>>	>	<	R	R	>>>
B	!	!	<<<	!	<	!	<	<	<	<	<	!
BP	>	>	!	>	!	>>>	>>>	!	<	<	R	>>>
AF	>	!	<<<	!	<<<	!	<	<	<	<	<	!
ET	>	>	<<<	>	<<<	>	!	<	<	<	<	>
VM	>	>	<	>	!	>	>	!	<	<	R	>>>
TIS	>	>	>	>	>	>	>	>	!	>	>	>>>
VP	>	>	R	>	>	>	>	>	<	!	>	>>>
GP	>	>	R	>	R	>	>	R	<	<	!	>>>
PC	>	R	<<<	!	<<<	!	<	<<<	<<<	<<<	<<<	!

With GH = Goat hotel, MCH = milk cow hotel, GM = goat meat, B = broilers, BP = beef production, AF = animal feed, ET = eco-tourism, VM = veldt management, TIS = taung irrigation scheme, VP = vegetable production, GP = grain production, PC = perennial crops.

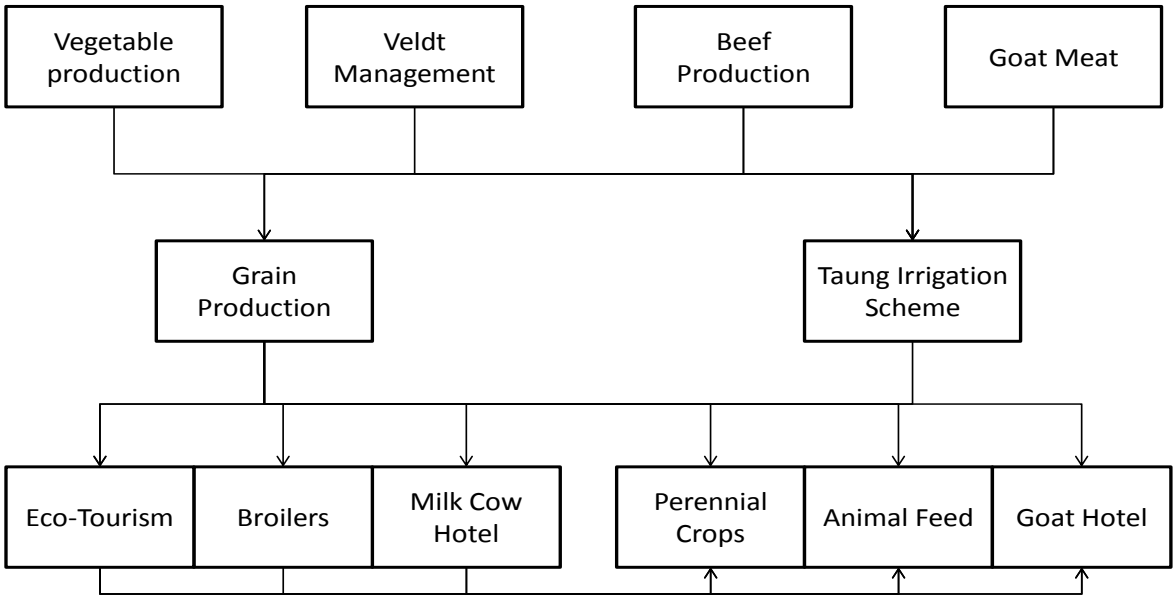

Figure 1. Scenario 1 (multilevel preference function).

preference order, which does not reflect the preferences of the decision makers in the NWP; it will not contribute to the final analysis. Therefore, business plans like beef, goat meat and vegetable production remain highly likely to yield the highest returns in terms of the objective. Alternatives such as the eco-tourism, milk cow hotel, broilers, perennial crops, animal feed and the goat hotel remained lower in terms of achieving the objective. Thus, one might argue that when faced with a budget constraint, investing money or allocating funds towards beef, goat meat and vegetable development initiatives will most likely achieve the set objective (that is, welfare improvement while conserving the province for future use). Note that these results are based on the outcomes that will result from the business concepts and the size of the enterprise/venture.

Conclusion

It is evident from the results that the criteria and the ranking priorities have a significant influence on the

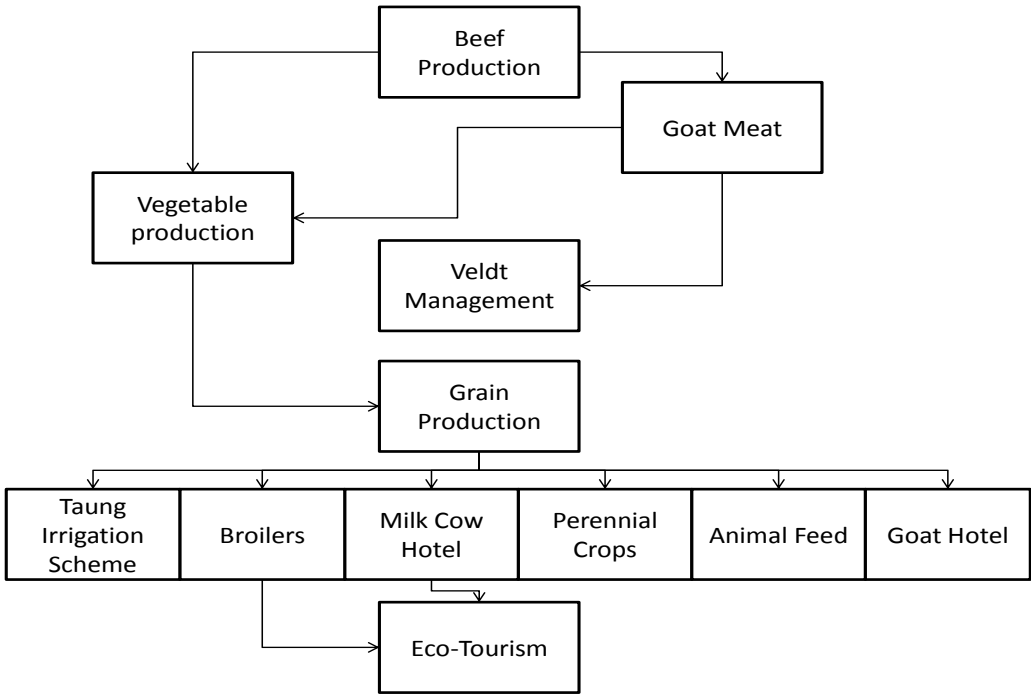

Figure 2. Scenario 2 (0-1 preference function).

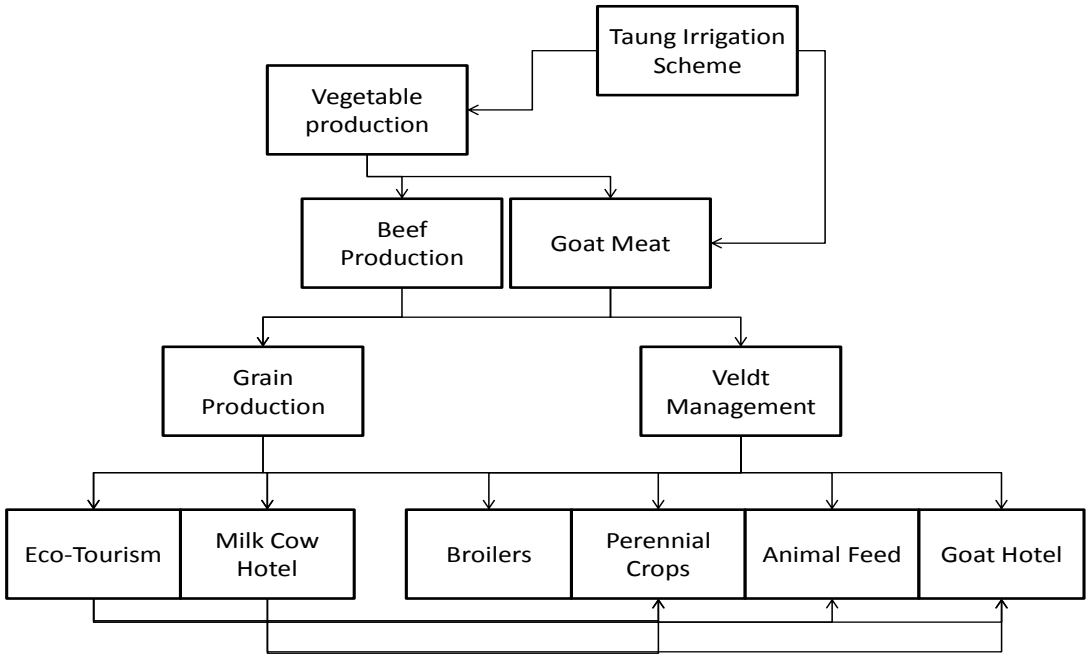

Figure 3. Scenario 3 (multilevel preference function with different ranking of criteria).

outcome of the MCA. However, when considering all relevant scenarios, one might conclude that beef production (regarding the business concept and viable size of the enterprise) is the plan that is most likely to improve the success of agricultural development, and by doing so, to improve the welfare of the province. On the contrary, although, the opportunities exist to engage perennial crop, goat milk and animal feed production in

the province, they are evaluated as the plans which are the least likely to achieve the set objective. Therefore, based on the set criteria and the ranking orders, it is recommended that funds firstly be allocated towards the implementation of beef production initiatives (provided they are based on a joint venture business concept and linked to the Western Frontier Beef Beneficiation Program). Following beef production is vegetable production which makes use of the contract grower concept, goat meat (public private partnership), grain (joint venture), veldt management and the taung irrigation scheme which employs contract farming. As mentioned earlier, other business concepts might also be used to exploit these opportunities. However, once the business concept changes, the depicted ranking order will no longer hold. The reason for this is that once the business model is changed, the way in which the plan satisfies the criteria, that is, number of jobs that will be created by the venture, capital required and income generated etc, will change, resulting in a different ranking order. The ranking order depicted in this chapter therefore, is only valid for the given business concepts and the size of operations.

Abbreviations: AF, Animal feed; **AHP,** analytic hierarchy process; **AgMRC,** agricultural marketing and research council; **AMP,** agricultural master plan; **B,** broilers; **BP,** beef production; **CAM,** conflict analysis method; **CBA,** cost benefit analysis; **CEA,** cost benefit analysis; **CIAMD,** the chair in international agricultural marketing and development; **CUA,** cost utility analysis; **EC,** Eco-tourism; **GH,** goat hotel**; GM,** goat meat; **GGP,** multiple criteria analysis; **MCA,** milk cow hotel; **NGO,** gross geographical product; **GP,** grain production; **MCA,** non-governmental organisation; **NMV,** non-market valuations; **NWDACERD,** north west department of agriculture, conservation, environment and rural development; **NWP,** north west province; **PC,** perennial crops; **PIR-test,** Preference, Indifference and Incomparability test; **PROMETHEE,** preference ranking organization method for enrichment evaluations; **SAB,** south african breweries; **SWOT,** strengths, weaknesses, opportunities and threats; **TIS,** taung irrigation scheme; **VM,** veldt management; **VP,** Vegetable production.

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