EVALUATING DIFFERENT MULTI-CRITERIA DECISION METHODS FOR THE COMPARISON AND INVESTIGATION OF PUBLIC TRANSPORT PROJECTS

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ABSTRACT

Public transport in Cape Town is considered unsatisfactory by many South Africans and private vehicle usage is preferred by most users. The investment in more attractive public transport services is one of the ways to combat the unsustainable move towards private vehicles. Public transport projects are, generally, evaluated using Cost-Benefit Analyses. This research aims to establish an evaluation method, which includes non-monetary criteria, such as accessibility, reliability and convenience. Specifically, it evaluates existing public transport in Cape Town (rail, bus, Bus Rapid Transit (BRT) and minibus taxis), as well as a hypothetical integrated public transport system, using various forms of Multi-Criteria Decision Analysis (MCDA), assuming both weighted and unweighted criteria. The information used in this study was obtained as secondary data through organisations linked to the management of the systems, as well as previous studies. This information was used to determine the criteria that the public transport projects would be measured against. These criteria were weighted using the Analytical Hierarchy Process method with input from academics, government employees, transport engineers and non-profit organisations within the transport discipline. The same survey was then extended to the general public transport users. The scenarios were then evaluated using the Simple Additive Weighting (SAW) method, as well as the Evaluation of Mixed Data (EVAMIX) method of multi-criteria analysis. While the results of the SAW and EVAMIX methods differ slightly, aggregation methods were applied to establish a final ranking. Both MCDA methods provided feasible results and can be applied in the South African context. This project concluded that integrated public transport is the most desirable mode of public transport, while BRT is considered the least attractive.

1. INTRODUCTION

There is a need for affordable, reliable and safe public transport in South Africa. In Cape Town, the most popular modes of public transport are rail, bus, Bus Rapid Transit (BRT) and minibus taxis. At this stage, the various modes are not integrated and, in some instances, are running in parallel.

Many research papers have focused on comparing the capital costs and benefits of public transport investments, resulting in the exclusion of the effects of criteria that are not easily monetised. In South Africa, the Cost-Benefit Analysis (CBA) is often used to evaluate public transport projects, whereas, in this research, Multi-Criteria Decision Analysis

(MCDA) methods are investigated and used. The main objective of this research is to investigate and evaluate existing MCDA methods and establish an alternative method, or tool, that public transport planners can use when evaluating projects.

The often-used CBA involves monetising all costs and benefits relating to a project or policy strategy, and examining the ratio of total benefits with respect to total costs, i.e. The benefits-cost ratio (Browne & Ryan, 2011). According to Bruun & Vanderschuren (2017) and Zak (2010), public transport projects should be evaluated using performance indicators related to the ‘triple bottom line’, i.e. economic, social and environmental impacts.

While MCDA often include ‘cost’ as a heavily weighted criteria, other non-monetised criteria are considered, such as accessibility, reliability, safety, travel time, environmental effects, etc. The lesser researched effects of public transport, such as the effect of property prices and job creation, can be evaluated using a multi-criteria decision analysis should the project lend itself to that.

1.1 Problems to be Investigated

This research aims to test and evaluate the MCDA methods as a tool to assist transport planners in comparing public transport project proposals. The scenarios being compared, using the MCDA methods, are based on the existing modes of public transport in Cape Town, as well as an additional theoretical scenario. Therefore, the five scenarios being compared using the MCDA methods are: Rail (MetroRail); Bus (Golden Arrow); BRT (MyCiTi) Minibus Taxis, and a theoretical integrated public transport system. These scenarios were compared, based on several criteria, including economic, social and environmental impacts.

1.2 Purposes of this Investigation

Little to no research exists comparing different MCDA methods for various modes of public transport, especially in Cape Town where the public transport landscape and the geographical layout of the city differs to other cities around the world. The purpose of the investigation is to provide an analysis tool to assist transport planners working on bettering the existing public transport, as well as assessing the efficiency of proposed public transport projects, before introducing new modes/upgrading the existing modes available.

The research aims to establish which method of analysis and public transport mode (or combination thereof) provide the highest levels of service and positive effects for the lowest overall costs. The research also aims to provide a simple guide to the use of MCDA methods in public transport planning, including the strengths and weaknesses of the multi-criteria decision methods available.

2. LITERATURE REVIEW

A variety of comparative evaluation methods exist. Within this, the popular methods for public transport appraisal are Cost-Benefit Analysis and a variety of Multi-Criteria Decision Analysis methods.

2.1 Cost-Benefit Analysis Method

CBA is the most used evaluation method for assessing infrastructural investments. In the transport field, it is the basic tool used in most countries (Beria et al., 2012). CBA is based on the monetisation and inter-temporal discount. Money is the measure unit used as common numeracy to translate all costs and benefits associated to an investment or a policy. Once all relevant effects of an investment are quantified, the concept of inter-temporal discount is used to translate future costs and benefits to present day, by means of a social discount rate. In this way, the future can be compared with the present (Beria et al., 2012).

CBA weighs the pros and cons of a project in a rational and systematic process. It inherently requires the creation and evaluation of at least two options, “do it or not”, plus it requires an evaluation at several different scales (nothing, minimum and all, as the least requirements) (OECD, 2006; EC, 2008; Ninan, 2008 as cited in Jones et al, 2014).

Costs generally considered in a CBA include those related to construction and future maintenance, such as capital, major rehabilitation, and annual maintenance costs over the life cycle of the project. Other considerations include discounting of future costs and benefits, dealing with opportunity costs, inflation, avoidance of double counting, avoidance of sunk costs, dealing with joint costs and conducting a sensitivity analysis (Kentucky Transportation Center, 2016).

Bruun & Vanderschuren (2017) state that Germany, The United States of America, England, Wales and Denmark use the CBA method. It should be noted that traditionally Cape Town uses the CBA method as well. The advantages highlighted are that it is well-structured, one dimensional, gives an economic result in a transparent manner and a sensitivity analysis is possible. The disadvantages listed are that not all criteria can be converted to monetary values, many calculations are required to conduct the conversion, monetary values and discount costs vary in different countries, and benefits to future generations are omitted.

Analysis that only considers direct impacts and uses a short-term perspective tends to undervalue transit, especially rail (Litman, 2014). It was also found that conventional cost-benefit appraisal consistently yields higher benefit cost ratios for road projects, rather than for most public transport investments (Marsay, 2017). According to Marsay, Eddington showed that the economic benefits could be up to 50% on top of direct vehicle operating cost (VOC) and value of time (VOT) benefits usually captured in transport CBA studies. The reason for this could be the importance placed on travel times, which may underestimate other criteria, such as environmental impact (Browne & Ryan, 2011).

Lastly, it could be argued that many cost estimates have significant variation and uncertainty, as some transportation studies lack details of assumptions and, therefore, estimates may reflect lower costs (Browne & Ryan, 2011).

2.2 Multi-Criteria Decision Analysis Methods

In an attempt to mitigate the weaknesses of the CBA, Multi-Criteria Decision Analysis (MCDA) methods were investigated. In general, a multiple criteria decision problem is a scenario in which a set of actions/solutions (Do nothing / Upgrade Rail / Additional buses etc.) are defined. MCDA consists of a family of criteria (cost / accessibility / safety etc.), the Decision Maker (DM), that tends to determine the best subset of actions and solutions according to the criteria (choice problem), divide the solutions into subsets representing specific classes of solutions, according to the concrete classification rules (sorting problems) or rank the actions and solutions from best to worst, according to the criteria (Zak, 2010).

As previously mentioned, there are many MCDA methods available. Macharis & Bernardini (2015) performed an investigation to establish the most commonly used methods in the transport field. The top three most popular methods are AHP/ANP (Analytic Hierarchy/ Network Process) – often used in combination with another method, such as the Evaluation of Mixed Data method (EVAMIX), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) and Fuzzy Set – often used as part of another method, such as the Simple Additive Weighting Method (SAW, also known as Weighted Sum).

The SAW method appeals to the school of thought of unified scores across alternatives, applying weighting and sums the result per alternative. The EVAMIX method appeals to the second school of thought, which takes it one step further and, after the unification of scores, the alternatives are compared pairwise (Vanderschuren & Frieslaar, 2008).

To compare the outcomes of different methods without the use of specialised software to make the method accessible, the SAW method and EVAMIX method will both be used in conjunction with the AHP method, therefore, appealing to both schools of thought. The methods are described below.

The AHP method, as developed by Saaty (1980) is a helpful tool for managing qualitative and quantitative criteria involved in decision-making. As stated in the name, it is based on a hierarchical structure (Taherdoost, 2017). The AHP method also develops a linear additive model, but in its standard format, uses procedures for deriving weights and the scores achieved by alternatives which are based, respectively, on pair-wise comparisons between criteria and/or options (Department of Communities and Local Government, 2009). The fundamental input to the AHP method is the decision makers' answers to a series of questions in the general form, 'How important is criterion A relative to criterion B?' These pair-wise comparisons can be used to establish the weights for criteria and the performance scores for the options on the different criteria (Department of Communities and Local Government, 2009).

The SAW method, also known as weighted linear combination, weighted summation or scoring methods, is a simple and often used multi attribute decision technique. The method is based on the weighted average. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by the decision maker, followed by summing of the products for all criteria. The advantage of the method is that it is a proportional linear transformation of the raw data, which means the relative order of magnitude of the standardised scores remains equal (Afshari et al., 2010).

The EVAMIX method was first introduced by Voogd (1982, 1983) and developed by Nijkamp et al. (1990), Martel and Matarazzo (2005) cited in Tuş Işık & Aytaç Adalı (2016). A key component of the method is that it includes and combines both ordinal and cardinal, beneficial and non-beneficial data within the same evaluation matrix, hence the name. The EVAMIX method makes different computations to the data in the evaluation matrix depending on whether it is ordinal or cardinal (Hajkowicz & Higgins, 2008, cited in Tuş Işık & Aytaç Adalı, 2016). The EVAMIX is a simple decision support tool: it requires pairwise comparison of alternatives, for each pair of alternatives, and a dominance score for the ordinal and cardinal criteria are calculated. Then these dominance scores are combined into an overall dominance score of each alternative (Hinloopen et al., 2004, as cited in Tuş Işık & Aytaç Adalı, 2016). Finally, the alternatives are ranked based on the appraisal scores (Chatterjee & Chakraborty, 2013, cited in Tuş Işık & Aytaç Adalı, 2016).

A summary of the methods is provided in Table 1:

Table 1: Method Summary for SAW and EVAMIX

Simple Additive Weighting (SAW)	**Evaluation of Mixed Data (EVAMIX)**
Method as described by Afshari, Mojahed & Yusuff (201): STEP 1: Implement the AHP method, as described above, to determine the criteria weights STEP 2: Construct a decision matrix (*m* x *n*) that includes *m* alternatives and *n* criteria. Calculate the normalised decision matrix for positive and negative criteria STEP 3: Apply the weighting and sum the result per alternative Results are generally between 0 and 1, with higher numbers being a more desirable score	The method, as described by Tuş Işık & Aytaç Adalı (2016) STEP 1: Criteria are divided into two categories: ordinal and cardinal STEP 2: The original data is normalised using linear normalisation procedure using different equations for beneficial and non-beneficial criteria STEP 3: Unique pairs of alternatives are identified and the dominance scores of the alternative, on each ordinal and cardinal criterion with respect to other alternatives, are calculated. Thereafter, compute the dominance scores of each alternative pair (i,i’) for all the ordinal and cardinal criteria STEP 4: Calculate the standardized dominance score STEP 5: Calculate the overall dominance score STEP 6: Calculate the appraisal score for each alternative Higher appraisal scores are more desirable

The two chosen MCDA methods will rank the alternatives, however, the results of these rankings may not be the same, because of the different assumptions made in each method, as well as the difference in criteria weights between the weighted and unweighted analyses. In this case, the aggregation of the methods may be needed.

2.3 Aggregation Methods

In this paper, it is proposed that the Borda and Copeland methods are used, as well as the Average Ranking Procedure. The Average Ranking Procedure ranks the alternatives by their mean values, as opposed to the Borda and Copeland Method which rank alternatives by voting (Cheng & Saskatchewen, 2000).

2.4 Stakeholder Involvement

A stakeholder is, by definition, any individual or group of individuals that can influence or are influenced by the achievement of the organisation's objectives (Freeman, 1984, as cited in Macharis et al., 2008).

Multi-Actor Multi-Criteria Analysis (MAMCA) allows evaluating different alternatives on the objectives of the different stakeholders that are involved. It explicitly includes the points of view of different stakeholders (Macharis et al., 2012).

It should be noted that in the case of evaluating transport projects, when the government is one of the stakeholders, it is assumed that this stakeholder represents society's point of view and should, therefore, be the one to use in the evaluation. Analysis of the points of view of the other stakeholders, like users, local population, manufacturers, and so on, will then show if a certain measure will possibly be adopted or rejected by these groups (Macharis et al., 2012).

This thesis adopts a multi-actor multi-criteria analysis using three analysis views (specialist, academic and transport users).

3. STUDY METHOD

There are four popular modes of public transport in Cape Town: rail, the bus service, the BRT service and the minibus taxi service. For the benefit of the study performed, each mode was assumed to be operating exclusively as a scenario / alternative in the MCDA. In addition to this, a fifth, theoretical integrated public transport system, was included as a scenario.

It should be noted that for the theoretical integrated transport system, it will be assumed that the existing rail, BRT and bus service will continue operating and the minibus taxis will operate as feeders to the system. No services will operate in parallel. In addition to this, it is also assumed that the BRT system will not expand and, instead, the funds available will be used to upgrade the existing public transportation along proposed routes.

The scenarios above were evaluated against a set of criteria. To develop the criteria, the most important ones were identified by evaluating official statements and government documents to establish what the focus is regarding public transport in South Africa.

Two methods of MCDA were used, i.e. SAW method and the EVAMIX method, as previously mentioned. The criteria weights were obtained using the AHP method of pairwise comparisons of the chosen criteria. Specialists within the transport discipline (engineers, environmental practitioners, academics etc.) as well as public transport users, were surveyed.

4. STUDY FINDINGS

4.1 Criteria Analysed

Based on the IPTN Development Plan (2018), the following criteria were identified as those with the highest priority in South Africa:

- Public transport system performance (e.g. travel times, reliability, transfer rates).
- Non-motorised system performance (e.g. coverage, condition).

- Traffic safety (e.g. accident, fatality rates).
- Social goals (e.g. affordability, improving access for low-income households to jobs. healthcare and education, making public transport more affordable for the poor. reducing public transport travel times and other aspects of travel difficulty).
- Developmental goals (e.g. building of business capabilities and opportunities for previously disadvantaged groups in the provision of services).
- Environmental goals (e.g. reducing local and greenhouse gas emissions).
- Land use (e.g. the degree to which an alternative might induce non-motorised and transit-oriented land development; the possibilities for increasing public open space).
- Financial efficiency (e.g. improving the financial performance of public transport).
- Cost-effectiveness/value for money, (e.g. the life cycle (all capital, operating and maintenance costs) of achieving transportation objectives, such as travel time savings, accident, and emission reductions….).
- Financial sustainability for the responsible local and provincial governments.

Using the recommended criteria and sub-criteria above as a guideline, a word count was performed in the statements and press releases mentioned previously. The top eight mentioned criteria/impacts are as follows:

1. Cost.
2. Land-Use.
3. Affordability for Users.
4. Accessibility.
5. Estimated Speed.
6. Convenience & Reliability.
7. Environmental Effects.
8. Safety & Security.

A survey, comprised of 28 questions comparing the criteria above, was sent to the transport specialists, as previously described, as well as general public transport users. The criteria were compared using Saaty's nine-point scale (1980), which indicates the importance of criteria A over criteria B and assigns a value (see Table 2).

Table 2: Responses of relative importance based on Saaty's nine-point scale

Preference Index Assigned	**How important is *A* relative to *B***	**Explanation**
1	Equally Important	Two criteria contribute equally to the objective
3	Moderately more important	Experience and judgement slightly favour one criteria over the other
5	Strongly more important	Experience and judgement strongly favour one criteria over the other
7	Very strongly more important	A criteria is strongly favoured over the other (its dominance may even be demonstrated in practice)
9	Overwhelmingly more important	The evidence favouring one criteria over the other is the highest possible order of affirmation
2, 4, 6 and 8 are intermediate values that can be used to represent shades of judgement between the five basic assessments. If *B* is judged to be more important than *A*, the reciprocal relevant index is assigned. Example, if *B* is judged to be *x* more important than *A*, the value of 1/*x* would be assigned to *A* relative to *B*.		

(Source: Berritella et al., 2009)

As mentioned, the results were collated and the weights determined using the AHP method. The final weights are shown below in Table 3, including the academic weighting where all weights were considered equal.

Table 3: Specialist, Public and Academic Weights Calculated

Criteria	Specialist Weight	Public Weight	Academic Weight
Cost	0.14	0.12	0.13
Land-Use	0.13	0.11	0.13
Affordability	0.18	0.16	0.13
Accessibility	0.17	0.20	0.13
Speed	0.06	0.05	0.13
Convenience & Reliability	0.09	0.10	0.13
Environment	0.05	0.09	0.13
Safety & Security	0.19	0.16	0.13
Sum	1	1	1

The general public rated ‘Accessibility’ as the top criteria, whereas the specialists in the private sector and public sector agreed that ‘Safety & Security’ is most important, which is the second most valued criteria to the general public. In addition to rating ‘Safety & Security’ as the second most important criteria, the public also voted for ‘Affordability’ as being equally important as ‘Safety & Security’. The private sector also voted for ‘Affordability’ as the second most important criteria and the public sector voted for ‘Accessibility’ in second place. In third place, the general public, as well as the specialists in the public sector, agreed that ‘Cost’ is important, whereas the private sector rated ‘Accessibility’ as the third most important criteria. While the three perspectives differed in ranking, it can be seen that the top four criteria across the board, in no particular order, are ‘Accessibility’, ‘Affordability’, ‘Safety & Security’ and ‘Cost’.

On the other end of the scale, the lowest weighted criteria were ‘Speed’, for the general public, and ‘Environmental’ for engineers in both the public and private sector. The engineers in both the public and private sector agree that ‘Speed’ is the second least important criteria and, conversely, the general public has ‘Environmental’ listed as the second least important criteria. All three perspectives agree that ‘Convenience & Reliability’ is the third least important criteria. Therefore, it is noted that the bottom three criteria, in no particular order, are ‘Speed’, ‘Environmental’ and ‘Convenience & Reliability’.

Using the AHP method, the consistency ratio was calculated based on the survey results. A consistency ratio of under 10% was achieved. Therefore, it can be concluded that the survey responses were consistent in their answers and, therefore, the participants understood the questions as well as the survey method.

The AHP method is a useful tool for establishing weights in public transport planning as a variety of stakeholders are, and should be, involved in public transport planning, long before implementation. The AHP method lends itself to including an unlimited number of stakeholders from different backgrounds. The AHP method used in this research paper was set up using Microsoft Excel and, while the data input is heavy, it is a cost-efficient and simple solution. Software programmes specialising in AHP exist for larger surveys.

4.2 MCDA Analysis and Results

The criteria mentioned above were measured as follows:

- "Cost" in this study refers to average operating costs and maintenance of infrastructure per km travelled annually (estimated from available secondary data and previous studies performed).

- "Land-use" criterion was evaluated based on the value or size of land currently devoted to transportation facilities (measured in square metres).

- "Affordability" for users will be measured by the estimated cost of travel as calculated in *Affordability and Subsidies in Urban Public Transport: Assessing the impact of public transport affordability on subsidy allocation in Cape Town* (Piek, 2017). The indirect financial benefits to users will not be considered in this criterion, to avoid double counting and vague results.

- "Accessibility" refers to the Geographic Accessibility in this study, i.e., distances between activities and public transport stations/stops, as well as non-motorised transport and parking facilities available. This was evaluated using ArcGIS, the placement of stops and the percentage of Cape Town that is covered by the existing placement of stations/stops.

- "Speed" refers to the speed of the vehicle, which is tied to the travel time. Therefore, this criterion will be measured as User Travel Time in and out of the vehicle.

- "Convenience" focuses on crowd density, as well as other available facilities at stations, namely, toilets, retail, seating, air-conditioning, etc. This was established based on the Western Cape's respondents in the NHTS (2013). As per the NHTS (2013), the level of crowding and availability of facilities were evaluated as two separate questions using the same method of ranking from 1 to 4, with 1 being the best and 4 being the worst. This was coupled with "Reliability" which refers to the punctuality of the public transport mode (NHTS, 2013). The questions, factored into the final result, were based on Frequency, Punctuality and Overall Service. The same ranking of 1 to 4 was applied.

- "Environmental Impacts" refer to the impacts the various modes of transportation have on the environment. However, information for Metrorail, Golden Arrow busses, MyCiTi busses and minibus taxis was not available, therefore, generic figures were used based on passenger rail, busses, BRT and minibus taxi information available.

- The "Safety" criterion is two-fold, referring to both the safety and security of the public transport user. This will be evaluated based on the NHTS (2013). The questions factored into the final "Safety" result were based on Security on the walk to or from the Stop/Station, Security at the Stop/Station, Security on the Vehicle and Accidents. Each question was evaluated using the same method of ranking from 1 to 4, as previously described.

A decision matrix was constructed to include all scenarios and the values/quantities assigned to each criteria, as shown in Table 4. This decision matrix will be used in both the weighted and unweighted MCDA analyses (SAW and EVAMIX methods).

Table 4: Decision Matrix showing the alternatives and criteria

Alternatives / Criteria	Cost (R/km)	Land-Use (area sqm km)	Affordability (%)	Accessibility (%)	Speed (mins)	Convenience & Reliability (Rating)	Environment (CO^2/ pass.km)	Safety (Rating)
Train	21.78	6.57	43	11	113.6	2.66	14	2.44
Bus	25.65	0.2	66	21	104.8	2.2	68	2.26
BRT	85.2	0.48	90	7	97	1.75	68	1.86
Minibus Taxi	4.5	0.24	107	78	75.5	2.35	55	2.35
Integrated	4.65	7.49	77	100	97.7	1	54	2.23

For the SAW method, the decision matrix was normalised and the final score per alternative was calculated, using the sum of the values in the normalised matrix, multiplied by the weights previously calculated. The results of the SAW MCDA are provided in Table 5.

Table 5: SAW Method Results and Ranking

Alternatives / Criteria	Score (Specialist)	Ranking	Score (Public)	Ranking	Score (Unweighted)	Ranking
Train	0.62	4th	0.60	4th	0.64	4th
Bus	0.68	3rd	0.62	3rd	0.66	3rd
BRT	0.582	5th	0.527	5th	0.57	5th
Minibus Taxi	0.836	2nd	0.78	2nd	0.81	1st
Integrated	0.84	1st	0.814	1st	0.80	2nd

As can be seen in the results, the specialist and public weightings result in the same ranking of alternatives, whereas the unweighted analysis ranks slightly differently. However, the least desirable alternative, BRT, is common amongst all three analyses.

For the EVAMIX method, the decision matrix was normalised using a different method. Thereafter, standardised dominance scores were calculated for each pair of alternatives. Finally, an appraisal score was calculated for each alternative. This score was used for the final ranking, which is shown in Table 6.

Table 6: EVAMIX Method Results and Ranking

Alternatives / Score	Specialist Score	Ranking	Public Score	Ranking	Academic Score	Ranking
Train	0.10	5th	0.16	3rd	0.049	4th
Bus	0.18	3rd	0.09	4th	0.08	3rd
BRT	0.11	4th	0.03	5th	0.052	5th
Minibus Taxi	0.29	2nd	0.27	2nd	0.60	2nd
Integrated	0.99	1st	1.77	1st	0.96	1st

As can be seen in the results in Table 6, all three weightings result in slightly different rankings, however, the best alternative (Integrated Public Transport System) is common amongst them.

In order to establish a final ranking, three aggregation methods were used, BORDA, COPELAND and the Average Ranking Procedure. The aggregation ranking results are shown below in Table 7.

Table 7: Aggregation Ranking Results

Alternatives	BORDA	COPELAND	ARP
Train	4th	4th	4th
Bus	3rd	3rd	3rd
BRT	5th	5th	5th
Minibus Taxi	2nd	2nd	2nd
Integrated	1st	1st	1st

As can be seen in Table 7, while there are slight differences in the rankings, it is clear that the Integrated Transport System is considered the 'best' existing option, and the current BRT system is considered the least desirable.

5. CONCLUSIONS AND RECOMMENDATIONS

In conclusion, both MCDA methods generated feasible results and, therefore, both methods are easily applicable in the investigation of public transport projects in Cape Town. A MCDA allows for the inclusion of a number of criteria, that the traditional CBA excludes. The MCDA would, therefore, compliment the CBA when investigating potential public transport projects and comparing multiple projects.

Should the results differ, the aggregated ranking provides a clear ranking of alternatives. In this study, the theoretical integrated public transport system is the most attractive scenario, while BRT is unanimously the least attractive.

It should be noted that this evaluation of MCDA methods included secondary data and a theoretical approach to the integrated transport system. Once the system is designed, further analyses, using accurate data, should be performed. This may change the ranking outcome.

It is recommended that, as far as possible, primary data be collected when implementing public transport evaluations. It is also recommended to investigate public transport projects over the lifecycle of the chosen project. Generally, public transport projects are evaluated by or for the City of Cape Town or Western Cape Government. Should this be the case, access to more accurate data should be achievable. It is further recommended that, should an integrated transport system be considered, the analysis is re-evaluated with the detailed design of the integrated transport system. This would provide more precise data, influencing the results.

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