



ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

**Analytic Network Process based evaluation and
analysis of railway station site selection in Ethiopia**

By

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Declaration

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Abstract

This paper deals with the problem of finding an optimum site for a railway station, simultaneously it is intended to investigate, analyze and evaluate the Ethiopian railway station site selection using the method of Analytic Network Process (ANP). The paper identifies five major criteria: (1) Environmental, (2) Engineering, (3) Institutional, (4) Social, and (5) Economical factors. In addition, there are 23 sub criteria. Data are collected from Ethiopian Railways Corporation (ERC), questionnaire and survey, prepared in four types: (i) pairwise comparisons between major criteria with respect to the goal, (ii) pairwise comparisons between sub criteria with respect to common cluster, (iii) pairwise comparison between sub criteria with respect to the goal (i.e. the outer dependences between sub criteria of different clusters), and (iv) pairwise comparison between alternatives with respect to sub criteria. The results from the questionnaire are feed into ANP in order to evaluate and identify the most suitable site. Then, the study evaluates the ERC decision in three selected railway station sites, Dire Dawa, Bike, and Dewenle and have got the same in Dire Dawa and Dewenle, but different in Bike. Finally, the output of this particular paper is applicable not only on railway station site selection but also on rail/road route, pipeline, waste disposal selection etc.

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Lists of Acronyms

AHP	Analytic Hierarchy Process
ANP	Analytic Network process
BOCR	Benefit-Opportunity-Cost-Risk
CREC	China Railway Engineering Corporation
DMs	Decision Makers
ELECTRE	Elimination and Choice Translating Reality
ERC	Ethiopian Railways Corporation
ES	Expert Systems
GIS	Geographic Information Systems
LRT	Light Rail Transit
MCDA	Multi Criteria Decision Analysis
MCDM	Multi Criteria Decision Making
MCE	Multi Criteria Evaluation
NRNE	National Railway Network of Ethiopia
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

Construction of a new transportation facilities are major, long-term investments for owners and investors. An appropriate site selection is a critical decision that could significantly affect the profit and loss of the project owners and investors. Decisions associated to the locations of the facilities like metro-rail routes, stations, depots, etc. significantly influences economies of the metropolitan area and the life style of the nearby communities. Therefore, creating awareness in railway station site selection is not a simple issue when it is accounted in terms of resources committed, variety of decision-makers involved, size of communities affected, or the communities prosperity influenced.

Every new railway station is a multifaceted system that has to attain a number of objectives, some of these objectives are: - adequate capacity, economic feasibility, come up with the existing and planned developments, accessibility, environmentally friendly, etc. in order to fulfill these and unlisted objectives it is necessary to develop and propose, for the planning and realization of new or upgrading the existing railway stations. Railway stations vary greatly with regard to their complexity, suitability and effectiveness of operations nonetheless all, in one or another way, will have a direct contact with their final customer, the passenger.

Like that of all transportation infrastructures, railway infrastructure development should also begin with the identification of an existing or projected need to meet the present and the rising demand in the future. This identification prompts the series of actions starting with searching out and screening of geographic areas of interest and specific locations. Locations that satisfy the screening criteria are subjected to detailed evaluation [1].

In the past, site selection was based almost purely on economic and technical criteria. Today, a higher degree of sophistication is expected. Selection criteria must also satisfy a number of social and environmental requirements, which are enforced by legislations and government regulations.

In a process of site selection, the analyst tries to determine the ideal location that would satisfy the predetermined selection criteria that was determined by the proponent's. The

selection process attempts to optimize a number of objectives in determining the desirability of a specific site for a railway station. Such optimization often involves a multitude of decision factors, which are frequently contradicting, and the process often involves a number of possible sites each has advantages and limitations.

A number of tools have been used to select proper sites for construction of new transport facilities. These tools include Expert Systems (ES), Geographic Information Systems (GIS), and Multi-Criteria Decision-Making (MCDM) methods. Although these tools have played an important role in solving site selection problems, each tool has its own limitations and could not be used alone to reach an optimum selection [2]. This poses the challenge of integrating these decision support tools. Such integration was achieved through loose and tight coupling techniques. However, these techniques suffer many drawbacks and limitations. Some of the issues that add to the complexity of the site selection process include: - existence of numerous possible options within a sought territory, multiple objectives, intangible objectives that are difficult to quantify, diversity of interest groups and their priorities, lack of quantitative measures of the factors' impact, uncertainties regarding impact timing and magnitude, uncertainties regarding government influence on the selection process through legislations, and uncertainties regarding possible delays of permitting and construction [3].

1.2 Statement of the Problem

An important subject in the planning of a new railway line is the design of the railway stations, since they affect the various operations for example the capacity, flexibility and the safety of the rail transport system. Ethiopia is underway constructing a new railway line. With the growing interest in the railway sector, there is also a need to increase the efficiency of the railway lines. Constructing a new railway line needs a careful selection of stations. However, the selection of stations in Ethiopia has no clear and defined procedural selection or it is not recognized in a better systematic ways. Especially it is not conducted according to the following major factors which should be included in railway station site selection processes. These are:

1. The selection criteria's are whether limited in number or not included (which means the factors to be included are less in number or totally not included) and also the scope is limited only to some engineering criteria and economic criteria but the other major criteria are not included or limited to detailed investigation.

2. As we have assessed the information from the ERC the selection was done only by the contractors of a specific route. Which may be only by expert's judgment (i.e. the contractors are foreigners they may assume according to their country's selection priority criteria). Thus in turn causes financial losses, expropriation of properties, land acquisition etc. and they have not also consider the country's (Ethiopia) "rules and norms".

Since Ethiopia is one of the countries which are new for railway systems it needs careful selection criteria and procedures. Such a country will suffer lots of problems in designing and planning of railways. Assessing railway station location is one of the most difficult task in its multi-criteria objectives. In this context the paper will contribute considerable value.

1.3 Research Objectives

1.3.1 General objective

The general objective is to find a model for railway station site selection by using Multi-Criteria Decision Making (MCDM) methods i.e. Analytic Network Process (ANP) with the support of personal judgments, and considering the influence of various factors.

1.3.2 Specific objectives

In order to achieve the general objective mentioned, the following four specific objectives will be accomplished in this study:

- Identifying criteria and sub-criteria
- Develop railway station site selection model
- Using the model evaluate, and identify the most suitable site.
- According to the model developed evaluate Ethiopian Railways Corporation's decision.

1.4 Significance of the study

Literature reviews reveals that there are some research papers on site selection: like a research on "Route/Site Selection of Urban Transportation Facilities: An Integrated GIS/MCDM Approach" by Farkas A., a paper on "The analytic network process (ANP) approach to location selection: a shopping mall illustration" by Eddie W.L., and Akjol D. has done his thesis on "Multi-criteria decision making and GIS for railroad planning in Kyrgyzstan" etc... According to these research works this study has found there is no

researches on the areas of railway station site section by considering such a criteria and methods. And also, we have not encountered a research on railway station site selection in Ethiopia before. Therefore this paper have a significant advantage to fill the gap and to contribute new practices to the areas of railway station site selection.

1.5 Scope and Limitation of the study

The scope of this paper is limited to personal experiences (judgments), and opinion rather than the real data which can be observed on fields of specific station locations.

The limitation of the paper are lack of adequate data from the concerned organization ERC and it was difficult to find the proper group of experts rather than finding individuals to deal with. So, these and other factors limits our work especially in identification of the whole criteria and sub criteria those should be considered and defining the importance priorities of criteria and making of the proper possible potential alternatives is impossible.

1.6 Organization of the paper

This study is organized in to six chapters including this introduction. Literature review regarding spatial multi criteria decision making is introduced in chapter two. Chapter three explains the ANP methodologies and procedural judgments as well as ANP as tools for excellence decision support systems. Chapter four discusses about the development of the model for railway station site selection and it was developed in a well manner by using the methods described in chapter three. Chapter five validates the model developed by taking the Addis Ababa- Dewayne routes as a case to examine the effectiveness of the proposed model and explain results as well as discussions. Lastly, in chapter six conclusions and recommendations are forwarded.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Spatial decision making is a routine activity that is common to individuals and to organizations [4]. People make decisions influenced by location when they choose a store to shop, a route to drive, or a neighborhood for a place to live, to name but a few [4]. Organizations are not much different in this respect. They take into account the realities of spatial organization when selecting a site, choosing a land development strategy, allocating resources for public health, and managing infrastructures for transportation or public utilities [5]. Spatial decision making is a highly complex process of choosing among alternatives to attain an objective or a set of objectives under constraints [4]. It can be a structured process involving problems with standard solution procedures, or an unstructured process consisting of problems with no clear-cut solution procedures, or even semi-structured problems for which combinations of standard procedures and individual judgments have to be used to find a solution. All these processes generally involve voluminous spatial and aspatial information, structured and unstructured knowledge, and human valuation and judgment [6]. Spatial decision-making problems are multifaceted challenges. Not only do they often involve numerous technical requirements, but they may also contain economic, social, environmental and political dimensions that could have conflicting objectives. Malczewski J. [7], defined the main characteristics of spatial decision problems as follows:

- ✚ A large number of decision alternatives.
- ✚ The outcomes or consequences of the decision alternatives are spatially variable.
- ✚ Each alternative is evaluated on the basis of multiple criteria.
- ✚ Some of the criteria may be qualitative while others may be quantitative.
- ✚ There are typically more than one decision maker (or interest group) involved in the decision-making process.
- ✚ The decision makers have different preferences with respect to the relative importance of evaluation criteria and decision consequences.
- ✚ The decisions are often surrounded by uncertainty.

Solving this complex type of decision problems usually requires an intelligent and integrative use of information, domain specific knowledge and effective means of communication [6].

2.2 Site Selection Tools

The goal in a route/site selection project is to find the best location with desired conditions that satisfy predetermined selection criteria [1]. As shown in Figure 1, route/site selection typically involves two main phases:

- (i) Site screening (i.e., identification of a small number of candidate sites from a broad geographic area and a range of selection factors) and
- (ii) Site evaluation (i.e., in-depth examination of each candidate site to find the most suitable one) [2]. The selection process attempts to optimize a number of objectives in determining the suitability of a particular route/site for a defined transit facility [1].

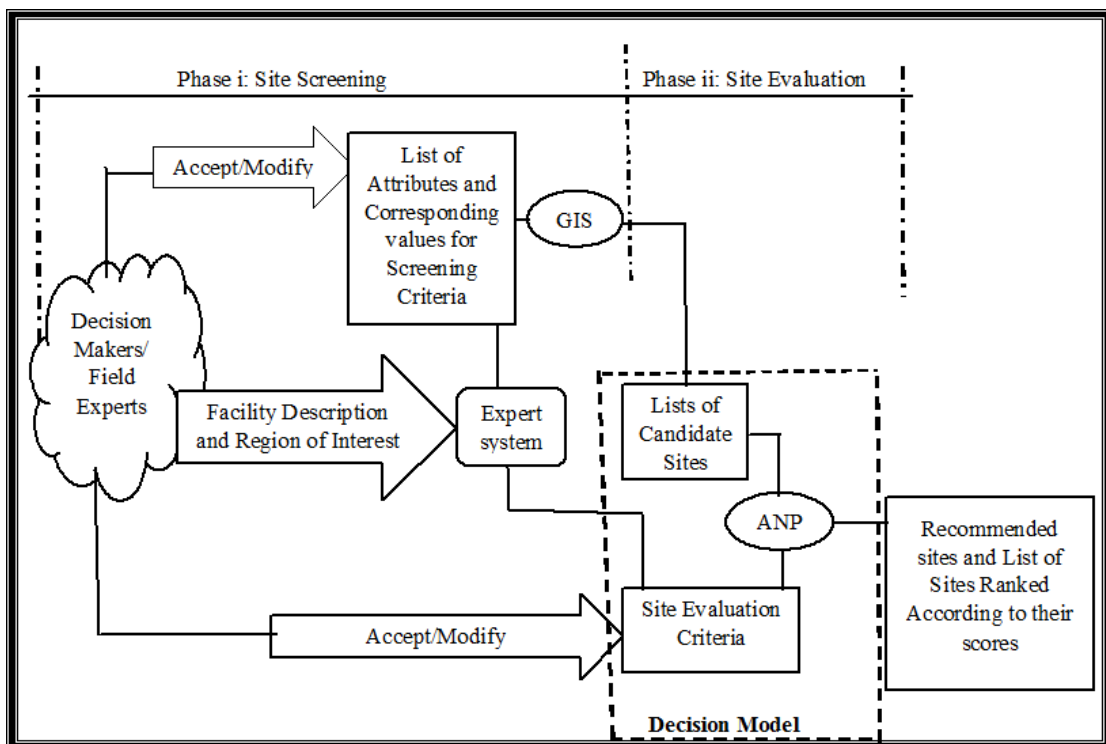


Figure 1: Site Screening and Evaluation Processes

For the last three decades, Expert Systems (ES), Geographic Information Systems (GIS), and Multi-Criteria Decision-Making (MCDM) techniques have been used in solving site selection problems. A brief description of the strength and weakness of each tool with regard to sitting problems is provided below [2].

- 1) Expert Systems: - An Expert system is an intelligent computer program that uses stored knowledge and inference procedures to solve problems that require significant human expertise for their solutions [2]. Many expert systems have

attempted to solve various site selection problems that are heavily dependent on human judgment and experience. Expert systems, however, are incapable of generating solutions using spatial data. ES use symbolic knowledge to represent the human understanding of the problem on hand, which is not suited for processing spatial data. Furthermore, they lack essential capabilities such as the ability to represent buffering (i.e., defining a zone of a specified distance around features) and overlay (i.e., integration of different data layers), which are crucial to spatial data analysis [2].

- 2) Geographic Information Systems: - Geographic Information Systems (GIS) is a computer-based technology and methodology for collecting, managing, analyzing, modeling, and presenting geographic data for a wide range of applications. GIS appeared in the literature in early 1960s and their use in siting analysis started in late 1970s [2]. The success of GIS in siting problems is attributed to its ability to perform deterministic overlay and buffer operations [2]. Although GIS possess ideal capabilities for performing spatial searches based on mappable data, they are incapable of processing multiple criteria and conflicting objectives. They are also limited in integrating geographical information with subjective values/priorities imposed by the decision maker [7].
- 3) Multi-Criteria Decision-Making Methods: - These methods were developed to evaluate alternatives based on the decision maker's subjective and objective values and priorities. They have been used to solve various site selection. However, they assume homogeneity within the study area, which is unrealistic for site selection problems [7]. The MCDM method was elaborated more in the following section.

2.3 Multi-Criteria Decision Making

Given the complexity of life today, most of our important decisions require a multiple criteria decision making process. Some decisions may be made considering a single criterion, but these are very limited to the simple and relatively unimportant ones. Almost no decision of significance can be made based on only one criterion. Given these conditions, the two terms "multiple criteria" and decision making" are nearly inseparable, especially when making complex decisions that require consideration of all the different aspects that affect the decision [8].

Recently, multi-criteria decision-making (MCDM) methods are noted to be helpful in reaching important decisions that cannot be determined straightforwardly. The underlying principle of MCDM is that decisions should be made by use of multiple criteria [9].

Moreover, MCDA can facilitate communication among Decision Makers (DMs) and stakeholders in order to reach a justifiable decision through a systematic, transparent and documented process [10]. Spatial decision problems typically involve a large set of feasible alternatives and multiple, conflicting and incommensurate evaluation criteria. The alternatives are often evaluated by a number of individuals (decision-makers, managers, stake-holders, interest groups). The individuals are typically characterized by unique preferences with respect to the relative importance of criteria on the basis of which the alternatives are evaluated [11]. Accordingly, many spatial decision problems give rise to the GIS-based multi-criteria decision analysis (GIS-MCDA). These two distinctive areas of research, GIS and MCDA, can benefit from each other [12], [7], [13], [14]. On the one hand, GIS techniques and procedures have an important role to play in analyzing decision problems. Indeed, GIS is often recognized ‘as a decision support system involving the integration of spatially referenced data in a problem solving environment’ [15]. On the other hand, MCDA provides a rich collection of techniques and procedures for structuring decision problems, and designing, evaluating and prioritizing alternative decisions. At the most rudimentary level, GIS-MCDA can be thought of as a process that transforms and combines geographical data and value judgments (the decision-maker’s preferences) to obtain information for decision making [11].

Decision making is a process that involves a sequence of procedures, starting with decision problem identification and ending with recommendations. The quality of the decisions depends on the sequence of procedures taken. These procedures in the decision making process are focused on generating alternatives that use the evaluation criteria as the fundamental element.

Decision making is defined to include any choice or selection of alternative course of procedures, which are of importance in the many fields of both social and natural sciences, including geographical information science. The general principle for structuring the decision making process is that the evaluation criteria specified and the

decision alternatives are generated to achieve the best result. This means focusing first on what is desired and then on alternatives to achieve it.

In the decision making process the original data are interpreted and analyzed to produce information. The information used in the decision making process is categorized as “hard” and “soft”. Hard information is derived from reports, census data, remote sensing data, etc. Soft information is based on intuition, questionnaires, comments and opinion of decision makers. Using this type of information is necessary because any spatial decision making must focus on a mix of hard and soft information [7].

Decision-Making problem is the process of defining the decision goals, gathering relevant information, and selecting the optimal alternative [16]. There are many MCDM methods have been developed such as the Elimination and Choice Translating Reality (ELECTRE), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), The Analytic Hierarchy Process (AHP), but these methods do not deal with the interdependence among elements [17]. Analytic Network Process (ANP) is a relative new MCDM method recently introduced by Thomas Saaty [18] which can deal with all kinds of dependences systematically. It can be used as an analysis tool in those problems where there are interactions and dependencies among the elements of a system [19]. Most decisions are analyzed in terms of what is important to a person or a group and what is seen as preferred in making a choice. But when we allow feedback, what is likely to turn out as a result of all the influences is what one really would like to know. The resulting priorities enable one to take the necessary actions and make the investments in resources. One would also like to ensure through sensitivity analysis, not only that the most preferred outcome will take place but also that it remain stable to perturbing forces that may occur after it is implemented. Thus the ANP is a useful tool for prediction and for representing a variety of competitors with their explicitly known and implicitly assumed interactions and the relative strengths with which they wield their influence in making a decision. It is also useful in conflict resolution where there can be many opposing influences.

As mentioned above, the ANP requires a network structure to represent the problem, as well as pairwise comparisons to establish the relationships within the structure. In order to develop an ANP model, it is necessary to carry out five fundamental steps [10].

The first step consists in developing the structure of the decision-making process. This involves defining its main objective and identifying groups or ‘clusters’ constituted by various elements (‘nodes’) that influence the decision, and alternatives or options from which to choose. After having chosen which structure is more suitable in the decisional context, whether the simple or the complex Benefits–Opportunities–Costs–Risks (BOCR) one [20], the relationships between the different elements of the network must be identified. All the elements in the network can be related in different ways since the network can incorporate feedback and complex inter relationships within and between clusters, thus providing a more accurate modelling of complex settings as shown in figure 2 below.

The second step consists of pairwise comparisons, in order to establish the relative importance of the different elements, with respect to a certain component of the network. Comparative or relative judgments are made on pairs of elements to ensure accuracy. In paired comparisons, the smaller element is used as the unit, and the larger element becomes a multiple of that unit with respect to the common property or criterion for which the comparisons are made. It is important to highlight that there are two levels of pairwise comparisons in the ANP: the cluster level, which is more strategic, and the node level, which is more specialized. In pairwise comparisons, a ratio scale of 1–9, (as show in table 1) that is the Saaty’s fundamental scale, is used to compare any two elements. The main eigenvector of each pairwise comparison matrix represents the synthesis of the numerical judgments established at each level of the network [21].

Table 1: Ratio Scale of Relative Importance's (Saaty, 2004)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
Ratios	Ratios arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix
1.1–1.9	When activities are very close a decimal is added to 1 to show their difference as appropriate.	A better alternative way to assigning the small decimals is to compare two close activities with other widely contrasting ones, favoring the larger one a little over the smaller one when using the 1-9 values

The third step consists of the progressive formation of three super-matrices: the initial or un-weighted one, the weighted one and, finally, the limit one. The un-weighted super-matrix contains all the eigenvectors that are derived from the pairwise comparison matrixes of the model. The eigenvector obtained from the cluster level comparison, with respect to the control criterion, is applied to the initial super-matrix as a cluster weight and the result is the weighted super-matrix. The super-matrix elements allow a resolution to be made of the interdependencies that exist between the elements of the system.

The fourth step concerns the elicitation of the final priorities. In this step, the weighted super- matrix is raised to a limiting power, as in Equation (1), in order to converge and to obtain, as stated in the Perron–Frobenius theorem, a long-term stable set of weights that represents the final priority vector [10].

$$\lim_{k \rightarrow \infty} W^k \quad (1)$$

In the case of the complex network structure, it is necessary to synthesize the outcome of the alternative priorities for each of the BOCR sub networks in order to obtain their overall synthesis through the application of different aggregation formulas [22].

The fifth and last step consists in carrying out the sensitivity analysis on the final outcome of the model in order to test its robustness.

This report uses the suggested station locations when the station site selections are proposed and analyzed. To generalize the methodology what will use are presented graphically.

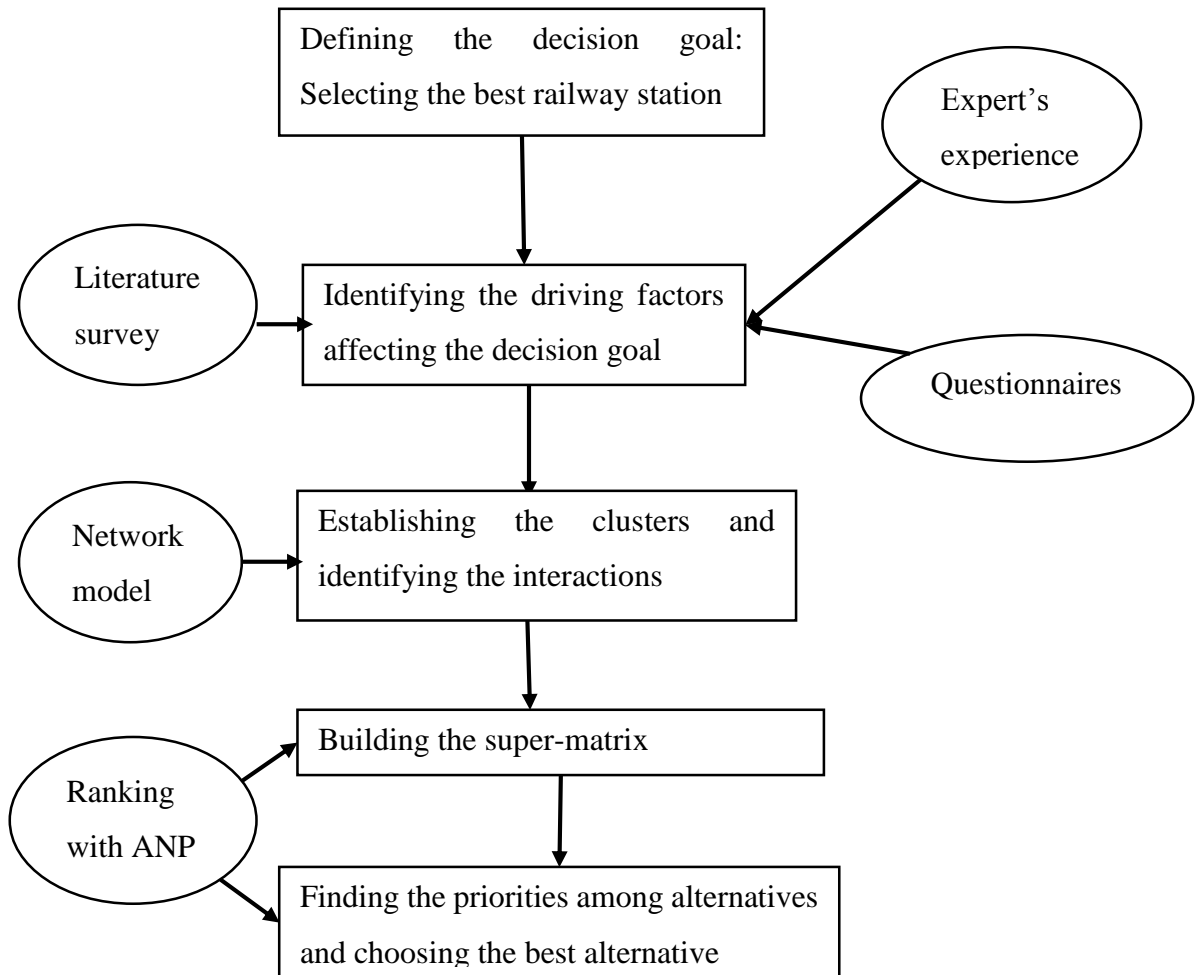


Figure 2: The proposed ANP procedure

2.3.1 Distinguishing Features of ANP with AHP

In making a decision, we need to distinguish between the hierarchic and the network structures that we use to represent that decision [23]. In a hierarchy we have levels arranged in a descending order of importance as shown in the figure 3 (a) below. The elements in each level are compared according to dominance or influence with respect to the elements in the level immediately above that level. The arrows descend downwards from the goal even if influence, which is a kind of service, is sought for in elements in lower levels that contribute to the well-being and success of elements in higher levels. We can interpret the downward pointing of the arrows as a process of stimulating the influence of the elements in the lower level on those in the level above [23].

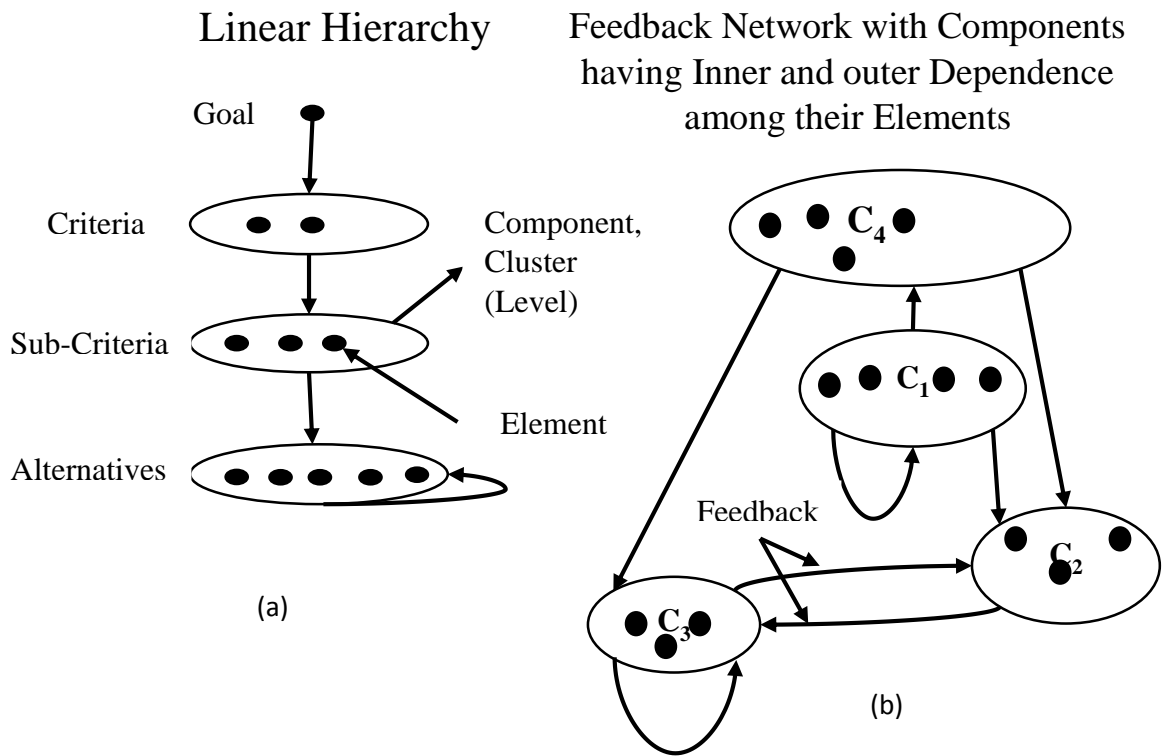


Figure 3: How a hierarchy compares to a network (Saaty, 2004)

A loop in linear hierarchy indicates that each element depends only on itself, while a loop in a network indicates inner dependence of the elements in the same component with respect to a common property. Arc from component C_4 to C_2 indicates the outer dependence of elements in C_2 on the elements in C_4 with respect to a common property.

In a network, the components (counterparts of levels in a hierarchy) are not arranged in any particular order, but are connected as appropriate in pairs with directed lines. Again an arrow points from one component to another to stimulate the influence of the elements of the second component on those in the first. The pairwise comparisons of elements in a component are made according to the dominance of influence of each member of a pair on an element in the same or in another component as shown in figure 3 (b). Influence may be evaluated in terms of importance, preference or likelihood [23].

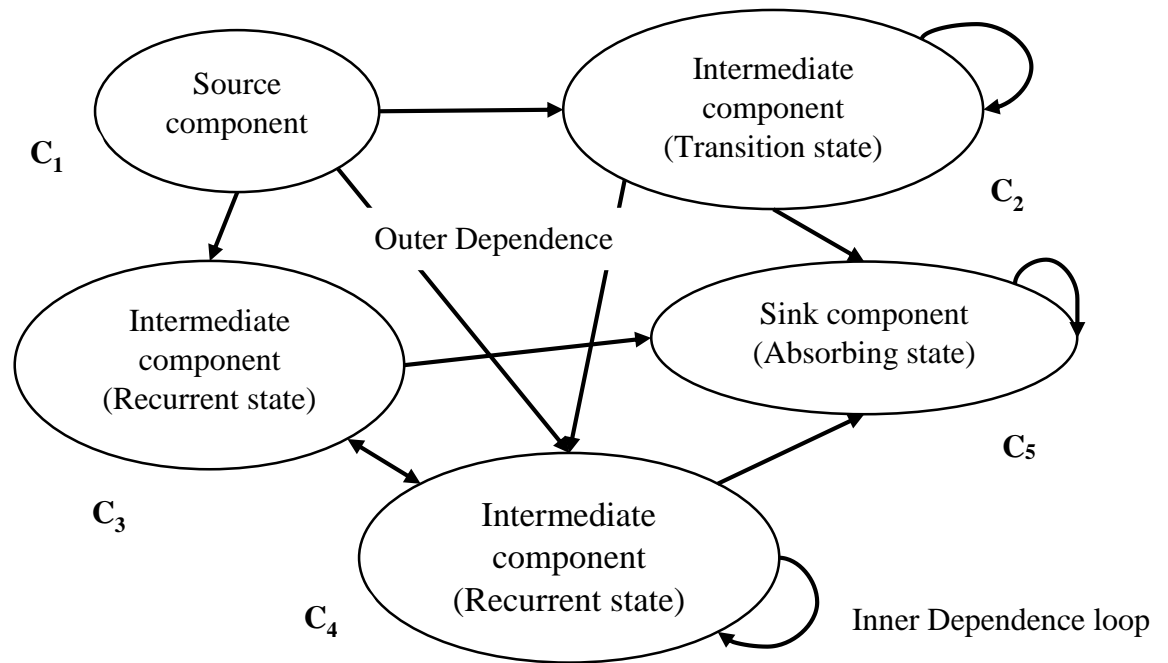


Figure 4: Connections in a network (Saaty, 2004)

Both AHP and ANP methods are claimed to possess qualitative and quantitative components. On one hand they are used to identify decision criteria (qualitative component). This involves the creation of a structural model for the decision problem. On the other hand, they employ the procedure for assigning weights to the criteria (quantitative component). However, AHP is restrictive to solve problems with a hierarchically structural model. ANP is a generic form of AHP as it can take interdependent relationships into consideration, resulting in the possibility to form a network like structural model as shown in figure 4 above [24]. As claimed by R.W. Saaty [25], ANP is able to solve various decision problems because it can produce the most comprehensive analytic framework for making societal, governmental, and corporate decisions.

In addition, in a network, the system of components may be regarded as elements that interact and influence each other with respect to a criterion or attribute that is outside the system of influences [23]. That attribute itself must be of a higher order of complexity than the components and a fortiori of higher order than the elements contained in the components. We call such an attribute a control criterion. Thus even in a network, there is a hierarchic structure that lists control criteria above the networks [23]. The result is that such control criteria and/or their sub-criteria serve as the basis for all comparisons made under them, both for the components and for the elements in

these components. In a hierarchy one does not compare levels according to influence because they are already arranged in a predetermined order of importance from top to bottom. The criteria for comparisons are either included in a level, or more often implicitly replaced by using the idea of “importance, preference or likelihood” with respect to the goal, without being more finely detailed about what kind of importance it is. The control criteria for comparisons in a network are intended to be explicit about the importance of influence that they represent [23].

In a hierarchy, we ask the question for making a comparison, which of two elements is more dominant or has more influence (or in the opposite sense is influenced more) with respect to a certain element in the level above? In a network we ask, which of two elements is more dominant in influencing another element in the same or in another component with respect to a control criterion? In both hierarchies and networks the sense of having influence or being influenced must be maintained in the entire analysis; the two should not be mixed together [23].

The ANP frees us from the burden of ordering the components in the form of a directed chain as in a hierarchy. Many decision problems cannot in fact be structured hierarchically since they involve the interaction and dependence of the higher level elements in the hierarchy on the lower level ones. Moreover, the feedback networks lead to the consideration that the importance of the alternatives determines the importance of the criteria, whereas the traditional hierarchy only leads to the consideration that the importance of the criteria determines the importance of the alternatives [25]. Thus, in order to deal with the complexity of real problems in a non-simplistic way, we have to use feedback networks to arrive at the kind of decisions needed to cope with the future. The ANP enables such inter-dependences to be surveyed and measured by generalizing the approach of the super-matrices introduced by the AHP and it is gaining merit as a useful tool to help technicians make their decision processes traceable and reliable. We can represent any decision as a directed network. While the AHP has a visibly better structure that derives from a strict understanding of the flow of influence, the ANP allows the structure to develop more naturally, and therefore is a better way to describe faithfully what can happen in the real world. These observations lead us to conclude that hierarchic decisions, because of imposed structure are likely to be more subjective and predetermined. Further, by including dependence and feedback and by cycling their influence with the super-matrix, the ANP is more

objective and more likely to capture what happens in the real world. It does things that the mind cannot do in a precise and thorough way. Putting the two observations together, the ANP is likely to be a strongly more effective decision-making tool in practice than the AHP [23].

Table 2: Summary of Differences between AHP and ANP

S. No	Analytic Hierarchy Process (AHP)	Analytic Network Process (ANP)
1	Elements of the problem, goal, sub goals, time horizons, scenarios, actors and stakeholders, their objectives and policies, criteria, sub criteria, attributes, and alternatives.	Feedback, inner and outer dependence.
2	Hierarchic structure.	Influence with respect to a criterion.
3	Judgments- absolute numbers, homogeneity, clustering, pivot elements, tangibles and intangibles.	The control hierarchy or system.
4	Comparisons, dominance and reciprocity with respect to an attribute, inconsistency and the eigenvector, use of actual measurements.	The super matrix.
5	The number of judgments; how to take fewer judgments.	The limiting super matrix and limiting priorities.
6	Derived ratio scales - in AHP the priorities are derived and are proven to belong to a ratio scale.	Primitivity, irreducibility, cyclicity.
7	Interval judgments, stochastic judgments.	Make the limiting super matrix stochastic: why clusters must be compared.
8	Synthesis – multi linear forms - density.	Synthesis for the criteria of a control hierarchy or a control system.

“Table 2: Continued”

S. No	Analytic Hierarchy Process (AHP)	Analytic Network Process (ANP)
9	Rank - the dominance mode, the performance mode with respect to an ideal.	Synthesis for benefits, costs, opportunities, and risks control hierarchies.
10	Absolute measurement - rating alternatives one at a time.	Formulation to compute the limit.
11	Benefits, opportunities, costs and risks hierarchies.	Relation to Neural Network Firing - the continuous case.
12	Parallel with human thinking - neural firing creates awareness and intensity of stimuli for both tangibles and intangibles. Measurements are data to be interpreted.	The density of neural firing and distributions and their applications to reproduce visual images and symphonic compositions. Further research in the area is needed.
13	Group Decision Making and the reciprocal property; Pareto optimality: if each prefers A to B, then the group does.	
14	Sensitivity Analysis.	
15	Learning and revision as a process.	

2.4 ANP Steps to Build Network Model

An Analytic Network Model of a problem may consist of a single network or a number of networks. To build an Analytic Network Process (ANP) network, you need to:

1. Think about the elements in it and decide what kind of logical grouping of nodes and clusters would best describe the problem. In our case the elements are that five criteria and their sub criteria’s and our network model is the “simple network model”.
2. Build a cluster first, then create the nodes within it. We had built six clusters and twenty three nodes in their corresponding clusters.

3. Select one node as a potential parent node and examine all the clusters in turn to determine if they have nodes that the parent node either influences or is influenced by to select its children nodes in that cluster.
4. Create the links between the parent node and all its children nodes in each cluster this is how the comparison sets of nodes are created.
5. Clusters are linked automatically when nodes are linked.
6. Make sure the influences or is influenced by question is posed in a consistent way throughout this network.
7. Make pairwise comparison judgments on nodes and clusters. As well rating assessments, assessing the alternatives in ratings.
8. Super matrix computations; un-weighted super matrix- made up of the local priority vectors obtained from the comparison groups, weighted super matrix- the local priority vectors in the un-weighted super matrix have been multiplied times the cluster weights, and limit super matrix- in a simple straightforward network the process of obtaining the limit matrix is to raise the weighted super matrix to powers until it stabilizes - that is, all the columns in the matrix have the same values. The entries in a column are the priorities of the nodes at the left (they are "weighted" by cluster weights though, so each cluster's nodes need to be normalized to make their priorities add up to 1 computations.
9. Synthesizing the results for the alternatives. There must be a cluster named alternatives in either that cluster, or in attached sub networks, for there to be synthesis results. If the results are zero, probably you don't have alternatives. The synthesis command will give the priorities of the alternatives for the network where the command is invoked and all of its sub networks, sub-sub networks, etc.
10. Prioritizing to determine the priorities of all the nodes in a network, normalized by cluster (organized by cluster with the sum of the priorities of the nodes in the cluster adding up to 1.0), and limiting with respect to the network (the sum of the priorities of all the nodes in the network adding up to 1.0)
11. Performing sensitivity

2.4.1 Illustrative Examples for Feedback Network, the Bridge Model

Bridge is a decision problem to pick the better of two bridge designs. It is a simple network of one level that contains only two clusters, with two nodes in each cluster, and links between the nodes. A network is structured of clusters, nodes and links. We use this model to show how feedback arises in a network decision structure and how the pairwise comparison questions are formulated when there is feedback. Here the clusters are outer dependent, that is, nodes in a cluster are compared only with respect to nodes in the other cluster [25].

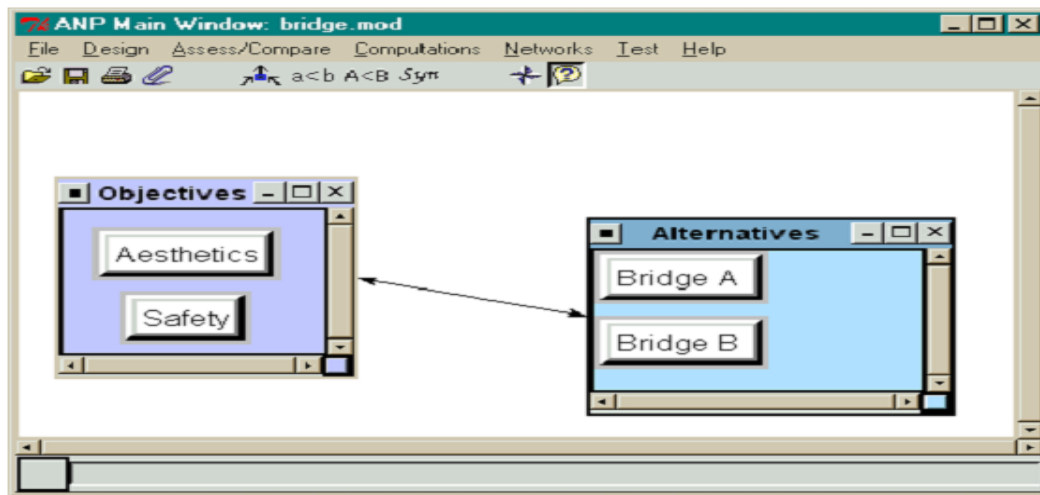


Figure 5 : The bridge model: a simple network

The decision in this model is to select the best bridge. The objectives are to have a safe bridge and an aesthetically pleasing bridge. If one were doing the model from the top down as in a hierarchy, there would be a goal with Aesthetics and Safety as the criteria and Bridge A and Bridge B as the alternatives. One would compare Aesthetics to Safety, Safety would likely be perceived as extremely more important, so the safest bridge would be the "best" choice.

But in a feedback network one compares the bridges for preference with respect to Aesthetic and to Safety, and one also compares the prevalence of Aesthetics versus Safety for each bridge. The net result of this is that priorities are obtained for all four nodes in the system. Suppose the safest bridge, B, is unattractive, and the nicer looking bridge, A, is very safe, though not as safe as B. The priorities of the criteria depend on the bridges available and since both are quite safe, the priority of safety in the feedback system ends up less than it would be in a hierarchy where one compares Safety to Aesthetics in the abstract and apart from any specific bridge. It make common sense

that if both bridges are very safe, one should pick the better-looking bridge, even though one bridge is far safer than the other. The Analytic Network Process through feedback guides us to the best choice in a way that matches our common sense.

The Aesthetics node in the Objectives cluster is linked to Bridge A and to Bridge B, and because there is a link between nodes, a link appears from the Objectives cluster to the Alternative cluster. Because at least one node in the Objectives cluster is linked to nodes in the Alternative cluster, a link appears automatically from the Objectives cluster to the Alternatives cluster.

Aesthetics is the parent node and Bridge A will be compared to Bridge B with respect to it. The node Safety is also linked to Bridge A and Bridge B, and they will be compared for preference with respect to safety.

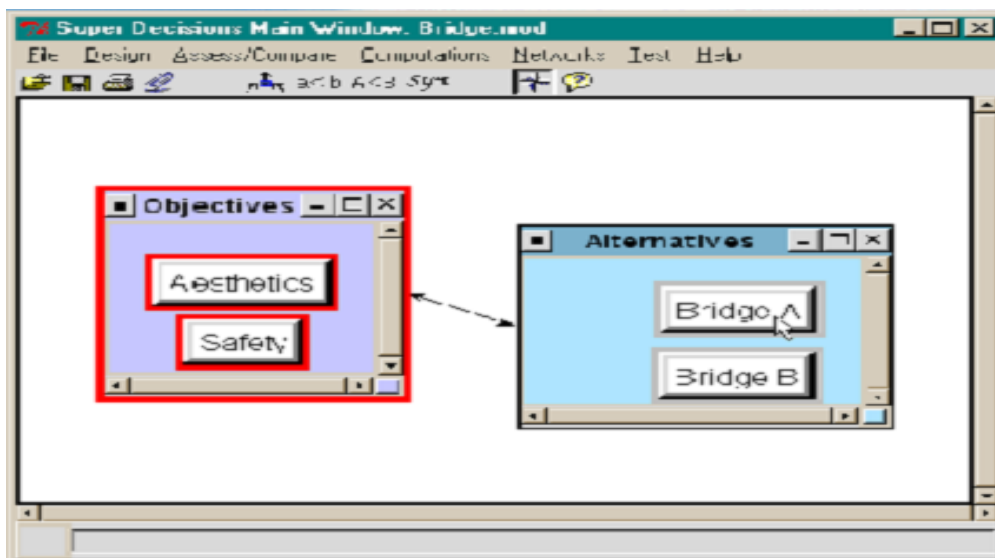


Figure 6: Aesthetics Node is connected to Bridge A and Bridge B

Feedback Links

It is easy for those who have used the Analytic Hierarchy Process to understand how to pairwise compare Bridge A and Bridge B with respect to Aesthetics. Bridge A would be highly preferred. But what may be new is the idea that criteria may be compared with respect to an alternative. What does that mean? When comparing, for example, Aesthetics and Safety with respect to Bridge A, the question is: What is more a more pronounced or prevalent characteristic of Bridge A, its aesthetics or its safety? Bridge A is beautiful and that is what we like best about it. Its safety, though quite adequate, is nothing notable. So we strongly prefer its aesthetics to its safety.

For Bridge B what is its more preferable characteristic, aesthetics or safety? Since it is quite ugly, the answer is that the Safety of Bridge B is extremely preferable to its Aesthetics. These kinds of preference questions and answers, both directions, help us establish our true priorities for all the elements in the problem.

The Un-Weighted, Weighted and Limit Super matrices

There are three super matrices associated with each network: the Un-weighted Super matrix, the Weighted Super matrix and the Limit Super matrix.

The un-weighted super matrix contains the local priorities derived from the pairwise comparison throughout the network as shown in Figure 7. For example, the priorities of the element Aesthetics and Safety, with respect to Bridge A are shown in the two bottom cells of the first column, 0.857143 and 0.142857. This may be interpreted with the statement, "The Aesthetic characteristic of Bridge A is between strongly and very strongly, or 6 times, more its dominant preferred characteristic than its Safety aspect." All the local priority information can be read directly from the un-weighted Super matrix.

Cluster Node Labels		Alternatives		Objectives	
		Bridge A	Bridge B	Aesthetics	Safety
Alternatives	Bridge A	0.000000	0.000000	0.875000	0.333333
	Bridge B	0.000000	0.000000	0.125000	0.666667
Objectives	Aesthetics	0.857143	0.100000	0.000000	0.000000
	Safety	0.142857	0.900000	0.000000	0.000000

Done

Figure 7: Un-weighted Super Matrix for Bridge model

The weighted super matrix is obtained by multiplying all the elements in a component of the un-weighted super matrix by the corresponding cluster weight. In this example there were no cluster comparisons, since there are only two clusters and cluster comparisons cannot be made when there are only two. The weighted and un-weighted super matrices are the same in this example and are shown in Figure 8. Notice that

as the columns already sum to one in the un-weighted super matrix there is no need to weight the components to make the columns sum to one in the weighted super matrix.

Cluster Node Labels		Alternatives		Objectives	
		Bridge A	Bridge B	Aesthetics	Safety
Alternatives	Bridge A	0.000000	0.000000	0.875000	0.333333
	Bridge B	0.000000	0.000000	0.125000	0.666667
Objectives	Aesthetics	0.857143	0.100000	0.000000	0.000000
	Safety	0.142857	0.900000	0.000000	0.000000

Done

Figure 8: Weighted Super Matrix for Bridge model

The limit super matrix is obtained by raising the weighted super matrix to powers by multiplying it times itself. When the column of numbers is the same for every column, the limit matrix has been reached and the matrix multiplication process is halted. The limit super matrix for the Bridge Model is shown in Figure 9.

Cluster Node Labels		Alternatives		Objectives	
		Bridge A	Bridge B	Aesthetics	Safety
Alternatives	Bridge A	0.328456	0.328456	0.328456	0.328456
	Bridge B	0.171544	0.171544	0.171544	0.171544
Objectives	Aesthetics	0.298688	0.298688	0.298688	0.298688
	Safety	0.201312	0.201312	0.201312	0.201312

Done

Figure 9: Limit Super Matrix for Bridge model

The Computations Priorities command on the menu displays the priorities in two ways: as they appear in the super matrix, and with the priorities normalized by cluster as shown in Figure 10. The columns of the limit super matrix are all the same, so the priorities for all the nodes can be read from any column.

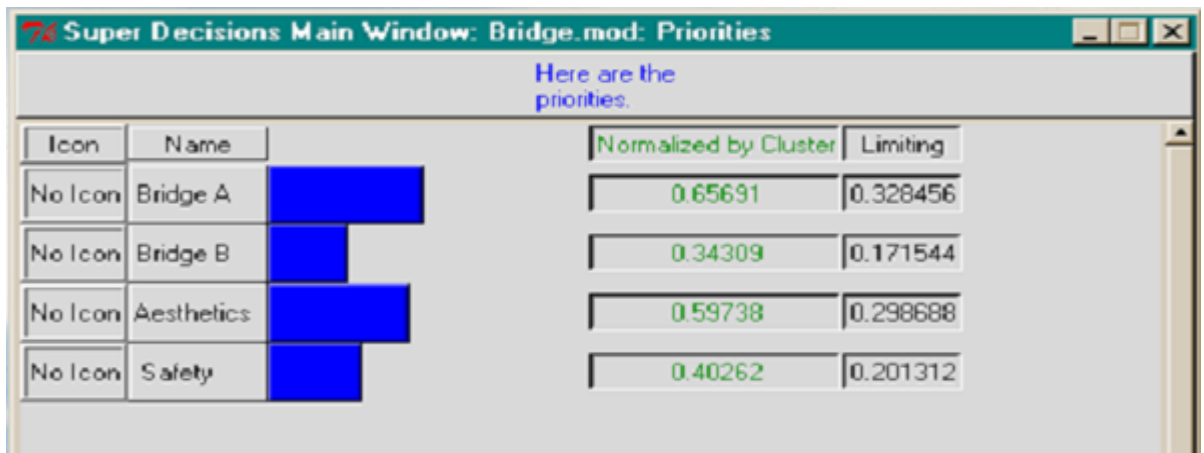


Figure 10: Priorities from the Limit Super Matrix

The Computations Synthesize command displays the final results in three ways as shown in Figure 11. The Raw column gives the priorities from the limiting super matrix (which also appear in the Limiting column above), the Normals column shows the results normalized for each component (which also appear in the Normalized by Cluster column above) and the Ideals column shows the results obtained by dividing the values in either the normalized or limiting columns by the largest value in the column.

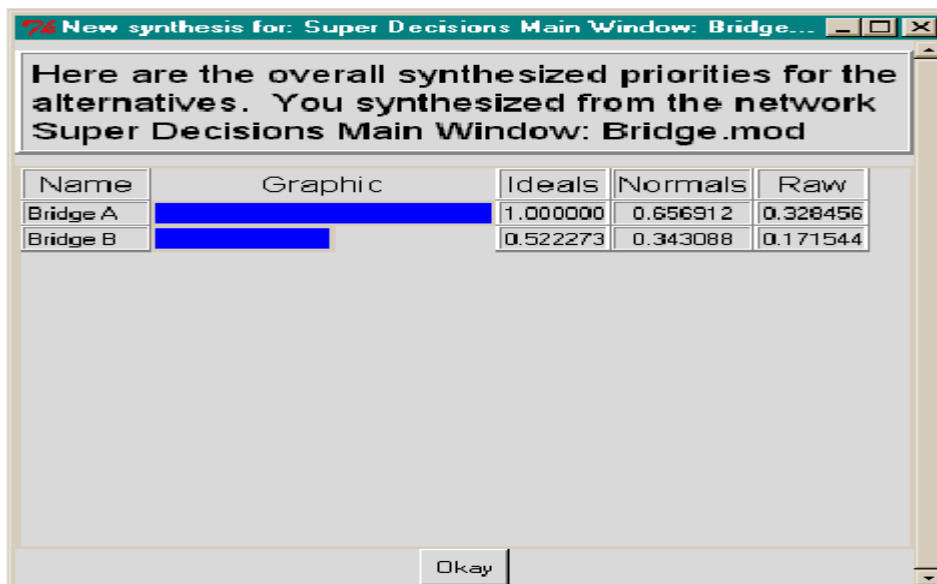


Figure 11: Synthesized Values- result for the Alternatives

The results show that Bridge A is best. This matches our intuition: "Bridge A is very safe and also the best looking, so choose it. Bridge B has overkill so far as safety is concerned, and it is not good looking – so it is not the best bridge overall. Do not choose it."

A very large and consolidated amount of MCDA literature exists in which it is possible to find a wide range of techniques. As far as both the AHP and the ANP are concerned, the basic reference is the literature production of the American researcher T.L. Saaty, starting from 1980. With particular reference to ANP, the literature is more recent and some publications can be found in different fields [10]. Mention can be made of some works in the sphere of site selection.

In this particular work the decision making involves both model developing and locating a railway station. The literature review on site selection reveals that there are some research papers like; “Route/Site Selection of Urban Transportation Facilities: An Integrated GIS/MCDM Approach” by Farkas A. [1], “The analytic network process (ANP) approach to location selection: a shopping mall illustration” by Eddie W.L. [9], “Multi-criteria decision making and GIS for railroad planning in Kyrgyzstan” by Akjol D [26], and “An Analytic Network Process-based Approach for Location Problems: The Case of a New Waste Incinerator Plant in the Province of Torino (Italy)” by Marta B. and Valentina F. etc. As it is described above there are a little literature in railway station site selections like the one done by Farkas, again it is for urban transportation facilities. Also, we have not encountered a research on railway station site selection in Ethiopia. According to the gaps mentioned above, the paper is unique and it is a new discovery, since it uses MCDM technique ANP to solve the problems of interdependence and feedback nature of railway station site selection criteria, to provide best station location.

CHAPTER 3 RESEARCH METHODS

In this section the paper tries to develop the methods which are proposed to be used. The paper has encountered the following sub topics: - overview of study areas to make the study areas more brief, the methods indicates that the actual procedures and methods to be used in the analysis was dealt, the data collections section was used to describe how the data were collected and utilized according to the procedures which were discussed in the methods part, and the data analysis section: in this data analysis section the paper provides a general framework to deal with decisions without making any assumptions about the methods, criteria used and alternatives to choose from. So, overview of the study area, methods, data collections and, data analysis were discussed in their respective sub topics.

3.1 Overview of the Study Area

The Study area comprises a part of the East to West African Railway Network in the eastern part of Ethiopia. It is under the Ethiopia – Djibouti railway project of Addis Ababa –Dewenle route. The total length of Addis Ababa- Dewenle route is 656 Km. it is double track from Addis Ababa to Adama which comprises length of 107 km and the rest from Adama to Dewenle is single track which is 549 Km. The corridor connects Addis Ababa with the port of Djibouti and it is used for both freight and passenger transportation. The corridor is also driven by renewable energy/ or electric traction throughout the line and it uses the standard 1435 mm gauge. The Addis Ababa – Djibouti railway project has its special features like reduces the time travel from Djibouti port to Addis Ababa by more than fifty percent, and it will contribute to the economic development of hinterland Ethiopia. The route has 17 major stations, from these stations about 16 are in Ethiopian territory and the left one is in Djibouti. The major stations are:- Sebeta, Lebu, Indode, Bishoftu, Modjo, Adama, Metehara, Awash, Mieso, Mulu, Afdem, Bike, Erer, Dire Dawa, Shinle, Dewele, and Djibouti port stations. From these major stations in the corridor the paper gives due attention to the Mieso – Dewenle route. Then to be specific the paper considers only three stations from Mieso – Dewenle route, these are Bike, Dire Dawa, and Dewenle stations.

3.2 Methods

According to the aspects/factors mentioned in the above section (i.e. Environmental, Engineering, Institutional, Social, and Economic factors), the study proposes a simple

structure where these above mentioned aspects have been considered as a cluster. In this work, it has been decided to analyze all the above mentioned aspects. For this reason, the elements of the problem have been organized according to five clusters/ or major criteria, namely environmental factors, engineering factors, institutional factors, social factors and economic factors. Thus organizing the network is anxious, and indication should be made to the fact that, as stated by Miller [28], it is important not to have too many elements to compare through the expression of relative judgments because the decision aid tool should not be interpreted as an algorithm that is able to automatically give the desired solution but it should instead support the DMs who has to make a systematic analysis of the alternative solutions and who is solely responsible for the final choice. In this sense, for each of the major criteria, the number of the elements is limited and they are discussed with respect to their major criteria's. These selection of major criteria's and their corresponding sub criteria are based only on literature survey. Therefore, the elements (sub criteria's) may be changed, if expert's experiences and target group survey may come up with conflicting ideas. Anyways the procedures and the tools proposed to be used are still workable to address the decision. This simple structure is analyzed by ANP based on questionnaires data which was prepared in four parts (i) pairwise comparison between major criteria's with major criteria's with respect to the goal and (ii) pairwise comparison between sub criteria's and sub criteria's with respect to major criteria's (corresponding cluster's) (iii) pairwise comparison between sub criteria's of one major criteria (factor) with sub criteria's of another major criteria (factor) respect to each other, if they have influence/or priority between criteria's (iv) pairwise comparison between the alternatives with respect to the whole sub criterion. It is to be filled based on group of experts or individuals experience, opinion and judgment. The scale is divided in to nine points which show the relative importance of the major or sub criteria with respect to the specific objectives to be shown along with each table. As mentioned above it is filled based on group of experts or individuals experience, opinion and judgment, if they believe that they have influence one over another unless they leave the comparison and which means that the elements have no influence one another.

The values or the result of the questionnaire have been taken to the fantastic decision making tool super decisions. The ANP makes the necessary comparisons,

computations, ratings, synthesis, and so on. According to the computations and the comparisons the ANP ranks the various alternatives with multiple objectives.

Therefore this work is intended to identify the way how Ethiopian railway station should be located and the consistency with the countries “rules and norms” are analyzed. Here the methods used are a little bit a recent in decision making tools, ANP and we have considered the major decision criteria in railway station site selection.

3.3 Data Collection

Collection of data starts with searching information from Ethiopian Railways Corporation (ERC) (especially the Addis Ababa/Sebeta-Mieso/Dewenle project and Addis Ababa LRT (CREC) and concerned organizations. After all the study have decided to use one of the route from the National railway Network of Ethiopia (NRNE) for the purpose of examining the effectiveness of the proposed methodology. The specific route is the part of Addis Ababa/ Sebeta-Mieso/Dewenle of Mieso-Dewenle route. Collection of data (information) from the ERC or NRNE is only for seeking how they are using the methodologies and what are the criteria that they are using for the selection of railway station site selection. The project consists of a literature study/or literature survey and questionnaires’.

The first part of the investigation is on a literature study with the purpose to answer the questions regarding the different aspects that are important for railway station site selection as well as finding out the main criteria’s for selecting railway station alternatives. By support of these literatures we have gathered a considerable factors. This study tries to dig out the major factors/or aspects which influence railway station site selection. These are environmental, engineering, institutional, social and economic aspects. These major criteria’s have their particular sub criteria’s/ elements which are listed in the previous chapter. An important part of the literature that is used for this paper are the control criteria’s. The identification of the control criterion is the most important phase and simultaneously selecting the elements and their indicators are another challenging problem in the application of ANP for railway station site selection. The next part is the questionnaires which are filled by specialists/or railway experts within the subject. In the last part of the report, the information gained during the literature study and the questionnaires is used to suggest possible future layouts for the railway stations site selection in the whole country Ethiopia. Moreover, the data

collection is almost rely on questionnaires' which will be filled by group of railway experts or by an individual. Attributes of geometric objects are collected at the same time as the questionnaire is filled e.g. number of population in cities, the category of roads, rivers and so on.

3.4 Data Analysis

Decision making involves criteria and alternatives to choose from. The criteria usually have different importance and the alternatives in turn differ in our preference for them on each criterion. To make such tradeoffs and choices we need a way to measure. Measuring needs a good understanding of methods of measurement and different scales of measurement [27].

From the analytic point of view the ANP provides a general framework to deal with decisions without making assumptions about the independence of higher level elements from lower level elements and about the independence of the elements within a level as in a hierarchy. In fact the ANP uses a network without the need to specify levels. As in the AHP, dominance or the relative importance of influence is a central concept. In the ANP, one provides a judgment from the fundamental scale of the AHP by answering two kinds of question with regard to strength of dominance:

- ✚ Given a criterion which of two elements is more dominant with respect to that criterion,
- ✚ Which of two elements influences a third element more with respect to a criterion?

In order that all such influences be considered with respect to the same criterion so they would be meaningful to synthesize, it is essential that the same criterion be used to make all the comparisons. Such a criterion is called a control criterion. A control criterion is an important way to focus thinking to answer the question of dominance, thus first decomposing a complex problem with a variety of influences and then pulling it back together by using the weights of these influences. Synthesis has the requirement that scales can be added and multiplied to deal with dependence and feedback using judgments about importance and preference along with likelihood as in presidential elections. Real data and statistics representing probabilities and likelihood can also be used in relative form instead of making pairwise comparisons in the ANP as they are in the AHP [24].

The idea of influence is central in decision-making. It is a general term applicable in the physical world (e.g. gravitational pull) in biology (giving birth or dying) in psychology (loving and hating) in politics (persuading, negotiating and opposing) and in every conceivable domain of the world in which we live and the society in which we participate [24]. Influence is a force that produces change, to make order or to create chaos. In process thinking, change is known to be the most fundamental process in nature. As time changes so do all things change subject to the influences that exist from instant to another instant? Anything that exists influences the behavior of other things or influences the state of the environment near and sometimes far away from where it is. When we make a decision we need to look at all the potential influences and not simply the influences from top to bottom or bottom to top as in a hierarchy. Influences spread as in a network or even more generally as in a manifold. Conscious existence is a function of time and is generally recognized in different acts of consciousness, although we try to think about it as a continuous historical event. It is more meaningful for us to understand decisions mathematically in the discrete form of the spread of influence rather than as continuous processes, although the necessary continuous mathematics is in a way easier to develop as generalization of the discrete case.

CHAPTER 4 MODEL DEVELOPMENT

In this model development section this study have done the procedural modeling of networks by considering the above mentioned ANP steps. In order to develop the railway station site selection model we should also deal with the objectives (major criteria's), sub criteria's, and also alternatives to achieve the goal. Therefore, to achieve the goal it is better to see the following ideas in brief. Identification of the major criteria; these are the aspects which influences significantly the station location in one or other way, definition of sub criteria; these are the elements which influence in one or other way the major factors (the influences may be advantageous or disadvantageous), and alternatives generation were discussed.

4.1 Identification of Major Criteria's

The major and most important stage in the development of the railway station site selection model by the application of ANP was the identification of the factors which influence railway station locations. More important criteria and sub criteria are identified including all characteristics aspects of railway station site selection. However, the decision maker can expand any criteria which are relevant to the stations under consideration. Here in this paper the major criteria's are used as the clusters/or components. A component or a cluster in the ANP is a collection of sub criteria's/or elements whose function drives from the synergy of their interaction. The criteria that are used for comparing the components are the goal of the project. This study has identified five major criteria's/or factors which can influence railway station site selection. The identified major criteria's are used as a component/ cluster. Under these clusters there are a collection of sub criteria's/or elements were included accordingly with their relations and interactions. The major criteria's are engineering, institutional, economic, social, and environmental. These major criteria's are discussed in brief as follows.

4.1.1 Engineering Criteria

The engineering criteria is all about the engineering measures of the specific railway station. It is measured in accordance with the efficiency, construction and geology, suitable infrastructure, and engineering characteristics and alignment as sub criteria's.

4.1.2 Institutional criteria

This criteria measures the relation between the railway systems and spatial policies of governmental/or urban municipality, again this is concerned with the accessibility, connectivity, linkages to strategic growth centers, expropriation of property, and connections to other transit systems.

4.1.3 Economic criteria

A number of criterion is used to measure how well an option performs on each indicator like net present value, return on investment, construction cost, land acquisition, and demolition work: these criteria's describe the economic feasibility of the specific railway station.

4.1.4 Environmental criteria

This factor measures the relation between the railway systems with the environments around the station locations. The main factors considered in evaluating a railway station site selection from an environmental point of view include: ecological protection, intrusion to sensitive areas, noise impaction, and, emission level and energy consumption.

4.1.5 Social criteria

This aspect measures the relation between the railway systems and the societies of the metropolitan areas and it has the following building blocks/or sub criteria's: mobility, access to residential or shopping areas, linkages to employment or educational centers, disruption to community, and serve areas of disadvantaged.

4.2 Identification of sub criteria's

The identification of sub criteria's are the other tedious and unambitious task for using ANP as a tool. As mentioned above the study has found five major criteria/or factors which influence railway station site selection. Under these major criteria's the study have developed a total of 23 sub criteria. From these the engineering criteria includes four sub criteria, institutional criteria has five sub criteria, the economic criteria has five sub criteria, the social criteria has five, and the remaining four sub criteria belongs to the environmental criteria. These are presented in table with respect to their major criteria/or cluster.

Table 3: Control criteria's with their corresponding sub criteria's

Control Criteria	Environmental Factors	Engineering Factors	Institutional Factors	Social Factors	Economic Factors
Sub criteria's	Ecological protection	Efficiency	Accessibility	Mobility	Net present Value
	Intrusion to sensitive areas	Construction and geology	Connectivity	Disruption to community	Return on Investment
	Noise impaction	Suitable infrastructure	Linkages to strategic growth centers	Access to residential/ shopping areas	Cost of construction
	Emission levels & energy consumption	Engineering characteristics and alignment	Expropriation of property	Linkages to employment /educational	Land acquisition
			Connection to other transit systems	Serve dis advantaged districts	Demolition Work

Here this study have discussed the sub criteria's which are generated from the major criteria with respect to their interactions and synergy. Finally all the sub criteria's identified are presented and defined as follows.

- 1) Efficiency it is measured by examining the option which contributes to a reduction in travel time compared to time spent on the roads and provides a close-to-optimal convenience for pedestrian access and links to other local and commuter transportation modes, and, also an effective connection of housing jobs, retail centers, recreation areas is beneficial and will score high.
- 2) From the construction and geology point of view, areas which have high demand to alternative rail routes like high-density built-up areas, commercial centers, industrial and institutional areas, will score high. This aspect, however, particularly when it is accompanied by poor geological conditions at a route/site option, conflicts with a low construction cost requirement [1].

- 3) Engineering characteristics and alignment are evaluated with respect to the measures/attributes constituting the geological environment (including soil mechanics, intrusive rock structure, stratification, etc.); hydro-geological conditions (including underground water-level, chances of inrush, perviousness, locations of permeable or impermeable layers, chemical and physical characteristics of underground water and their effects on the built-in architectural structures) and geo-technics (rock boundaries, response surfaces, geographic configuration) [1]. Special focus should be given to safety. Therefore, the recognition and control of risk factors are of utmost importance (water intrusion, gas explosion, earth quake) [1].
- 4) Another measure of engineering factor is suitable infrastructure which involves the careful examination/analysis of over ground building up, the suitability of the existing public utility network capability and the required over ground organization to be made before the construction works are started [1].
- 5) Accessibility measures the availability of stations to the governmental institutions, maximizing the accessibility will score high.
- 6) Connectivity to the existing public transport systems; maximizing connectivity will score high.
- 7) Linkages to strategic growth centers as designated/proposed in local plans, maximizing linkages to strategic growth centers will score high.
- 8) Expropriation of property taking someone's property lawfully for the purpose of public use like railway stations. Minimizing expropriation of properties will score high.
- 9) Connections to other transit systems: to provide good linkages among urban centers and suburban railway networks, airports, long-distance bus stations, park and ride lots. Maximizing these connections will rank high.
- 10) Ecological protection: It is necessary to separate ecologically reserved areas with possible decision areas. The designed railway station project should minimize damage to the environment during site construction, reservation of ecology will score high.
- 11) Intrusion to sensitive areas: Minimal intrusion into environmentally sensitive and reserved areas during construction a head. The designed railway station project should minimize intrusion to the environment, minimizing intrusion rate will score high.

- 12) Noise impactation: Minimal noise impact to sensitive land use (such as hospitals, residential buildings and schools) during site construction, low level of noise will score high.
- 13) Emission level and energy consumption: A reduction in energy consumption, minimal emission levels during site construction, minimization of emissions will rank high.
- 14) Mobility: the ability to move easily from one job, place to live, or social class to another. Establishment of a transit system should increase social mobility by way of easy access to existing and future settlements. Maximizing mobility will score high.
- 15) Disruption to community: any railway system should minimize situations in which something is prevented from continuing in its usual way, minimize disruption to neighborhood communities. Minimizing this criteria will score high.
- 16) Access to residential/shopping centers: This can be measured by forecasting the passenger/km reduction for residential to employment areas, and residential to educational institutions. Efficiency of the land use objective should be achieved by maximizing access between residential areas and shopping, service and recreational centers [1]. Maximizing this criteria will score high.
- 17) Linkages to employment/educational areas: maximize linkages to major employment areas/centers and Based on plans and ideas of future settlements employment and educational institutions [1]. Maximizing this criteria will score high.
- 18) Serve areas of disadvantaged: Such systems would serve highly populated areas and particularly disadvantaged areas (low cost settlements), would increase access to tourism attraction areas. Maximizing this criteria will score high.
- 19) Return on investment: economic objectives seeks to maximize feasible economic return on investment from the system, maximizing this criteria will rank high.
- 20) Net present value: The difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment or project.

Table 4: Summary of Main Selection Criteria and their Sub Criteria

Criteria	Symbol	Summary
<i>Environmental</i>		
Ecological protection	1EP	The higher the conservation of ecology, the higher the score
Intrusion to sensitive areas	2ISA	The lesser the intrusion to sensitive areas the higher the rank
Noise impaction	3NI	The lesser the noise impact, the higher the score
Emission levels and energy consumption	4ELEC	The lesser emission levels and energy consumption, the higher the rank
<i>Social</i>		
Mobility	1MO	The higher the mobility, the higher the rank
Disruption to community	2DC	The lesser the disruption to community, the higher the rank
Access to residential/ or shopping areas	3ARSA	The higher the access to residential/ or shopping areas, the higher the score
Linkages to employment/ or educational centers	4LEEC	The higher the linkages to employment/ or educational areas, the higher the score
Serve areas of disadvantaged	5SAD	The higher the server areas of disadvantaged, the higher the rank
<i>Engineering</i>		
Efficiency	1EFF	The higher the efficiency, the higher the rank
Construction and geology	2CG	The higher the construction and geological setup, the higher the rank
Suitable infrastructure	3SI	The higher the suitable infrastructure, the higher the score
Engineering characteristics and alignment	4ECA	The higher the engineering characteristics and alignment, the higher the score

“Table 4: Continued”

Criteria	Symbol	Summary
<i>Economic</i>		
Net present value	1NPV	The higher the NPV, the higher the score
Return on investment	2RI	The higher the rate of return, the higher the score
Construction costs	3CC	The lesser the construction cost, the higher the rank
Land acquisition	4LA	The lesser the land acquisition, the higher the rank
Demolition work	5DW	The lesser the demolition work, the higher the rank
<i>Institutional</i>		
Accessibility	1ACC	The higher the accessibility governmental institutions, the higher the score
Connectivity	2CON	The higher the connectivity to existing public transport systems, the higher the rank
Linkages to strategic growth centers	3LSGC	The higher the linkages to strategic growth centers, the higher the score
Expropriation of property	4EXP	The lesser the expropriation of individuals property, the higher the rank
Connections to other transit systems	5COTS	The higher the connections to other transit systems, the higher the score
<i>Alternatives</i>		
Dire Dawa 1	1DD1	This is the station selected by ERC judgment
Dire Dawa 2	2DD2	The possible option for selected Dire Dawa site
Dewenle 1	1D1	This is Dewenle station chosen by ERC decision
Dewenle 2	2D2	The potential which may be the possible alternative
Bike 1	1B1	The station that was chosen by ERC decision maker
Bike 2	2B2	The possible station for Bike alternative

21) Construction cost and operation cost: the costs which are invested for construction and operation should be minimum if it is possible, minimizing criteria will rank high.

22) Land acquisition: the act of getting land, intensification of existing land use and maximizing the potential of the location is better than acquisition of land, minimizing land/real estate acquisition will score high.

23) Demolition work: it is a process of deliberately demolishing building, this should be minimized as possible, minimizing demolition will rank high.

4.3 Generation of alternatives

The other building block of the ANP model development is the generation of alternatives. Unless it is not workable to provide the priorities, synthesis, and sensitivity analysis. Here the stations are selected for the evaluation in the Mieso-Dewenle route only by the relative availability data's. In these case this study have three stations with their possible options. For each of these stations the paper have two possible options with their unique characteristics. The proposed stations are Dire Dawa, Bike, and Dewenle stations with their corresponding possible alternatives. For their uniqueness let's see the Dire Dawa station and its alternatives according to the reports: Dire Dawa (the existing station) has much importance than Dire Dawa 2 (the possible option) in respect of linkages to strategic growth centers, and Dire Dawa 1 is much emission levels and energy consumptions than Dire Dawa 2, Dire Dawa 1 is much accessible than Dire Dawa 2, and Dire Dawa 1 has much expropriation of individuals property than Dire Dawa 2, and so many such contradicting features are there in the possible options. All two alternatives have their own advantages and disadvantages. Like that of Dire Dawa station, in the other stations there are a contradicting characteristics were there and they are discussed in the next chapter.

4.4 ANP model

The ANP model was built using the Super Decisions software for evaluating. The pairwise comparisons for the criteria, sub-criteria and alternatives were carried out by experts from the Ethiopian Railways Corporation through group discussion followed by agreement, and finally, the judgment was put into the software. Each set of pairwise comparisons was checked for consistency and revised if necessary until the maximum inconsistency was below 0.1, which is considered the minimum standard level in the literature. Based on the above criteria and sub-criteria, an ANP model for railway station site selection was developed. The model is made up of six clusters with inner and outer dependences, and feedback networks (See Figure 12).

- From these six cluster the four groups of clusters were the major criteria's which includes: engineering, institutional, economic, social, and environmental criteria.
- The other one is the goal cluster to select the most optimal railway station site selection.
- The final one is the alternatives cluster which includes the possible potential stations being proposed with the objective being to select the best station location from among the alternatives, or to rank all the possible potential stations by their optimality.

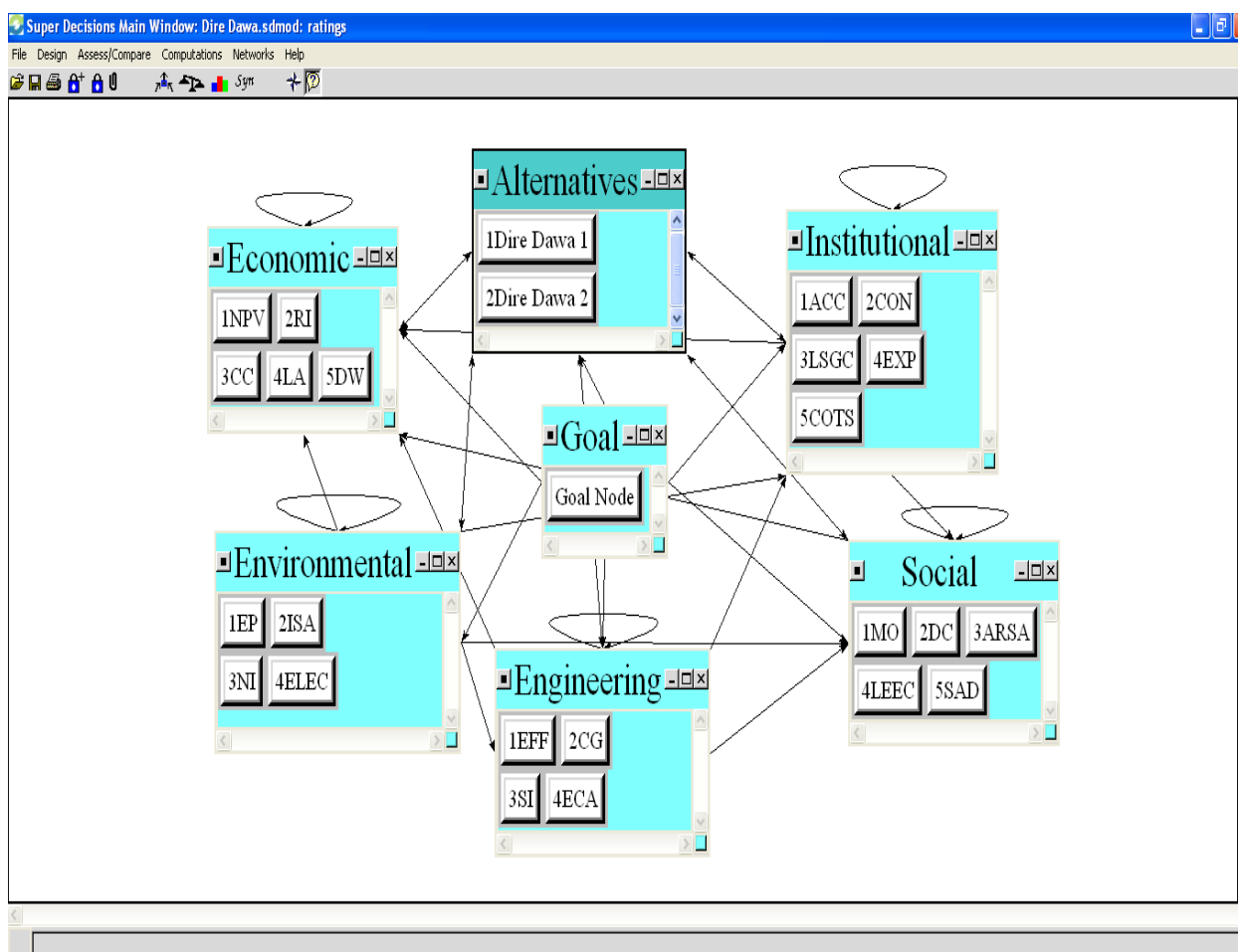


Figure 12: Basic network of the problem (particularly for Dire Dawa station)

Here as the paper have discussed in the above sections the identification of criteria, identification of sub criteria and the generated alternatives are new in this areas of research. In addition still now there is no literature which uses such a network for site selection in general and railway station in particular. Therefore the network developed by using ANP model for railway station site selection is totally belongs to this work.

CHAPTER 5 MODEL VALIDATION

This section discusses the validation of the model developed above by using the selected sample stations in the Mieso - Dewenle route. From these route the paper had chosen three stations with their possible potential alternatives. These stations are Dire Dawa, Bike, and Dewenle with one possible options for each stations. From these stations all the station were used for the validation here in this. In this topic the study have discussed the pairwise comparisons of criteria, and sub criteria, the super matrix computations (all the three i.e. un-weighted super matrix, weighted super matrix, and limiting super matrices), and limiting priorities and normalized by cluster priorities computations, the synthesized values- the results for the alternatives, and the sensitivity analyses were discussed in brief.

5.1 Pairwise Comparison of Major criteria's

It is essential in real life problems that one know the importance of the groups or clusters to which the elements belong because the final priorities do (and should) depend on that. As we have found from the respondents the major criteria have the following share to constitute a railway station site selection. Here the inconsistency is less than the limit 0.1 which is 0.07224, therefore the judgment is so realistic and reasonable. As we have seen in the figure below the priorities of the major criteria are: engineering, institutional, economic, social, and environmental criteria weighs 0.42668, 0.33209, 0.13308, 0.06684, and 0.04131 respectively with respect to the goal criteria. As I had received from the experts the result is realistic.

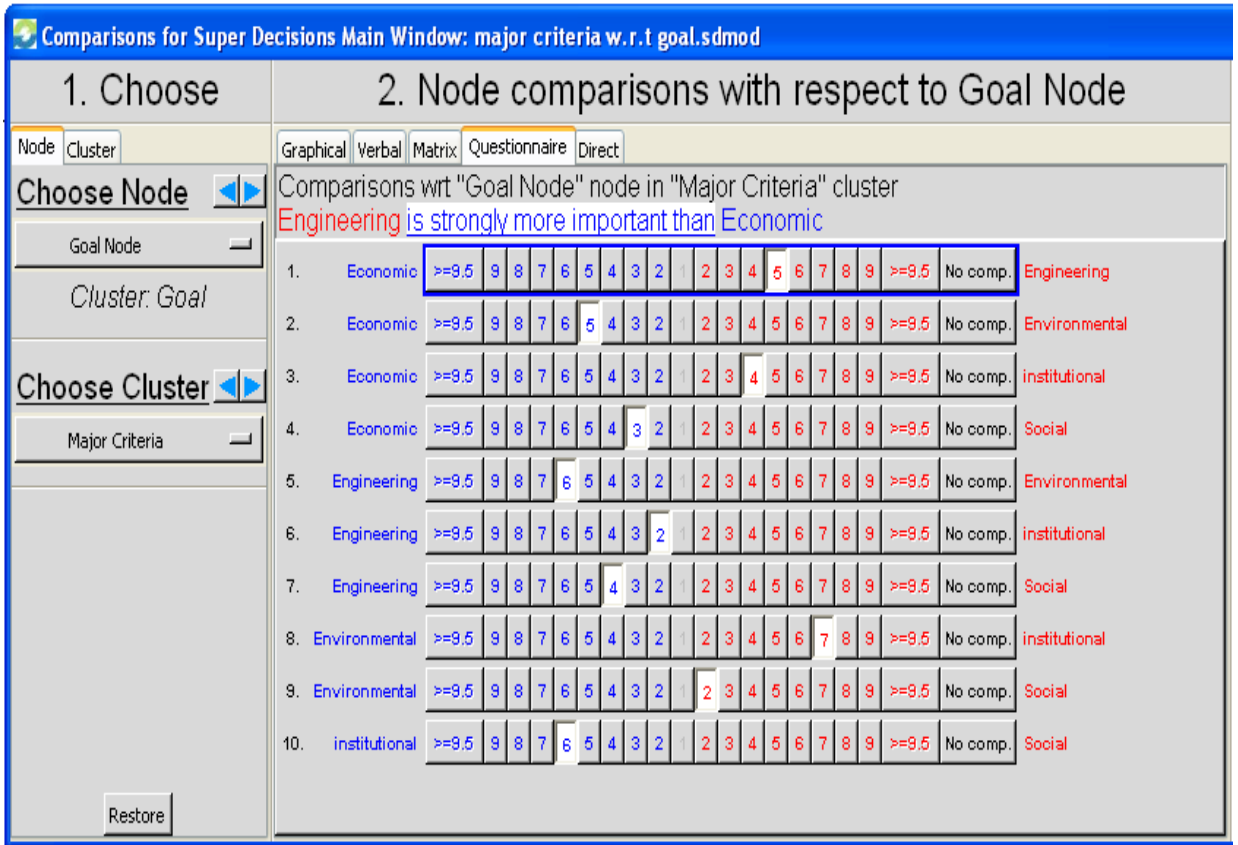


Figure 13: The Questionnaire Mode for Cluster Comparisons w.r.t. alternatives

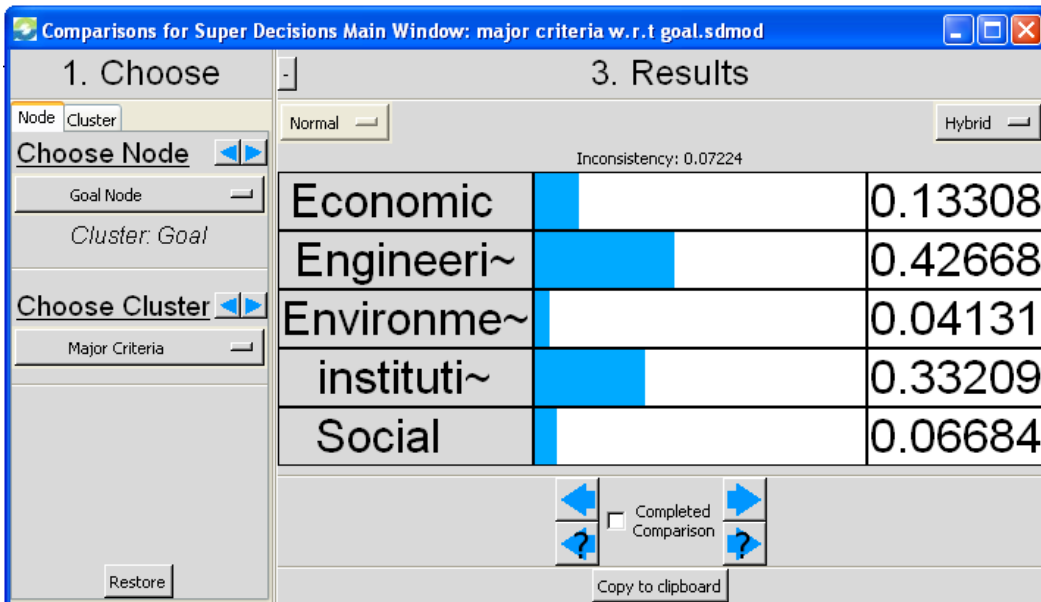


Figure 14: Cluster Ratings w.r.t. the goal

5.2 Dire Dawa Railway Station and Its Alternative

Dire Dawa lies in the eastern part of the Ethiopia. Dire Dawa is one of the two chartered cities in the nation. It is located on the Dechatu River, at the foot of a ring of cliffs that

has been described as "somewhat like a cluster of tea-leaves in the bottom of a slop-basin. At a latitude and longitude of $9^{\circ}36'N$ $41^{\circ}52'E$, it is the second largest city in Ethiopia.

Dire Dawa is served by station on Addis Ababa – Djibouti railway project, and it is a common station for two railway routes (the Chemin De Fer Djibouti – Ethiopian railway and road route via Dewenle) for Ethiopia – Djibouti. Therefore it is the largest and most necessary station in the routes. Dire Dawa Railway Station is located in next to YeSelam Adarash Bete Mengist. In this particular paper the existing station was designated to be Dire Dawa 1 (1DD1), the possible option for this station is designated by Dire Dawa 2 (2DD2). These stations (i.e. 1DD1 and 2DD2) have a contradicting values with respect of different objectives. For example 1DD1 has much importance than 2DD2 in respect of linkages to strategic growth centers, and 1DD1 is much emission levels and energy consumptions than 2DD2, 1DD1 is much accessible than 2DD2, and 1DD1 has much expropriation of individuals property than 2DD2, and so many such contradicting features are there in any of the possible options. So, in order to optimize these contradicting objectives to be minimal we have done the following analysis and evaluations.

5.3 Un-weighted Super matrix to Dire Dawa Station

The results of all the pairwise comparisons are entered in the un-weighted super matrix. It contains the local priorities derived from the pairwise comparison throughout the network as shown in table 5. It is used to compute the local priorities, For example, the priorities of the sub criteria ecological protection, intrusion to sensitive areas, noise impact, and emission levels and energy consumption with respect to Dire Dawa 1 are in order of (1) noise impact 0.51579, (2) both emission level and energy consumption, and intrusion to sensitive areas 0.18941 and (3) ecological protection 0.10539 as shown in the four bottom cells of the first column. This may be interpreted with the statement, "The intrusion to sensitive areas of Dire Dawa 1 is between equally to moderately important than ecological protection, or 2 times, more it's dominant to intrusions to sensitive areas than the protection of ecological areas." All the local priority information can be read directly from the un-weighted Super matrix.

Table 5: Un-weighted Super matrix for Dire Dawa Station

		Alter.		Economic				
		1DD1	2DD2	1NPV	2RI	3CC	4LA	5DW
Alter.	1DD1	0	0	0.85714	0.9	0.875	0.9	0.88889
	2DD2	0	0	0.14286	0.1	0.125	0.1	0.11111
Economic	1NPV	0.06211	0.45001	0.52548	0	0	0	0
	2RI	0.17187	0.18905	0.26433	0	0	0	0
	3CC	0.19144	0.16913	0.10463	0.33333	0	0	0
	4LA	0.26281	0.10872	0.05035	0.33333	0.5	0	0
	5DW	0.31177	0.0831	0.05522	0.33333	0.5	1	0
Engineering	1EFF	0.25	0.25	0	0	0	0	0
	2CG	0.25	0.25	0	0	0	0	0
	3SI	0.25	0.25	0	0	0	0	0
	4ECA	0.25	0.25	0	0	0	0	0
Environmental	1EP	0.10539	0.43366	0	0	0	0	0
	2ISA	0.18941	0.23887	0	0	0	0	0
	3NI	0.51579	0.08861	0	0	0	0	0
	4ELEC	0.18941	0.23887	0	0	0	0	0
Institutional	1ACC	0.12543	0.23567	0	0	0	0	0
	2CON	0.12543	0.23567	0	0	0	0	0
	3LSGC	0.12543	0.23567	0	0	0	0	0
	4EXP	0.30906	0.14781	0	0	0	0	0
	5COTS	0.31466	0.14518	0	0	0	0	0
Social	1MO	0.11111	0.27273	0	0	0	0	0
	2DC	0.11111	0.27273	0	0	0	0	0
	3ARSA	0.33333	0.09091	0	0	0	0	0
	4LEEC	0.33333	0.09091	0	0	0	0	0
	5SAD	0.11111	0.27273	0	0	0	0	0

“Table 5: Continued”

		Engineering				Institutional				
		1EFF	2CG	3SI	4ECA	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1DD1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.85714	0.9
	2DD2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.14286	0.1
Economic	1NPV	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2RI	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3CC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5DW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Engineering	1EFF	0.64433	0	0	0	0	0	0	0	0
	2CG	0.10534	0	0	0	0	0	0	0	0
	3SI	0.04512	0.5	0	0	0	0	0	0	0
	4ECA	0.20522	0.5	1	0	0	0	0	0	0
Environmental	1EP	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0
Institutional	1ACC	0.2	0.2	0.2	0.2	0.0847	0	0	0	0
	2CON	0.2	0.2	0.2	0.2	0.1479	0	0	0	0
	3LSGC	0.2	0.2	0.2	0.2	0.32653	0.33333	0	0	0
	4EXP	0.2	0.2	0.2	0.2	0.06447	0.33333	0.5	0	0
	5COTS	0.2	0.2	0.2	0.2	0.3764	0.33333	0.5	1	0
Social	1MO	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2DC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3ARSA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LEEC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5SAD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

“Table 5: Continued”

		Social					Environmental			
		1MO	2DC	3ARSA	4LEEC	5SAD	1EP	2ISA	3NI	4ELEC
Alter.	1DD1	0.9	0.9	0.875	0.9	0.25	0.85714	0.875	0.9	0.875
	2DD2	0.1	0.1	0.125	0.1	0.75	0.14286	0.125	0.1	0.125
Economic	1NPV	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2RI	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3CC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5DW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Engineering	1EFF	0	0	0	0	0	0.25	0.25	0.25	0.25
	2CG	0	0	0	0	0	0.25	0.25	0.25	0.25
	3SI	0	0	0	0	0	0.25	0.25	0.25	0.25
	4ECA	0	0	0	0	0	0.25	0.25	0.25	0.25
Environmental	1EP	0	0	0	0	0	0.09795	0	0	0
	2ISA	0	0	0	0	0	0.62431	0.33333	0	0
	3NI	0	0	0	0	0	0.05711	0.33333	0.5	0
	4ELEC	0	0	0	0	0	0.22064	0.33333	0.5	1
Institutional	1ACC	0	0	0	0	0	0.2	0.2	0.2	0.2
	2CON	0	0	0	0	0	0.2	0.2	0.2	0.2
	3LSGC	0	0	0	0	0	0.2	0.2	0.2	0.2
	4EXP	0	0	0	0	0	0.2	0.2	0.2	0.2
	5COTS	0	0	0	0	0	0.2	0.2	0.2	0.2
Social	1MO	0.06137	0	0	0	0	0.2	0.2	0.2	0.2
	2DC	0.12876	0	0	0	0	0.2	0.2	0.2	0.2
	3ARSA	0.18411	0.33333	0	0	0	0.2	0.2	0.2	0.2
	4LEEC	0.25752	0.33333	0.5	0	0	0.2	0.2	0.2	0.2
	5SAD	0.36823	0.33333	0.5	1	0	0.2	0.2	0.2	0.2

5.4 Weighted Super matrix for Dire Dawa Station

The weighted super matrix is obtained by multiplying all the elements in a component of the un-weighted super matrix by the corresponding cluster weight. If we take the economic criteria as an example let’s see the results cluster weight for economic criteria is 0.13308 times the un-weighted weights of sub criteria’s (i.e. 1NPV, 2RI, 3CC, 4LA, 5DW have 0.06211, 0.17187, 0.19144, 0.26281, 0.31177 values respectively) results 0.008266, 0.022874, 0.025477, 0.034975, 0.041492 respectively with respect to Dire Dawa 1. Notice that as the columns already sum to one in the un-weighted super matrix

there is no need to weight the components to make the columns sum to one in the weighted super matrix.

Table 6 : Weighted Super matrix for Dire Dawa Station

		Alter.		Economic				
		1DD1	2DD2	1NPV	2RI	3CC	4LA	5DW
Alter.	1DD1	0	0	0.428571	0.45	0.4375	0.45	0.888889
	2DD2	0	0	0.071429	0.05	0.0625	0.05	0.111111
Economic	1NPV	0.008266	0.059888	0.262739	0	0	0	0
	2RI	0.022874	0.025159	0.132165	0	0	0	0
	3CC	0.025477	0.022508	0.052314	0.166667	0	0	0
	4LA	0.034975	0.014468	0.025173	0.166667	0.25	0	0
	5DW	0.041492	0.011106	0.027609	0.166667	0.25	0.5	0
Engineering	1EFF	0.106669	0.106669	0	0	0	0	0
	2CG	0.106669	0.106669	0	0	0	0	0
	3SI	0.106669	0.106669	0	0	0	0	0
	4ECA	0.106669	0.106669	0	0	0	0	0
Environmental	1EP	0.004353	0.017912	0	0	0	0	0
	2ISA	0.007824	0.009867	0	0	0	0	0
	3NI	0.021305	0.00366	0	0	0	0	0
	4ELEC	0.007824	0.009867	0	0	0	0	0
Institutional	1ACC	0.041654	0.078265	0	0	0	0	0
	2CON	0.041654	0.078265	0	0	0	0	0
	3LSGC	0.041654	0.078265	0	0	0	0	0
	4EXP	0.102636	0.049085	0	0	0	0	0
	5COTS	0.104496	0.048212	0	0	0	0	0
Social	1MO	0.007427	0.018229	0	0	0	0	0
	2DC	0.007427	0.018229	0	0	0	0	0
	3ARSA	0.02228	0.006076	0	0	0	0	0
	4LEEC	0.02228	0.006076	0	0	0	0	0
	5SAD	0.007427	0.018229	0	0	0	0	0

5.5 Limit Super matrix for Dire Dawa Station

The limit super matrix is obtained by raising the weighted super matrix to powers by multiplying it times itself. When the column of numbers is the same for every column, the limit matrix has been reached and the matrix multiplication process is halted. The limit super matrix for the Dire Dawa railway station site selection is shown in table 7 below. The priorities here are different than both un-weighted and weighted super matrix for example the priorities for economic criteria in un-weighted super matrix was 5DW, 4LA, 3CC, 2RI, and 1NPV, but here in limit super matrix this order is changed and it is 5DW, 4LA, 3CC, 1NPV, and 2RI with respect to Dire Dawa 1.

Table 7: Limit Super matrix for Dire Dawa Station

		Alter.		Economic				
		1DD1	2DD2	1NPV	2RI	3CC	4LA	5DW
Alter.	1DD1	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028
	2DD2	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439
Economic	1NPV	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106
	2RI	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781
	3CC	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137
	4LA	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262
	5DW	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051
Engineering	1EFF	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678
	2CG	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282
	3SI	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565
	4ECA	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396
Environmental	1EP	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192
	2ISA	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275
	3NI	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618
	4ELEC	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376
Institutional	1ACC	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124
	2CON	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158
	3LSGC	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433
	4EXP	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994
	5COTS	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201
Social	1MO	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877
	2DC	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919
	3ARSA	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485
	4LEEC	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945
	5SAD	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678

5.6 The Priorities for Dire Dawa Station

The computations of priorities displays the priorities in two ways: as they appear in the super matrix, and with the priorities normalized by cluster as shown in table 8. The columns of the limit super matrix are all the same, so the priorities for all the nodes can be read from any column.

Table 8: Priorities for Dire Dawa Station

Name	Symbol	Normalized By Cluster	Limiting
1Dire Dawa 1	1DD1	0.84937	0.25028
2Dire Dawa 2	2DD2	0.15063	0.04439
Net present value	1NPV	0.16205	0.04106
Return on investment	2RI	0.14924	0.03781
Construction costs	3CC	0.16328	0.04137
Land acquisition	4LA	0.20768	0.05262
Demolition work	5DW	0.31775	0.08051
Efficiency	1EFF	0.24649	0.03678
Construction and geology	2CG	0.21993	0.03282
Suitable infrastructure	3SI	0.23895	0.03565
Engineering characteristics and alignment	4ECA	0.29463	0.04396
Ecological protection	1EP	0.13118	0.00192
Intrusion to sensitive areas	2ISA	0.18814	0.00275
Noise impaction	3NI	0.42318	0.00618
Emission levels and energy consumption	4ELEC	0.2575	0.00376
Accessibility	1ACC	0.13352	0.02124
Connectivity	2CON	0.13563	0.02158
Linkages to strategic growth centers	3LSGC	0.1529	0.02433
Expropriation of property	4EXP	0.25105	0.03994
Connections to other transit systems	5COTS	0.3269	0.05201
Mobility	1MO	0.14546	0.01877
Disruption to community	2DC	0.14873	0.01919
Access to residential or shopping areas	3ARSA	0.19256	0.02485
Linkages to employment or educational areas	4LEEC	0.22822	0.02945
Serve areas of disadvantaged	5SAD	0.28503	0.03678

The results were synthesized throughout the model to yield the overall priorities of the sub criteria, as shown in table 8. The priorities of the sub criteria rank in the following order:- Demolition Work, Land Acquisition, Connections to Other Transit Systems, Engineering Characteristics and Alignment, Construction Costs, Net Present Value, Expropriation of Property, Return on Investment, Efficiency & Serve Areas of Disadvantaged, Suitable Infrastructure, Construction and Geology, Linkages to Employment and Educational Centers, Access to Residential/ or Shopping Areas, Linkages to Strategic Growth Centers, Connectivity, Accessibility, Disruption to Community, Mobility, Noise Impaction, Emission Levels and Energy Consumption,

Intrusion to Sensitive Areas, and Ecological Protection. The priorities of the alternatives rank as follows: Dire Dawa 1, and Dire Dawa 2.

Super Decisions Main Window: Dire Dawa.sdmod: rati... _ □ ×

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	1Dire Dawa 1	0.84937	0.250281
No Icon	2Dire Dawa 2	0.15063	0.044387
No Icon	1NPV	0.16205	0.041060
No Icon	2RI	0.14924	0.037814
No Icon	3CC	0.16328	0.041371
No Icon	4LA	0.20768	0.052620
No Icon	5DW	0.31775	0.080509
No Icon	1EFF	0.24649	0.036780
No Icon	2CG	0.21993	0.032816
No Icon	3SI	0.23895	0.035654
No Icon	4ECA	0.29463	0.043963
No Icon	1EP	0.13118	0.001916
No Icon	2ISA	0.18814	0.002748
No Icon	3NI	0.42318	0.006181
No Icon	4ELEC	0.25750	0.003761
No Icon	1ACC	0.13352	0.021244
No Icon	2CON	0.13563	0.021580
No Icon	3LSGC	0.15290	0.024327
No Icon	4EXP	0.25105	0.039943
No Icon	5COTS	0.32690	0.052012
No Icon	1MO	0.14546	0.018769
No Icon	2DC	0.14873	0.019191
No Icon	3ARSA	0.19256	0.024847
No Icon	4LEEC	0.22822	0.029448
No Icon	5SAD	0.28503	0.036778

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Figure 15: Priorities for Dire Dawa

5.7 Synthesis for Dire Dawa Station

The results were synthesized throughout the model to yield the overall priorities of the alternatives, shown in figure 16. The computations of synthesise displays the final results in three ways. The Raw column gives the priorities from the limiting super matrix (which also appear in the Limiting column above) of the sub criteria's with respect to Dire Dawa railway station, the Normals column shows the results normalized for each component (which also appear in the Normalized by Cluster column above) and the Ideals column shows the results obtained by dividing the values in either the normalized or limiting columns by the largest value in the column.

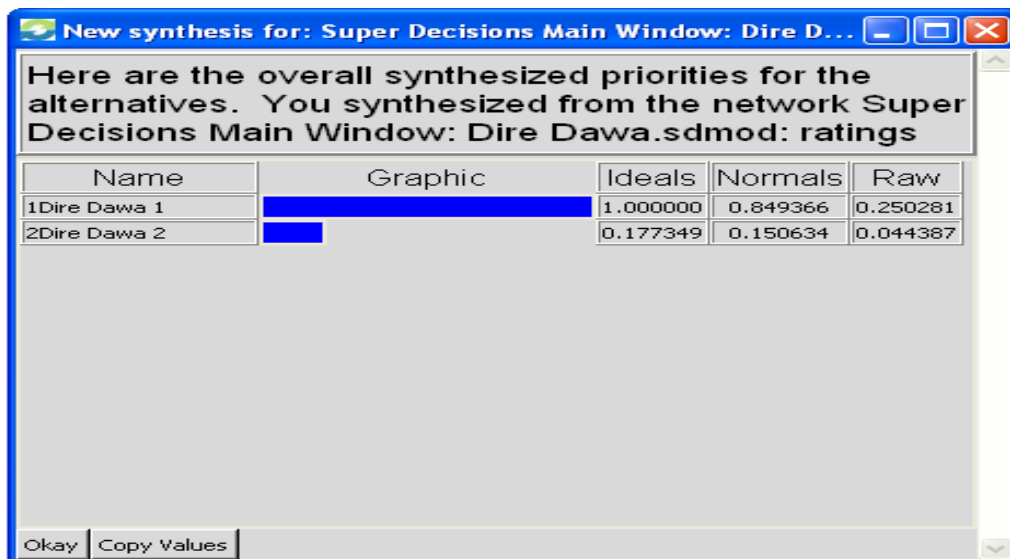


Figure 16: The Synthesized Values for Dire Dawa

The results show that station Dire Dawa 1 is best. This is the same as the decision of ERC what they had done. Station Dire Dawa 1 is an optimal station according to voluminous objectives which should have to be fulfilled, so choose it. Station Dire Dawa 2 is not optimal in respect of the evaluation criteria, so it is not the best station overall. Do not choose it.

5.8 Overview of Dewenle Station its Alternatives, Priorities, and Synthesis

Dewenle is the town on the Ethiopia and Djibouti border. It is located in the Shinile Zone in the Somali Region. It is one of the four towns in Ayesha Woreda, this town has a longitude and latitude of 11⁰²'N 42⁰³⁷'E with an elevation of 898 meters above sea level.

Dewenle was the first point inside the boundaries of Ethiopia to receive train service. It is served by a station on the Addis Ababa – Djibouti Railway. It serves as an official crossing point between Djibouti and Ethiopia, with a customs post. The station was built in the eastern part of the city on the road to Djibouti. This station is designated to be Dewenle 1 for this particular paper. The other potential alternative was assigned to be Dewenle 2 which is to the south of the station under construction (i.e. Dewenle 1). Dewenle 1 (1D1) is extremely more efficient than Dewenle (2D2), 1D1 has much intrusion to sensitive areas than 2D2, and 1D1 propagates much noise to the community than 2D2 and so on.

The results of all the pairwise comparisons are entered in the un-weighted super matrix for Dewenle station. The un-weighted super matrix contains the local priorities derived from the pairwise comparison. It is used to compute the local priorities, For example, the priorities of the sub criteria efficiency, construction and geology, suitable infrastructure, engineering characteristics and alignment are: engineering characteristics and alignment 0.4755, suitable infrastructure 0.33427, construction and geology 0.13063, and efficiency 0.05954 with respect to Dewenle 1. This may be interpreted with the statement, "The engineering characteristics and alignment of Dewenle 1 is moderately to strongly more important than construction and geology, or 4 times, more it's dominant to engineering characteristics than the construction and geology." All the local priority information can be read directly from the un-weighted Super matrix for Dewenle station as it is presented as a table in appendix.

The results were synthesized throughout the model to yield the overall priorities of the sub criteria for Dewenle railway station, as shown in table 9. The priorities of the sub criteria rank in the following order: demolition work, engineering characteristics and alignment, land acquisition, construction costs, connections to other transit systems, net

present value, suitable infrastructure, expropriation of property, linkages to strategic growth centers, return on investment, serve areas of disadvantaged, linkages to employment or educational centers, connectivity, disruption to community, access to residential or shopping areas, mobility, accessibility, construction and geology, efficiency, emission levels and energy consumption, intrusion to sensitive areas, ecological protection, and noise impact. The priorities of the alternatives are as follows: Dewenle 1, and Dewenle 2

Table 9: Priorities for Dewenle Station

Name	Symbol	Normalized By Cluster	Limiting
Dewenle 1	1D1	0.85035	0.25066
Dewenle 2	2D2	0.14965	0.04411
Net Present Value	1NPV	0.16306	0.04143
Return on Investment	2RI	0.14177	0.03602
Construction Costs	3CC	0.17111	0.04348
Land Acquisition	4LA	0.20947	0.05322
Demolition Work	5DW	0.31459	0.07993
Efficiency	1EFF	0.13643	0.01969
Construction and Geology	2CG	0.1383	0.01996
Suitable Infrastructure	3SI	0.28413	0.04101
Engineering Characteristics and Alignment	4ECA	0.44114	0.06368
Ecological Protection	1EP	0.16952	0.00248
Intrusion to Sensitive Areas	2ISA	0.30057	0.00439
Noise Impaction	3NI	0.1663	0.00243
Emission Levels and Energy Consumption	4ELEC	0.36361	0.00531
Accessibility	1ACC	0.1237	0.02012
Connectivity	2CON	0.14632	0.0238
Linkages to Strategic Growth Centers	3LSGC	0.22698	0.03692
Expropriation of properties	4EXP	0.24725	0.04021
Connections to Other transit Systems	5COTS	0.25576	0.0416
Mobility	1MO	0.1646	0.02133
Disruption to Community	2DC	0.18137	0.0235
Access to Residential or Shopping Areas	3ARSA	0.1667	0.0216
Linkages to Employment or Educational Centers	4LEEC	0.21071	0.0273
Serve Areas of Disadvantaged	5SAD	0.27662	0.03584

Again the results were synthesized throughout the model to yield the overall priorities of the alternatives, shown in figure 17. The computations of synthesize displays the final results in three ways. The Raw column gives the priorities from the limiting super

matrix of the sub criteria's with respect to Dewenle railway station, the Normals column shows the results normalized for each component and the Ideals column shows the results obtained by dividing the values in either the normalized or limiting columns by the largest value in the column.

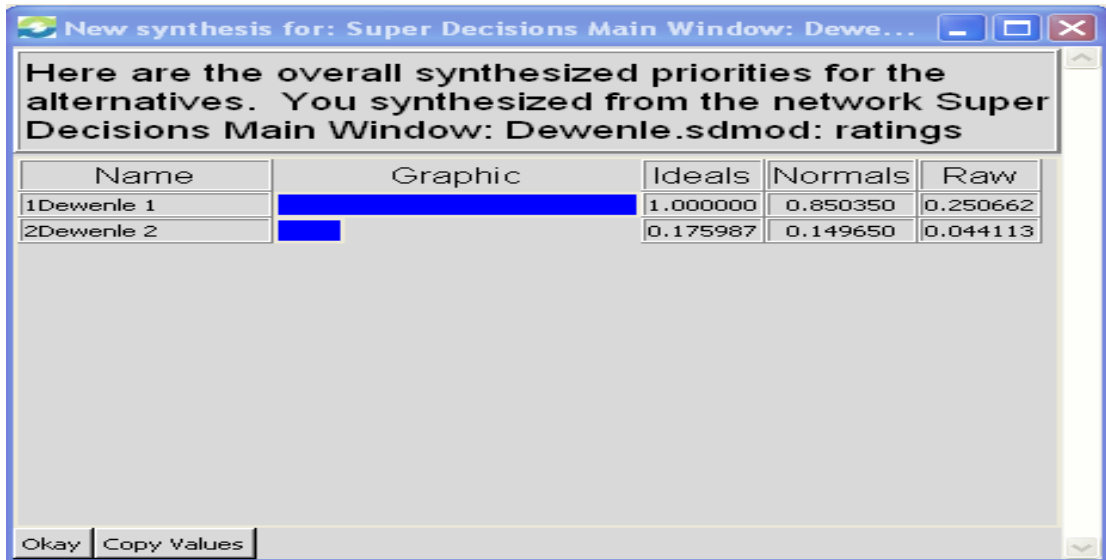


Figure 17: The Synthesized Value for Dewenle Station

The results show that station Dewenle 1 is best. This is the same as the decision of ERC what they had done before. Station Dewenle 1 is an optimal station according to voluminous objectives which should have to be fulfilled, so choose it. Station Dewenle 2 is not optimal in respect of the evaluation criteria, so it is not the best station overall.

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Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	1Dewenle 1	0.85035	0.250662
No Icon	2Dewenle 2	0.14965	0.044113
No Icon	1NPV	0.16306	0.041429
No Icon	2RI	0.14177	0.036020
No Icon	3CC	0.17111	0.043475
No Icon	4LA	0.20947	0.053220
No Icon	5DW	0.31459	0.079930
No Icon	1EFF	0.13643	0.019693
No Icon	2CG	0.13830	0.019962
No Icon	3SI	0.28413	0.041012
No Icon	4ECA	0.44114	0.063675
No Icon	1EP	0.16952	0.002477
No Icon	2ISA	0.30057	0.004392
No Icon	3NI	0.16630	0.002430
No Icon	4ELEC	0.36361	0.005313
No Icon	1ACC	0.12370	0.020119
No Icon	2CON	0.14632	0.023797
No Icon	3LSGC	0.22698	0.036916
No Icon	4EXP	0.24725	0.040213
No Icon	5COTS	0.25576	0.041597
No Icon	1MO	0.16460	0.021325
No Icon	2DC	0.18137	0.023497
No Icon	3ARSA	0.16670	0.021597
No Icon	4LEEC	0.21071	0.027298
No Icon	5SAD	0.27662	0.035838

Figure 18: priorities for Dewenle Station

5.9 Overview of Bike Station its Potential options, Priorities, and Synthesis

Bike is a town in central Ethiopia. Located in the Shinile Zone of the Somali Region it is one of the three towns in Afdem woreda. This town is served by a station on the Addis Ababa - Djibouti Railway. The station under construction is located in the south eastern part of the line. This station is designated to be Bike 1 (1B1) here for this paper, and the other alternative is designated to be Bike 2 (2B2). Station 2B2 has much accessibility to residents/ or shopping areas than 1B1, 1B1 is less connectivity to institutional areas than 2B2, 2B2 has high rate of return on investment than 1B1, and 2B2 may incur less construction costs than 2B2, and so on.

The un-weighted super matrix contains the local priorities derived from the pairwise comparison. It is used to compute the local priorities, For example, the priorities of the sub criteria efficiency, construction and geology, suitable infrastructure, engineering characteristics and alignment are: engineering characteristics and alignment 0.06362, suitable infrastructure 0.13168, construction and geology 0.26392, and efficiency 0.54078 with respect to Bike 1. The local priorities for Bike station were presented in the appendix.

The results were synthesized throughout the model to yield the overall priorities of the sub criteria for bike railway station, as shown in table 10. The priorities of the sub criteria rank in the following order: demolition work, engineering characteristics and alignment, land acquisition, construction costs, net present value, connections to other transit systems, suitable infrastructure, expropriation of property, linkages to strategic growth centers, return on investment, serve areas of disadvantaged, linkages to employment or educational centers, connectivity, disruption to community, access to residential or shopping areas, efficiency, mobility, accessibility, construction and geology, emission levels and energy consumption, intrusion to sensitive areas, noise impact, and ecological protection. The priorities of the alternatives are as follows: Bike 2, and Bike 1.

Table 10: Priorities for Bike Station

Name	Symbol	Normalized By Cluster	Limiting
1Bike 1	1B1	0.17333	0.051073
2Bike 2	2B2	0.82667	0.243591
Ecological protection	1EP	0.17103	0.002498
Intrusion to sensitive areas	2ISA	0.29632	0.004328
Noise impaction	3NI	0.17349	0.002534
Emission levels and energy consumption	4EL&EC	0.35917	0.005246
Mobility	1MO	0.16386	0.021205
Disruption to community	2DC	0.18019	0.023318
Access to residential or shopping areas	3AR/SA	0.16724	0.021642
Linkages to employment or educational areas	4LE/EC	0.21034	0.02722
Serve areas of disadvantaged	5SAD	0.27837	0.036023
Efficiency	1EFF	0.14752	0.02133
Construction and geology	2CG	0.14099	0.020386
Suitable infrastructure	3SI	0.27976	0.040452
Engineering characteristics and alignment	4ECA	0.43173	0.062426
Net present value	1NPV	0.16415	0.041719
Return on investment	2RI	0.14271	0.036271
Construction costs	3CC	0.17064	0.043369
Land acquisition	4LA	0.20884	0.053079
Demolition work	5DW	0.31366	0.07972
Accessibility	1ACC	0.12779	0.020775
Connectivity	2CON	0.14716	0.023924
Linkages to strategic growth centers	3LSGC	0.22471	0.036531
Expropriation of property	4EXP	0.24442	0.039736
Connections to other transit systems	5COTS	0.25592	0.041605

Super Decisions Main Window: Bike station.sdmod: ...

Here are the priorities.

Icon	Name	Normalized by Cluster	Limiting
No Icon	1Bike 1	0.17333	0.051073
No Icon	2Bike 2	0.82667	0.243591
No Icon	1NPV	0.16415	0.041719
No Icon	2RI	0.14271	0.036271
No Icon	3CC	0.17064	0.043369
No Icon	4LD	0.20884	0.053079
No Icon	5DW	0.31366	0.079720
No Icon	1EFF	0.14752	0.021330
No Icon	2CG	0.14099	0.020386
No Icon	3SI	0.27976	0.040452
No Icon	4ECA	0.43173	0.062426
No Icon	1EP	0.17103	0.002498
No Icon	2ISA	0.29632	0.004328
No Icon	3NI	0.17349	0.002534
No Icon	4ELEC	0.35917	0.005246
No Icon	1ACC	0.12779	0.020775
No Icon	2CON	0.14716	0.023924
No Icon	3LSGC	0.22471	0.036531
No Icon	4EXP	0.24442	0.039736
No Icon	5COTS	0.25592	0.041605
No Icon	1MO	0.16386	0.021205
No Icon	2DC	0.18019	0.023318
No Icon	3ARSA	0.16724	0.021642
No Icon	4LEEC	0.21034	0.027220
No Icon	5SAD	0.27837	0.036023

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Figure 19: Priorities for Bike Station

The results were synthesized throughout the model to yield the overall priorities of the alternatives, shown in figure 20. The computations of synthesize displays the final results in three ways. The Raw column gives the priorities from the limiting super matrix of the sub criteria's with respect to Bike railway station, the Normals column

shows the results normalized for each component and the Ideals column shows the results obtained by dividing the values in either the normalized or limiting columns by the largest value in the column.

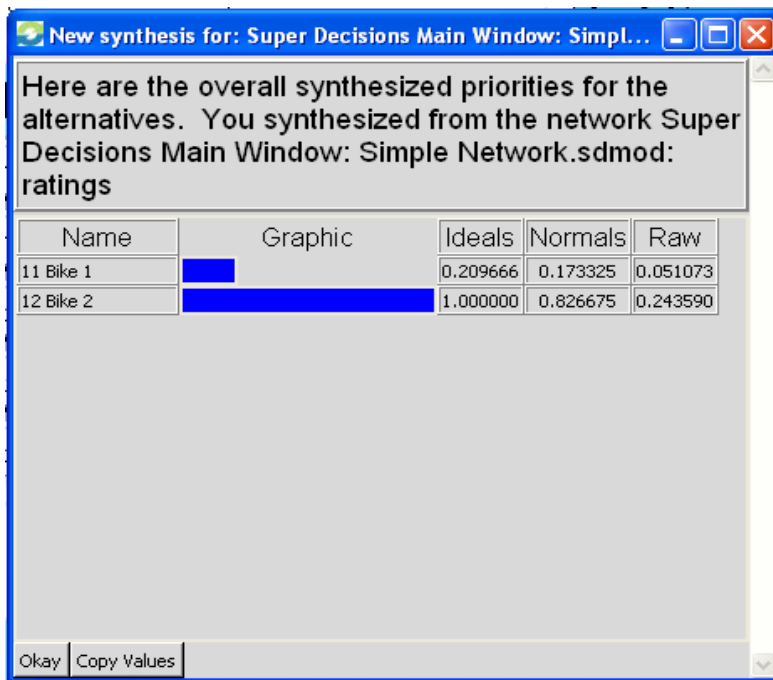


Figure 20: The Synthesized Values for Bike Station

The results show that station Bike 2 is best. This result differs from the decision of ERC what they had done before. Station Bike 2 is an optimal station according to voluminous objectives which should have to be fulfilled, so it has prior to be chosen. According to the study station Bike 1 is not optimal in respect of the evaluation criteria, so it is not the best station overall.

CHAPTER 6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This work have explored the capabilities of Multi Criteria Decision Making techniques for locating a railway station in Ethiopia. The study attempts to resolve some of the problems in the current railway system in the country and describes in detail the implementation and capabilities of Multi Criteria Decision Making method for the choice of better station location.

A spatial multi-criteria decision making (SMCDM) process and evaluation of the ERC decision was the main task of this thesis work. This SMCDM process is useful as it allows multi-criteria analysis and evaluation. Railway planners can design alternative stations and evaluate the environmental, social, engineering, institutional, and economic impact of each stations.

The development of suitable location for the railway station and the laying of the railroad was based on the physical spatial factors. For the railway station these factors were analyzed for optimality with the multi-criteria evaluation (MCE) method. Here they were standardized as factors for best selection. For the railway these factors were engineering, social, economic, institutional, and environmental factors. In general, the evaluation criteria include multiple measures, such as engineering, economic, institutional, social, and environmental factors.

The Analytic Network Process (ANP) has been successfully applied in this study for defining the relative importance of different parameters to the cases of locating a railway station in Addis Ababa - Dwenle route. The evaluation was made by using ANP and the experts' response in order to make ranking from potential station alternatives.

According to the results seen above the priorities developed were almost the same for the three evaluated stations. This indicates that the priorities of the criteria and sub criteria developed were not changing with the decision areas in railway station site selection.

Finally, as it is seen from the result the ERC decision making is relatively good, since from the three sample stations the two were the same but, the remaining one deviates from the decision of ERC. The two stations that conforms to ERC decision are Dire

Dawa and Dewenle. The remaining one that is different than ERC decision is Bike. The decision which is done by ERC and this particular thesis is the same for two third sample stations, however, as the information we have obtained from the concerned bodies from the corporation the selection process is not well studied rather they have chosen politically/or deliberately by default without considering the factors. Therefore they should have taken genuine discussion with the stakeholders in order to come up with a measurable decision. At the same time they should examine their procedures, methods, and factors considered whether they are wrong with respect to their identification of criteria's, what the method they used is not recent and good with their procedures.

6.2 Recommendation

Any major projects were implemented according to their merits and demerits to the target aims. Here the railway station site selection is also one among major projects it has merits and demerits to the societies especially metropolitan areas. These means that the design and implementation of railway station site selection was a multitude of characteristics and the procedures used must be good enough. Therefore this thesis has discussed the criteria and sub criteria considered in this thesis tries to identify the major aspects/ factors which should influence or influenced by building railway station. In addition the method we propose were recent and power full in decision making in general and it is a fantastic tool in site selection in particular. Therefore this study has such a good approach for railway station site selection in Ethiopia and we recommend to use this paper in the coming railway construction programs to select an optimal railway station location.

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Appendices

“Table 6: Continued”

		Engineering				Institutional				
		1EFF	2CG	3SI	4ECA	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1DD1	0.18	0.18	0.18	0.225	0.225	0.225	0.225	0.21429	0.3
	2DD2	0.02	0.02	0.02	0.025	0.025	0.025	0.025	0.03571	0.03333
Economic	1NPV	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	2RI	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	3CC	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	4LA	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	5DW	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
Engineering	1EFF	0.12887	0	0	0	0	0	0	0	0
	2CG	0.02107	0	0	0	0	0	0	0	0
	3SI	0.00902	0.1	0	0	0	0	0	0	0
	4ECA	0.04105	0.1	0.2	0	0	0	0	0	0
Environmental	1EP	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0
Institutional	1ACC	0.04	0.04	0.04	0.05	0.02118	0	0	0	0
	2CON	0.04	0.04	0.04	0.05	0.03698	0	0	0	0
	3LSGC	0.04	0.04	0.04	0.05	0.08163	0.08333	0	0	0
	4EXP	0.04	0.04	0.04	0.05	0.01612	0.08333	0.125	0	0
	5COTS	0.04	0.04	0.04	0.05	0.0941	0.08333	0.125	0.25	0
Social	1MO	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	2DC	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	3ARSA	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	4LEEC	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	5SAD	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667

“Table 6: Continued”

		Environmental				Social				
		1EP	2ISA	3NI	4ELEC	1MO	2DC	3ARSA	4LEEC	5SAD
Alter.	1DD1	0.14286	0.14583	0.15	0.14583	0.3	0.3	0.29167	0.3	0.125
	2DD2	0.02381	0.02083	0.01667	0.02083	0.03333	0.03333	0.04167	0.03333	0.375
Economic	1NPV	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	2RI	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	3CC	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	4LA	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	5DW	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
Engineering	1EFF	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
	2CG	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
	3SI	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
	4ECA	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
Environmental	1EP	0.01632	0	0	0	0	0	0	0	0
	2ISA	0.10405	0.05556	0	0	0	0	0	0	0
	3NI	0.00952	0.05556	0.08333	0	0	0	0	0	0
	4ELEC	0.03677	0.05556	0.08333	0.16667	0	0	0	0	0
Institutional	1ACC	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	2CON	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	3LSGC	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	4EXP	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	5COTS	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
Social	1MO	0.03333	0.03333	0.03333	0.03333	0.02046	0	0	0	0
	2DC	0.03333	0.03333	0.03333	0.03333	0.04292	0	0	0	0
	3ARSA	0.03333	0.03333	0.03333	0.03333	0.06137	0.11111	0	0	0
	4LEEC	0.03333	0.03333	0.03333	0.03333	0.08584	0.11111	0.16667	0	0
	5SAD	0.03333	0.03333	0.03333	0.03333	0.12274	0.11111	0.16667	0.33333	0

“Table 7: Continued”

		Engineering				Institutional				
		1EFF	2CG	3SI	4ECA	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1DD1	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028
	2DD2	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439
Economic	1NPV	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106
	2RI	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781
	3CC	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137
	4LA	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262
	5DW	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051
Engineering	1EFF	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678
	2CG	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282
	3SI	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565
	4ECA	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396
Environmental	1EP	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192
	2ISA	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275
	3NI	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618
	4ELEC	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376
Institutional	1ACC	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124
	2CON	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158
	3LSGC	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433
	4EXP	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994
	5COTS	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201
Social	1MO	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877
	2DC	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919
	3ARSA	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485
	4LEEC	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945
	5SAD	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678

“Table 7: Continued”

		Social					Environmental			
		1MO	2DC	3ARSA	4LEEC	5SAD	1EP	2ISA	3NI	4ELEC
Alter.	1DD1	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028	0.25028
	2DD2	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439	0.04439
Economic	1NPV	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106	0.04106
	2RI	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781	0.03781
	3CC	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137	0.04137
	4LA	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262	0.05262
	5DW	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051	0.08051
Engineering	1EFF	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678
	2CG	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282	0.03282
	3SI	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565	0.03565
	4ECA	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396	0.04396
Environmental	1EP	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192	0.00192
	2ISA	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275	0.00275
	3NI	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618	0.00618
	4ELEC	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376	0.00376
Institutional	1ACC	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124	0.02124
	2CON	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158	0.02158
	3LSGC	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433	0.02433
	4EXP	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994	0.03994
	5COTS	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201	0.05201
Social	1MO	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877	0.01877
	2DC	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919	0.01919
	3ARSA	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485	0.02485
	4LEEC	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945	0.02945
	5SAD	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678	0.03678

Table 11: The un-weighted Super matrix for Dewenle Station

		Alter.		Economic				
		1D1	2D2	1NPV	2RI	3CC	4LA	5DW
Alter.	1D1	0	0	0.85714	0.9	0.875	0.9	0.88889
	2D2	0	0	0.14286	0.1	0.125	0.1	0.11111
Economic	1NPV	0.09091	0.33333	0.52548	0	0	0	0
	2RI	0.09091	0.33333	0.26433	0	0	0	0
	3CC	0.27273	0.11111	0.10463	0.33333	0	0	0
	4LA	0.27273	0.11111	0.05035	0.33333	0.5	0	0
	5DW	0.27273	0.11111	0.05522	0.33333	0.5	1	0
Engineering	1EFF	0.05954	0.54078	0	0	0	0	0
	2CG	0.13063	0.26392	0	0	0	0	0
	3SI	0.33427	0.13168	0	0	0	0	0
	4ECA	0.47556	0.06362	0	0	0	0	0
Environmental	1EP	0.18906	0.26283	0	0	0	0	0
	2ISA	0.35091	0.14088	0	0	0	0	0
	3NI	0.10911	0.45541	0	0	0	0	0
	4ELEC	0.35091	0.14088	0	0	0	0	0
Institutional	1ACC	0.08879	0.36894	0	0	0	0	0
	2CON	0.15777	0.20627	0	0	0	0	0
	3LSGC	0.29783	0.10927	0	0	0	0	0
	4EXP	0.29783	0.10927	0	0	0	0	0
	5COTS	0.15777	0.20627	0	0	0	0	0
Social	1MO	0.29739	0.06228	0	0	0	0	0
	2DC	0.40137	0.04571	0	0	0	0	0
	3ARSA	0.07376	0.24383	0	0	0	0	0
	4LEEC	0.19479	0.09179	0	0	0	0	0
	5SAD	0.03269	0.55639	0	0	0	0	0

“Table 11: Continued”

		Engineering				Institutional				
		1EFF	2CG	3SI	4ECA	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1D1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.85714	0.9
	2D2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.14286	0.1
Economic	1NPV	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2RI	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3CC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5DW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Engineering	1EFF	0.64433	0	0	0	0	0	0	0	0
	2CG	0.10534	0	0	0	0	0	0	0	0
	3SI	0.04512	0.5	0	0	0	0	0	0	0
	4ECA	0.20522	0.5	1	0	0	0	0	0	0
Environmental	1EP	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0
Institutional	1ACC	0.2	0.2	0.2	0.2	0.0847	0	0	0	0
	2CON	0.2	0.2	0.2	0.2	0.1479	0	0	0	0
	3LSGC	0.2	0.2	0.2	0.2	0.32653	0.33333	0	0	0
	4EXP	0.2	0.2	0.2	0.2	0.06447	0.33333	0.5	0	0
	5COTS	0.2	0.2	0.2	0.2	0.3764	0.33333	0.5	1	0
Social	1MO	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2DC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3ARSA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LEEC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5SAD	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

“Table 11: Continued”

		Environmental				Social				
		1EP	2ISA	3NI	4ELEC	1MO	2DC	3ARSA	4LEEC	5SAD
Alter.	1D1	0.85714	0.875	0.9	0.875	0.9	0.9	0.875	0.9	0.25
	2D2	0.14286	0.125	0.1	0.125	0.1	0.1	0.125	0.1	0.75
Economic	1NPV	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2RI	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3CC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5DW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Engineering	1EFF	0.25	0.25	0.25	0.25	0	0	0	0	0
	2CG	0.25	0.25	0.25	0.25	0	0	0	0	0
	3SI	0.25	0.25	0.25	0.25	0	0	0	0	0
	4ECA	0.25	0.25	0.25	0.25	0	0	0	0	0
Environmental	1EP	0.09795	0	0	0	0	0	0	0	0
	2ISA	0.62431	0.33333	0	0	0	0	0	0	0
	3NI	0.05711	0.33333	0.5	0	0	0	0	0	0
	4ELEC	0.22064	0.33333	0.5	1	0	0	0	0	0
Institutional	1ACC	0.2	0.2	0.2	0.2	0	0	0	0	0
	2CON	0.2	0.2	0.2	0.2	0	0	0	0	0
	3LSGC	0.2	0.2	0.2	0.2	0	0	0	0	0
	4EXP	0.2	0.2	0.2	0.2	0	0	0	0	0
	5COTS	0.2	0.2	0.2	0.2	0	0	0	0	0
Social	1MO	0.2	0.2	0.2	0.2	0.06137	0	0	0	0
	2DC	0.2	0.2	0.2	0.2	0.12876	0	0	0	0
	3ARSA	0.2	0.2	0.2	0.2	0.18411	0.33333	0	0	0
	4LEEC	0.2	0.2	0.2	0.2	0.25752	0.33333	0.5	0	0
	5SAD	0.2	0.2	0.2	0.2	0.36823	0.33333	0.5	1	0

Table 12: The Weighted Super matrix for Dewenle Station

		Alter.		Economic				
		1D1	2D2	1NPV	2RI	3CC	4LA	5DW
Alter.	1D1	0	0	0.42857	0.45	0.4375	0.45	0.88889
	2D2	0	0	0.07143	0.05	0.0625	0.05	0.11111
Economic	1NPV	0.0121	0.04436	0.26274	0	0	0	0
	2RI	0.0121	0.04436	0.13217	0	0	0	0
	3CC	0.0363	0.01479	0.05231	0.16667	0	0	0
	4LA	0.0363	0.01479	0.02517	0.16667	0.25	0	0
	5DW	0.0363	0.01479	0.02761	0.16667	0.25	0.5	0
Engineering	1EFF	0.02541	0.23074	0	0	0	0	0
	2CG	0.05574	0.11261	0	0	0	0	0
	3SI	0.14263	0.05619	0	0	0	0	0
	4ECA	0.20291	0.02714	0	0	0	0	0
Environmental	1EP	0.00781	0.01086	0	0	0	0	0
	2ISA	0.0145	0.00582	0	0	0	0	0
	3NI	0.00451	0.01881	0	0	0	0	0
	4ELEC	0.0145	0.00582	0	0	0	0	0
Institutional	1ACC	0.02949	0.12252	0	0	0	0	0
	2CON	0.0524	0.0685	0	0	0	0	0
	3LSGC	0.09891	0.03629	0	0	0	0	0
	4EXP	0.09891	0.03629	0	0	0	0	0
	5COTS	0.0524	0.0685	0	0	0	0	0
Social	1MO	0.01988	0.00416	0	0	0	0	0
	2DC	0.02683	0.00306	0	0	0	0	0
	3ARSA	0.00493	0.0163	0	0	0	0	0
	4LEEC	0.01302	0.00614	0	0	0	0	0
	5SAD	0.00219	0.03719	0	0	0	0	0

“Table 12: Continued”

		Engineering				Institutional				
		1EFF	2CG	3SI	4ECA	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1D1	0.18	0.18	0.18	0.225	0.225	0.225	0.225	0.21429	0.3
	2D2	0.02	0.02	0.02	0.025	0.025	0.025	0.025	0.03571	0.03333
Economic	1NPV	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	2RI	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	3CC	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	4LA	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	5DW	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
Engineering	1EFF	0.12887	0	0	0	0	0	0	0	0
	2CG	0.02107	0	0	0	0	0	0	0	0
	3SI	0.00902	0.1	0	0	0	0	0	0	0
	4ECA	0.04105	0.1	0.2	0	0	0	0	0	0
Environmental	1EP	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0
Institutional	1ACC	0.04	0.04	0.04	0.05	0.02118	0	0	0	0
	2CON	0.04	0.04	0.04	0.05	0.03698	0	0	0	0
	3LSGC	0.04	0.04	0.04	0.05	0.08163	0.08333	0	0	0
	4EXP	0.04	0.04	0.04	0.05	0.01612	0.08333	0.125	0	0
	5COTS	0.04	0.04	0.04	0.05	0.0941	0.08333	0.125	0.25	0
Social	1MO	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	2DC	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	3ARSA	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	4LEEC	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667
	5SAD	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.06667

“Table 12: Continued”

		Environmental				Social				
		1EP	2ISA	3NI	4ELEC	1MO	2DC	3ARSA	4LEEC	5SAD
Alter.	1D1	0.14286	0.14583	0.15	0.14583	0.3	0.3	0.29167	0.3	0.125
	2D2	0.02381	0.02083	0.01667	0.02083	0.03333	0.03333	0.04167	0.03333	0.375
Economic	1NPV	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	2RI	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	3CC	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	4LA	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
	5DW	0.03333	0.03333	0.03333	0.03333	0.06667	0.06667	0.06667	0.06667	0.1
Engineering	1EFF	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
	2CG	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
	3SI	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
	4ECA	0.04167	0.04167	0.04167	0.04167	0	0	0	0	0
Environmental	1EP	0.01632	0	0	0	0	0	0	0	0
	2ISA	0.10405	0.05556	0	0	0	0	0	0	0
	3NI	0.00952	0.05556	0.08333	0	0	0	0	0	0
	4ELEC	0.03677	0.05556	0.08333	0.16667	0	0	0	0	0
Institutional	1ACC	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	2CON	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	3LSGC	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	4EXP	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
	5COTS	0.03333	0.03333	0.03333	0.03333	0	0	0	0	0
Social	1MO	0.03333	0.03333	0.03333	0.03333	0.02046	0	0	0	0
	2DC	0.03333	0.03333	0.03333	0.03333	0.04292	0	0	0	0
	3ARSA	0.03333	0.03333	0.03333	0.03333	0.06137	0.11111	0	0	0
	4LEEC	0.03333	0.03333	0.03333	0.03333	0.08584	0.11111	0.16667	0	0
	5SAD	0.03333	0.03333	0.03333	0.03333	0.12274	0.11111	0.16667	0.33333	0

Table 13: The Limit Super Matrix for Dewenle Station

		Alter.		Economic				
		1D1	2D2	1NPV	2RI	3CC	4LA	5DW
Alter.	1D1	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066
	2D2	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411
Economic	1NPV	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143
	2RI	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602
	3CC	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348
	4LA	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322
	5DW	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993
Engineering	1EFF	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969
	2CG	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996
	3SI	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101
	4ECA	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368
Environmental	1EP	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248
	2ISA	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439
	3NI	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243
	4ELEC	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531
Institutional	1ACC	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012
	2CON	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238
	3LSGC	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692
	4EXP	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021
	5COTS	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416
Social	1MO	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133
	2DC	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235
	3ARSA	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216
	4LEEC	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273
	5SAD	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584

“Table 13: Continued”

		Engineering				Environmental			
		1EFF	2CG	3SI	4ECA	1EP	2ISA	3NI	4ELEC
Alter.	1D1	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066
	2D2	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411
Economic	1NPV	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143
	2RI	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602
	3CC	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348
	4LA	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322
	5DW	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993
Engineering	1EFF	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969
	2CG	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996
	3SI	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101
	4ECA	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368
Environmental	1EP	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248
	2ISA	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439
	3NI	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243
	4ELEC	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531
Institutional	1ACC	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012
	2CON	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238
	3LSGC	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692
	4EXP	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021
	5COTS	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416
Social	1MO	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133
	2DC	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235
	3ARSA	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216
	4LEEC	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273
	5SAD	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584

“Table 13: Continued”

		Institutional					Social				
		1ACC	2CON	3LSGC	4EXP	5COTS	1MO	2DC	3ARSA	4LEEC	5SAD
Alter.	1D1	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066	0.25066
	2D2	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411	0.04411
Economic	1NPV	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143	0.04143
	2RI	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602	0.03602
	3CC	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348	0.04348
	4LA	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322	0.05322
	5DW	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993	0.07993
Engineering	1EFF	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969	0.01969
	2CG	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996	0.01996
	3SI	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101	0.04101
	4ECA	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368	0.06368
Environmental	1EP	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248	0.00248
	2ISA	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439	0.00439
	3NI	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243	0.00243
	4ELEC	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531	0.00531
Institutional	1ACC	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012	0.02012
	2CON	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238
	3LSGC	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692	0.03692
	4EXP	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021	0.04021
	5COTS	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416	0.0416
Social	1MO	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133
	2DC	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235
	3ARSA	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216
	4LEEC	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273
	5SAD	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584	0.03584

Table 14: The un-weighted Super matrix for Bike Station

		Alternatives		Environmental			
		1B1	2B2	1EP	2ISA	3NI	4ELEC
Alter.	1B1	0	0	0.125	0.1	0.25	0.1
	2B2	0	0	0.875	0.9	0.75	0.9
Environmental	1EP	0.26283	0.18906	0.097945	0	0	0
	2ISA	0.14088	0.35091	0.624306	0.333333	0	0
	3NI	0.45541	0.10911	0.05711	0.333333	0.5	0
	4ELEC	0.14088	0.35091	0.220639	0.333333	0.5	1
Social	1MO	0.06228	0.29739	0.2	0.2	0.2	0.2
	2DC	0.04571	0.40137	0.2	0.2	0.2	0.2
	3ARSA	0.24383	0.07376	0.2	0.2	0.2	0.2
	4LEEC	0.09179	0.19479	0.2	0.2	0.2	0.2
	5SAD	0.55639	0.03269	0.2	0.2	0.2	0.2
Engineering	1EFF	0.54078	0.05954	0.25	0.25	0.25	0.25
	2CG	0.26392	0.13063	0.25	0.25	0.25	0.25
	3SI	0.13168	0.33427	0.25	0.25	0.25	0.25
	4ECA	0.06362	0.47556	0.25	0.25	0.25	0.25
Economic	1NPV	0.33333	0.09091	0.2	0.2	0.2	0.2
	2RI	0.33333	0.09091	0.2	0.2	0.2	0.2
	3CC	0.11111	0.27273	0.2	0.2	0.2	0.2
	4LA	0.11111	0.27273	0.2	0.2	0.2	0.2
	5DW	0.11111	0.27273	0.2	0.2	0.2	0.2
Institutional	1ACC	0.36894	0.08879	0.2	0.2	0.2	0.2
	2CON	0.20627	0.15777	0.2	0.2	0.2	0.2
	3LSGC	0.10927	0.29783	0.2	0.2	0.2	0.2
	4EXP	0.10927	0.29783	0.2	0.2	0.2	0.2
	5COTS	0.20627	0.15777	0.2	0.2	0.2	0.2

“Table 14: Continued”

		Social					Engineering			
		1MO	2DC	3ARSA	4LEEC	5SAD	1EFF	2CG	3SI	4ECA
Alter.	1B1	0.14	0.13	0.3	0.167	0.8	0.2	0.1667	0.1	0.1
	2B2	0.86	0.88	0.8	0.833	0.3	0.8	0.8333	0.9	0.9
Environm ental	1EP	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0
Social	1MO	0.06	0	0	0	0	0.2	0.2	0.2	0.2
	2DC	0.13	0	0	0	0	0.2	0.2	0.2	0.2
	3AR/SA	0.18	0.33	0	0	0	0.2	0.2	0.2	0.2
	4LE/EC	0.26	0.33	0.5	0	0	0.2	0.2	0.2	0.2
	5SAD	0.37	0.33	0.5	1	0	0.2	0.2	0.2	0.2
Engineeri ng	1EFF	0	0	0	0	0	0.6	0	0	0
	2CG	0	0	0	0	0	0.1	0	0	0
	3SI	0	0	0	0	0	0	0.5	0	0
	4ECA	0	0	0	0	0	0.2	0.5	1	0
Economic	1NPV	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	2RI	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3CC	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4LA	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	5DW	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Institutional	1ACC	0	0	0	0	0	0.2	0.2	0.2	0.2
	2CON	0	0	0	0	0	0.2	0.2	0.2	0.2
	3LSGC	0	0	0	0	0	0.2	0.2	0.2	0.2
	4EXP	0	0	0	0	0	0.2	0.2	0.2	0.2
	5COTS	0	0	0	0	0	0.2	0.2	0.2	0.2

“Table 14: Continued”

		Economic					Institutional				
		1NPV	2RI	3CC	4LA	5DW	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1B1	0.17	0.17	0.1	0.125	0.1	0.2	0.125	0.1	0.1111	0.125
	2B2	0.83	0.83	0.9	0.875	0.9	0.8	0.875	0.9	0.8889	0.875
Environm ental	1EP	0	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0	0
Social	1MO	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2
	2DC	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2
	3ARSA	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2
	4LEEC	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2
	5SAD	0	0	0	0	0	0.2	0.2	0.2	0.2	0.2
Engineeri ng	1EFF	0	0	0	0	0	0	0	0	0	0
	2CG	0	0	0	0	0	0	0	0	0	0
	3SI	0	0	0	0	0	0	0	0	0	0
	4ECA	0	0	0	0	0	0	0	0	0	0
Economic	1NPV	0.53	0	0	0	0	0.2	0.2	0.2	0.2	0.2
	2RI	0.26	0	0	0	0	0.2	0.2	0.2	0.2	0.2
	3CC	0.1	0.33	0	0	0	0.2	0.2	0.2	0.2	0.2
	4LA	0.05	0.33	0.5	0	0	0.2	0.2	0.2	0.2	0.2
	5DW	0.06	0.33	0.5	1	0	0.2	0.2	0.2	0.2	0.2
Institutional	1ACC	0	0	0	0	0	0.1	0	0	0	0
	2CON	0	0	0	0	0	0.1	0	0	0	0
	3LSGC	0	0	0	0	0	0.3	0.3333	0	0	0
	4EXP	0	0	0	0	0	0.1	0.3333	0.5	0	0
	5COTS	0	0	0	0	0	0.4	0.3333	0.5	1	0

Table 15: The Weighted Super matrix for Bike Station

		Alternatives		Environmental			
		1B1	2B2	1EP	2ISA	3NI	4ELEC
Alter.	1B1	0	0	0.020833	0.016667	0.041667	0.016667
	2B2	0	0	0.145833	0.15	0.125	0.15
Environ mental	1EP	0.010857	0.007809	0.016324	0	0	0
	2ISA	0.005819	0.014495	0.104051	0.055556	0	0
	3NI	0.018811	0.004507	0.009518	0.055556	0.083333	0
	4ELEC	0.005819	0.014495	0.036773	0.055556	0.083333	0.166667
Social	1MO	0.004163	0.019877	0.033333	0.033333	0.033333	0.033333
	2DC	0.003055	0.026827	0.033333	0.033333	0.033333	0.033333
	3ARSA	0.016298	0.00493	0.033333	0.033333	0.033333	0.033333
	4LEEC	0.006135	0.01302	0.033333	0.033333	0.033333	0.033333
	5SAD	0.037189	0.002185	0.033333	0.033333	0.033333	0.033333
Engineer ing	1EFF	0.230737	0.025406	0.041667	0.041667	0.041667	0.041667
	2CG	0.11261	0.055736	0.041667	0.041667	0.041667	0.041667
	3SI	0.056187	0.142626	0.041667	0.041667	0.041667	0.041667
	4ECA	0.027143	0.202909	0.041667	0.041667	0.041667	0.041667
Economic	1NPV	0.044361	0.012099	0.033333	0.033333	0.033333	0.033333
	2RI	0.044361	0.012099	0.033333	0.033333	0.033333	0.033333
	3CC	0.014787	0.036296	0.033333	0.033333	0.033333	0.033333
	4LA	0.014787	0.036296	0.033333	0.033333	0.033333	0.033333
	5DW	0.014787	0.036296	0.033333	0.033333	0.033333	0.033333
Institutional	1ACC	0.122522	0.029486	0.033333	0.033333	0.033333	0.033333
	2CON	0.068499	0.052395	0.033333	0.033333	0.033333	0.033333
	3LSGC	0.036286	0.098909	0.033333	0.033333	0.033333	0.033333
	4EXP	0.036286	0.098909	0.033333	0.033333	0.033333	0.033333
	5COTS	0.068499	0.052395	0.033333	0.033333	0.033333	0.033333

“Table 15: Continued”

		Social					4 Engineering			
		1MO	2DC	3ARSA	34LEEC	5SAD	1EFF	2CG	3SI	4ECA
Alter.	1B1	0.0476	0.0417	0.0833	0.0556	0.375	0.04	0.0333	0.022	0.025
	2B2	0.2857	0.2917	0.25	0.2778	0.125	0.16	0.1667	0.178	0.225
Environm ental	1EP	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0
Social	1MO	0.0205	0	0	0	0	0.04	0.04	0.04	0.05
	2DC	0.0429	0	0	0	0	0.04	0.04	0.04	0.05
	3ARSA	0.0614	0.1111	0	0	0	0.04	0.04	0.04	0.05
	4LEEC	0.0858	0.1111	0.1667	0	0	0.04	0.04	0.04	0.05
	5SAD	0.1227	0.1111	0.1667	0.3333	0	0.04	0.04	0.04	0.05
Engineeri ng	1EFF	0	0	0	0	0	0.1289	0	0	0
	2CG	0	0	0	0	0	0.0211	0	0	0
	3SI	0	0	0	0	0	0.009	0.1	0	0
	4ECA	0	0	0	0	0	0.041	0.1	0.2	0
Economic	1NPV	0.0667	0.0667	0.0667	0.0667	0.1	0.04	0.04	0.04	0.05
	2RI	0.0667	0.0667	0.0667	0.0667	0.1	0.04	0.04	0.04	0.05
	3CC	0.0667	0.0667	0.0667	0.0667	0.1	0.04	0.04	0.04	0.05
	4LA	0.0667	0.0667	0.0667	0.0667	0.1	0.04	0.04	0.04	0.05
	5DW	0.0667	0.0667	0.0667	0.0667	0.1	0.04	0.04	0.04	0.05
Institutional	1ACC	0	0	0	0	0	0.04	0.04	0.04	0.05
	2CON	0	0	0	0	0	0.04	0.04	0.04	0.05
	3LSGC	0	0	0	0	0	0.04	0.04	0.04	0.05
	4EXP	0	0	0	0	0	0.04	0.04	0.04	0.05
	5COTS	0	0	0	0	0	0.04	0.04	0.04	0.05

“Table 15: Continued”

		Economic					Institutional				
		1NPV	2RI	3CC	4LA	5DW	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1B1	0.0833	0.0833	0.0625	0.0625	0.125	0.0417	0.0313	0.028	0.02778	0.04167
	2B2	0.4167	0.4167	0.4375	0.4375	0.875	0.2083	0.2188	0.222	0.22222	0.29167
Environm ental	1EP	0	0	0	0	0	0	0	0	0	0
	2ISA	0	0	0	0	0	0	0	0	0	0
	3NI	0	0	0	0	0	0	0	0	0	0
	4ELEC	0	0	0	0	0	0	0	0	0	0
Social	1MO	0	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
	2DC	0	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
	3ARSA	0	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
	4LEEC	0	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
	5SAD	0	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
Engineeri ng	1EFF	0	0	0	0	0	0	0	0	0	0
	2CG	0	0	0	0	0	0	0	0	0	0
	3SI	0	0	0	0	0	0	0	0	0	0
	4ECA	0	0	0	0	0	0	0	0	0	0
Economic	1NPV	0.2627	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
	2RI	0.1322	0	0	0	0	0.05	0.05	0.05	0.05	0.06667
	3CC	0.0523	0.1667	0	0	0	0.05	0.05	0.05	0.05	0.06667
	4LA	0.0252	0.1667	0.25	0	0	0.05	0.05	0.05	0.05	0.06667
	5DW	0.0276	0.1667	0.25	0.5	0	0.05	0.05	0.05	0.05	0.06667
Institutional	1ACC	0	0	0	0	0	0.0212	0	0	0	0
	2CON	0	0	0	0	0	0.037	0	0	0	0
	3LSGC	0	0	0	0	0	0.0816	0.0833	0	0	0
	4EXP	0	0	0	0	0	0.0161	0.0833	0.125	0	0
	5COTS	0	0	0	0	0	0.0941	0.0833	0.125	0.25	0

Table 16: The Limit Super Matrix for Bike Station

		Alternatives		Environmental			
		1B1	2B2	1EP	2ISA	3NI	4EL&EC
Alter.	1B1	0.051073	0.051073	0.051073	0.051073	0.051073	0.051073
	2B2	0.243591	0.243591	0.243591	0.243591	0.243591	0.243591
Environmental	1EP	0.002498	0.002498	0.002498	0.002498	0.002498	0.002498
	2ISA	0.004328	0.004328	0.004328	0.004328	0.004328	0.004328
	3NI	0.002534	0.002534	0.002534	0.002534	0.002534	0.002534
	4ELEC	0.005246	0.005246	0.005246	0.005246	0.005246	0.005246
Social	1MO	0.021205	0.021205	0.021205	0.021205	0.021205	0.021205
	2DC	0.023318	0.023318	0.023318	0.023318	0.023318	0.023318
	3ARSA	0.021642	0.021642	0.021642	0.021642	0.021642	0.021642
	4LEEC	0.02722	0.02722	0.02722	0.02722	0.02722	0.02722
	5SAD	0.036023	0.036023	0.036023	0.036023	0.036023	0.036023
Engineering	1EFF	0.02133	0.02133	0.02133	0.02133	0.02133	0.02133
	2CG	0.020386	0.020386	0.020386	0.020386	0.020386	0.020386
	3SI	0.040452	0.040452	0.040452	0.040452	0.040452	0.040452
	4ECA	0.062426	0.062426	0.062426	0.062426	0.062426	0.062426
Economic	1NPV	0.041719	0.041719	0.041719	0.041719	0.041719	0.041719
	2RI	0.036271	0.036271	0.036271	0.036271	0.036271	0.036271
	3CC	0.043369	0.043369	0.043369	0.043369	0.043369	0.043369
	4LA	0.053079	0.053079	0.053079	0.053079	0.053079	0.053079
	5DW	0.07972	0.07972	0.07972	0.07972	0.07972	0.07972
Institutional	1ACC	0.020775	0.020775	0.020775	0.020775	0.020775	0.020775
	2CON	0.023924	0.023924	0.023924	0.023924	0.023924	0.023924
	3LSGC	0.036531	0.036531	0.036531	0.036531	0.036531	0.036531
	4EXP	0.039736	0.039736	0.039736	0.039736	0.039736	0.039736
	5COTS	0.041605	0.041605	0.041605	0.041605	0.041605	0.041605

“Table 16: Continued”

		Social					Engineering			
		1MO	2DC	3ARSA	4LEEC	5SAD	1EFF	2CG	3SI	4ECA
Alter.	1B1	0.05107	0.0511	0.05107	0.0511	0.05107	0.05107	0.05107	0.05107	0.051073
	2B2	0.24359	0.2436	0.24359	0.2436	0.24359	0.24359	0.24359	0.24359	0.243591
Environm ental	1EP	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.002498
	2ISA	0.00433	0.0043	0.00433	0.0043	0.00433	0.00433	0.00433	0.00433	0.004328
	3NI	0.00253	0.0025	0.00253	0.0025	0.00253	0.00253	0.00253	0.00253	0.002534
	4ELEC	0.00525	0.0052	0.00525	0.0052	0.00525	0.00525	0.00525	0.00525	0.005246
Social	1MO	0.02121	0.0212	0.02121	0.0212	0.02121	0.02121	0.02121	0.02121	0.021205
	2DC	0.02332	0.0233	0.02332	0.0233	0.02332	0.02332	0.02332	0.02332	0.023318
	3ARSA	0.02164	0.0216	0.02164	0.0216	0.02164	0.02164	0.02164	0.02164	0.021642
	4LEEC	0.02722	0.0272	0.02722	0.0272	0.02722	0.02722	0.02722	0.02722	0.02722
	5SAD	0.03602	0.036	0.03602	0.036	0.03602	0.03602	0.03602	0.03602	0.036023
Engineeri ng	1EFF	0.02133	0.0213	0.02133	0.0213	0.02133	0.02133	0.02133	0.02133	0.02133
	2CG	0.02039	0.0204	0.02039	0.0204	0.02039	0.02039	0.02039	0.02039	0.020386
	3SI	0.04045	0.0405	0.04045	0.0405	0.04045	0.04045	0.04045	0.04045	0.040452
	4ECA	0.06243	0.0624	0.06243	0.0624	0.06243	0.06243	0.06243	0.06243	0.062426
Economic	1NPV	0.04172	0.0417	0.04172	0.0417	0.04172	0.04172	0.04172	0.04172	0.041719
	2RI	0.03627	0.0363	0.03627	0.0363	0.03627	0.03627	0.03627	0.03627	0.036271
	3CC	0.04337	0.0434	0.04337	0.0434	0.04337	0.04337	0.04337	0.04337	0.043369
	4LA	0.05308	0.0531	0.05308	0.0531	0.05308	0.05308	0.05308	0.05308	0.053079
	5DW	0.07972	0.0797	0.07972	0.0797	0.07972	0.07972	0.07972	0.07972	0.07972
Institutional	1ACC	0.02078	0.0208	0.02078	0.0208	0.02078	0.02078	0.02078	0.02078	0.020775
	2CON	0.02392	0.0239	0.02392	0.0239	0.02392	0.02392	0.02392	0.02392	0.023924
	3LSGC	0.03653	0.0365	0.03653	0.0365	0.03653	0.03653	0.03653	0.03653	0.036531
	4EXP	0.03974	0.0397	0.03974	0.0397	0.03974	0.03974	0.03974	0.03974	0.039736
	5COTS	0.04161	0.0416	0.04161	0.0416	0.04161	0.04161	0.04161	0.04161	0.041605

“Table 16: Continued”

		Economic					Institutional				
		1NPV	2RI	3CC	4LA	5DW	1ACC	2CON	3LSGC	4EXP	5COTS
Alter.	1B1	0.05107	0.0511	0.05107	0.0511	0.0511	0.05107	0.0511	0.05107	0.051073	0.05107
	2B2	0.24359	0.2436	0.24359	0.2436	0.2436	0.24359	0.2436	0.24359	0.243591	0.24359
Environ mental	1EP	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.002498	0.0025
	2ISA	0.00433	0.0043	0.00433	0.0043	0.0043	0.00433	0.0043	0.00433	0.004328	0.00433
	3NI	0.00253	0.0025	0.00253	0.0025	0.0025	0.00253	0.0025	0.00253	0.002534	0.00253
	4ELEC	0.00525	0.0052	0.00525	0.0052	0.0052	0.00525	0.0052	0.00525	0.005246	0.00525
Social	1MO	0.02121	0.0212	0.02121	0.0212	0.0212	0.02121	0.0212	0.02121	0.021205	0.02121
	2DC	0.02332	0.0233	0.02332	0.0233	0.0233	0.02332	0.0233	0.02332	0.023318	0.02332
	3ARSA	0.02164	0.0216	0.02164	0.0216	0.0216	0.02164	0.0216	0.02164	0.021642	0.02164
	4LEEC	0.02722	0.0272	0.02722	0.0272	0.0272	0.02722	0.0272	0.02722	0.02722	0.02722
	5SAD	0.03602	0.036	0.03602	0.036	0.036	0.03602	0.036	0.03602	0.036023	0.03602
Engineer ing	1EFF	0.02133	0.0213	0.02133	0.0213	0.0213	0.02133	0.0213	0.02133	0.02133	0.02133
	2CG	0.02039	0.0204	0.02039	0.0204	0.0204	0.02039	0.0204	0.02039	0.020386	0.02039
	3SI	0.04045	0.0405	0.04045	0.0405	0.0405	0.04045	0.0405	0.04045	0.040452	0.04045
	4ECA	0.06243	0.0624	0.06243	0.0624	0.0624	0.06243	0.0624	0.06243	0.062426	0.06243
Economic	1NPV	0.04172	0.0417	0.04172	0.0417	0.0417	0.04172	0.0417	0.04172	0.041719	0.04172
	2RI	0.03627	0.0363	0.03627	0.0363	0.0363	0.03627	0.0363	0.03627	0.036271	0.03627
	3CC	0.04337	0.0434	0.04337	0.0434	0.0434	0.04337	0.0434	0.04337	0.043369	0.04337
	4LA	0.05308	0.0531	0.05308	0.0531	0.0531	0.05308	0.0531	0.05308	0.053079	0.05308
	5DW	0.07972	0.0797	0.07972	0.0797	0.0797	0.07972	0.0797	0.07972	0.07972	0.07972
Institutional	1ACC	0.02078	0.0208	0.02078	0.0208	0.0208	0.02078	0.0208	0.02078	0.020775	0.02078
	2CON	0.02392	0.0239	0.02392	0.0239	0.0239	0.02392	0.0239	0.02392	0.023924	0.02392
	3LSGC	0.03653	0.0365	0.03653	0.0365	0.0365	0.03653	0.0365	0.03653	0.036531	0.03653
	4EXP	0.03974	0.0397	0.03974	0.0397	0.0397	0.03974	0.0397	0.03974	0.039736	0.03974
	5COTS	0.04161	0.0416	0.04161	0.0416	0.0416	0.04161	0.0416	0.04161	0.041605	0.04161