Multiple
Perspectives and Hierarchical Decision Modelling Applied to emerging technology used in the Artisanal mining and Small scale processing of sandstones in QwaQwa

By

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A doctoral research thesis submitted in fulfilment of the requirements for the degree of

POSTGRADUATE DEGREE - Doctor of Philosophy

in

Engineering Management

in the

Faculty of Engineering and the Built Environment

School of Engineering Management

at the

UNIVERSITY OF JOHANNESBURG

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Date of submission: September 2018

DEDICATION

This work is dedicated to:

The memory of my late father – Muzee Silvestro Ejon-Agwa – who showed me the value of life as a professional teacher and, in the process, instilled the values of and desire for education and lifelong learning.

My late Auntie – Imat Giladesi Alaba – for her support and encouragement during my early days as a school pupil in Lira.

The memory of my late sister – Margaret Alaba-Ejon – whom I spent all my youth with, as a close companion and mentor.

DECLARATION

I, John Francis Agwa-Ejon, hereby declare that this doctoral research thesis is wholly my own work and has not been submitted anywhere else – for academic credit – either by myself or by another person. I understand what plagiarism implies and declare that this research thesis is my own ideas, words, phrases, arguments, graphics, figures, results and organisation – except where reference is explicitly made to another's work. I understand further that any unethical academic behaviour, which includes plagiarism, is seen in a serious light by the University of Johannesburg and is punishable by disciplinary action.

Signed… Date…July 2018

ACKNOWLEDGEMENTS

I would like to express my gratitude to my beloved mother Concy Ejon, my wife Loice, my children Robson, Fiona, Rose and Hope who gave me the strength and inspiration to persevere by tolerating my absence during the times they needed me most.

My love and appreciation go to my brothers George and Tom as well as my sisters Alice, Rose, Grace, Molly, Lilly and Susan.

I am thankful to the staff and colleagues of the Faculty of Engineering and the Built Environment – especially the Department of Quality and Operations Management – for welcoming and supporting me during the course of my study.

I am grateful to the University of Johannesburg for giving me the opportunity to study for this degree – especially by financing my fees and granting me some teaching relief.

Special appreciation goes to Statkon staff – especially Dr Richard Devey – for assisting me with the analysis of my pairwise comparison data using the SPSS software.

I also wish to recognise the following: my friends and colleagues who spent time proofreading my final draft; the mine owners, mine operators and the QwaQwa community at large for giving their valuable time in talking to me and completing the study questionnaires; and the experts from the various specialties in the mining sector who gave their expert opinions during the pairwise comparison of all the attributes.

Most importantly, I would like to acknowledge the brains behind this study, that is, the people who encouraged me and made my work very interesting. I am referring to my promoters – Professor Antoine Floribert Mulaba-Bafubiandi and Professor Jan-Harm Pretorius – who worked tirelessly to ensure that I obtain above-average results.

Finally, I give thanks to the Almighty God – for giving me the capability and strength to complete this study successfully.

ABSTRACT

The objective of this research was to develop a decision model enabling a comprehensive, multi-perspective assessment of artisanal sandstone mining using a solar-energy-activated microwave. The multiple perspectives used included social, technological, economical, environmental, and political dimensions. The influence of the latter was judged against the mining operations and processes as well as the responses from the QwaQwa community. Each perspective consisted of multiple factors used to make a credible decision.

The methodology of this study involved a hierarchical structure decision modelling including expert subjective judgement and quantification that ranked the perspectives and criteria comparatively regarding the emerging technology used in the mining of sandstone. Thus, this modelling addressed and evaluated solar-power technology by comparing competing perspectives and criteria – using both qualitative and quantitative values assigned by the experts. The model was constructed by distinguishing the desired attributes of each criterion. The aggregate results were then synthesised, to establish a total numerical score that revealed that the solar power magnetron microwave mining equipment was the most preferred alternative for mining sandstone in QwaQwa, Free State Province, South Africa.

This model enables the assessment of the diverging viewpoints regarding artisanal sandstone mining. The developed model is likely to assist national government policy-makers, experts, and scholars concerning artisanal sandstone mining and small-scale processing. If successfully developed and implemented, this model will possibly improve production and efficacy in artisanal sandstone mining in QwaQwa. Integrating the abovementioned five perspectives in artisanal sandstone mining decision modelling – using solar-power-microwave-aided magnetron machinery – was the focus of this research. The latter aimed at realising a more effective method of mining sandstone, other than the traditional use of a chisel and a hammer.

The study, although divided into three sections, gave a very comprehensive assessment of the two options – through the analysis of specialists' views. The experts evaluated both the solar-energy-activated microwave mining and the traditional chisel-and-hammer mining, although very strong views were expressed in favour of the preservation of the Drakensberg Mountain. Therefore, this plea was also incorporated in the decision-making procedure. The results revealed an overall ranking of 0.42 for solar-activated microwave mining; 0.38 for the preservation of the landscape; and 0.30 for traditional mining tools. An overwhelming support for the microwave mining technology – by 42% compared to the current tradition method – was expressed.

Keywords: Artisanal Mining; MCDM; Microwave Energy; Sandstone
Solar Energy; QwaQwa Community.

LIST OF ABBREVIATIONS

ABM-	Agent-Based Modelling
ACM-	Association for Computing Machinery
AUC-	African Union Commission
AHP-	Analytical Hierarchical Process
AIS-	The Association for Information Systems
ANP-	Analytical Network Process
APA-	The American Psychological Association
ASM-	Artisanal and Small-Scale Mining
BEE-	Black Economic Empowerment
BOS-	Balance of Systems
OSHA	Occupational Health and Safety Administration
CCS-	Carbon Capture Storage
CIGS-	Copper Indium Gallium Selenide
c-Si-	Crystalline Silicon
CSP-	Concentrating Solar Power
CVM-	Contingent Valuation Method
DCEs-	Discrete Choice Experiments
DMR-	Department of Minerals Resources
DSS-	Decision Software Support
DSSMP-	Directorate of Small-Scale Mining Programme
EIA-	Environmental Impact Assessment
EIAPA-	Environmental Impact Assessment Procedure Act
EU-	European Union
FU-	Functional Unit
GIS-	Geographical Information System
HDSAs-	Historically Disadvantaged South Africans
H-field-	Magnetic Field
ICT-	Information and Communication Technology
IDT-	Innovation Diffusion Theory
IEEE-	The Institute of Electrical and Electronics Engineers
LCIA-	Life Cycle Inventory Analysis
LCIA-	Life Cycle Impact Assessment

LCOE-	Levelled Cost of Energy
MADM-	Multi-Attribute Decision-Making
MCDM-	Multi-Criteria Decision-Making
MODM-	Multi-Objective Decision-Making
MPRDA-	Minerals and Petroleum Resources Development Act 28 of 2002
NAM-	Norm Activation Model
NGOs-	Non-Governmental Organisations
NREL-	National Renewable Energy Laboratory
NSSMDF-	National Small-Scale Mining Development Framework
ORWARE-	Organic Waste Research (including economic and ecological Indicators)
PESTEL-	Political, Economic, Socio-cultural, Technological, Environment and Legal
PV-	Solar photovoltaic
RDP-	Reconstruction and Development Programme
RETs-	Renewable Energy Technologies
RFIC-	Radio Frequency Identification Technology
RTAM-	Responsible TAM
SADC-	Southern African Development Community
SCT-	Social Cognitive Theory
Si-	Silicon
SIA-	Social Impact Assessment
SLO-	Social Licence to Operate
SMAA-	Stochastic Multi-criteria Acceptability Analysis
SMART-	Simple Multi-Attribute Research Technique
STEEP-	Social, Technological, Economic, Environmental and Political
SWH-	Solar Water Heater
TAM-	Technology Acceptance Model
TICs-	Technological Innovation Capabilities
TLCC-	Total Life Cycle Cost
TRA-	Theory of Reasoned Actions
TSP-	Total Suspended Particulate
USA-	United States of America
UTAUT-	Unified Theory of Acceptance and Use of Technology

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Agwa-Ejon, J.F. and Pradhan, A., 2018. Life cycle impact assessment of artisanal sandstone mining on the environment and health of mine workers. *Environmental Impact Assessment Review*, *72*, pp.71-78.

WORK IN PROGRESS: JOURNAL ARTICLES

- Agwa-Ejon, J.F., A F Mulaba-Bafubiandi A.F. and Pretorius J.H., The hierarchal decision making algorithm as an analytical tool for understanding natural physical systems

- Agwa-Ejon J.F., A F Mulaba-Bafubiandi A.F. and Pretorius J.H., The dichotomy of sandstone artisanal mining in QwaQwa, Free State, South Africa

- Agwa-Ejon J.F., A F Mulaba-Bafubiandi A.F. and Pretorius J.H., The Impact of digital technology on the Multi-Criteria Decision Making process.

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Agwa-Ejon, J.F., Mulaba-Bafubiandi, A.F. and Pretorius, J.H., 2015, August. Technological feasibility and cultural acceptability study of solar power systems for microwave assisted sandstone artisanal mining. In *Management of Engineering and Technology (PICMET), 2015 Portland International Conference on the Technology Age* (pp. 2095-2102). IEEE.

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Agwa-Ejon, J.F., Mulaba-Bafubiandi, A. and Pretorius, J.H., 2017, July. The Multi-Criteria Decision Making, a Tool for the Promotion of Technological Inter-Connected World through Digital Decision Making. In *Management of Engineering and Technology (PICMET), 2017 Portland International Conference*, (pp. 1-7). IEEE.

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Monareng, M., Mulaba-Bafubiandi, A.F. and Agwa-Ejon, J.F., 2017, March. Optimization: A strategy for improving production scheduling of a small-scale mining project in QwaQwa, Free State. Accepted for oral presentation In *3rd Young Professional conference, 2017. Pretoria South Africa.* The Southern African Institute of Mining and Metallurgy (SAIMM).

Monareng, M., Mulaba-Bafubiandi, A.F. and Agwa-Ejon, J.F., 2018, August. Strategy and technology models in small-scale mining of sandstone to facilitate community-based economic development and growth. Accepted for oral presentation In *Management of Engineering and Technology (PICMET),* 2018 Portland International Conference in Hawaii U.S.A.

1.0 CHAPTER ONE
INTRODUCTION

1.1 Introduction

This chapter anchors the pillar of this research work. The chapter states the inquiry problem and provides the justification for the study. This chapter also outlines the research goals and details the procedure used in resolving the issues under investigation. The conclusion of this chapter outlines the findings and highlights the study's contribution and targeted audiences.

1.2 Research Problem Statement

Mining is one of the oldest techniques applied to extract mineral resources from the underground. Sandstone mined from QwaQwa – using traditional tools – presents several mining operations problems. Sandstone is a sedimentary rock composed of quartz and sand. This rock is found abundantly at the hills forming part of the Drakensberg Mountains in the Free State. Local artisans mine sandstone unconventionally – using a chisel and a hummer; thus putting themselves at enormous risks. Sandstone deposits are located in shallow places below the surface. Their mining mainly involves the surface extraction usually adopted for minerals with less valuable deposits, to incur minimal expense during the mining process. However, modern advances have enabled the deployment of new emerging mining technologies. By acquiring this new knowledge, miners are in a position to accomplish their goals much more easily. These emerging technologies are expected to improve productivity, reduce operating costs, and conserve energy. The ability to capture and store the solar energy used in the mining of sandstone will contribute significantly to decreasing power consumption, costs, and risks.

1.3 Research Questions

To resolve the above-stated problem in a logical and meaningful manner, the researcher has developed the following five research questions – to guide the investigation. The questions are split into two categories: the soft descriptive interrogations and the hard mathematical ones relating to decision-making processes. The following questions are posed:

- What are the viewpoints of practitioners and experts regarding the use of solar-energy-activated microwave technologies to mine sandstone based on social, technological, economical, environmental, and political (STEEP) perspectives?
- What best-known concepts and applications will enable the development of a scientific judgement on the best technology concerning the mining of sandstone in QwaQwa?
- How can the small-scale processing of sandstone be improved using scientifically safe and sustainable techniques?
- What are the major environmental issues emanating from the mining of sandstone in QwaQwa?
- How acceptable is the proposed new technology – in relation to landscape preservation and tourism – to the mining community in QwaQwa, local authorities, traditional leaders, and artisanal miners themselves?

1.4 The Purpose of the Study

The aim of this research is to evaluate the effectiveness of an emerging technology, namely the microwave-assisted solar energy, in the mining of sandstone. The investigation employed multiple-criteria standpoints and the hierarchical decision modelling procedure to compare/contrast the outmoded use of a chisel and a hammer with the microwave-based solar power in the quarrying of sandstones in the Drakensberg Mountains. Therefore, the research study entails the following:

- The evaluation of the various experts' viewpoints on the introduction of emerging technology into the artisanal mining of sandstone.
- The study of the operations and processes followed in artisanal sandstone mining in QwaQwa.
- The appraisal of the major environmental effects of mining sandstone using traditional methods.
- The assessment of the suitability of the novel emerging technology by the QwaQwa community.

1.5 The Research Objectives

This study explores the opportunity to use solar energy in activating microwave energy use in the mining of sandstone. The intended outcome is to assess the potential of developing a new mining tool to be used by artisans – at lesser risk to themselves and at lesser cost. The means under investigation has its own hazards that need to be managed. Indeed, the proposition is to use microwaves to heat and fracture the sandstone using solar-energy-activated microwave technology.

1.6 The Significance of the Study

It is hoped that, if adopted, this new technology will change the way QwaQwa-based artisanal miners operate. If the study is successful, it will lead to the increased productivity of sandstone, which will result in better pricing of sandstone and its by-products as well as more efficient and cost effective operations. Failing that, the study will still be useful in showing what does not work efficiently and will open the possibility of other researchers making the necessary improvements.

1.7 The Research Methodology

The approach adopted to tackle the research issue effectively is the formulation of a hierarchical decision model that will help to assess the various expert viewpoints. The easiest way adopted by the researcher was to select various criterion levels to be evaluated by expert panels consisting of experienced artisanal miners, mine executive or operational managers, government officials, traditional leaders, experienced academicians, and external mining industry analysts. These people were to give their collective judgments. The technology evaluation – with contending and conflicting perspective levels and standards – had to include these experts' qualitative and quantitative inputs. The model was to provide guidance in the selection and improvement of mining technologies. This would be for the benefit of government decision-makers, the QwaQwa community, and the small-scale mining industry worldwide.

1.8 Research Scope

QwaQwa artisanal sandstone miners use chisels and hammers. This traditional form of mining is extremely laborious and results in numerous casualties. Emerging technology, however, if adopted, could result in a more industrious, resourceful, effective, and sustainable operation. Thus, the research solicits the numerous perspectives of specialists in the mining paternity on the utility of solar power – as an emerging technology – in the mining of sandstone in QwaQwa.

1.9 Ethical Statement

This study was approved by the University of Johannesburg's Ethics Committee. Permission was also obtained from the QwaQwa local chief who encouraged her community to participate actively in the research activities. In addition, the QwaQwa local government also approved the conducting of interviews and the administering of questionnaires. All the experts who participated in the pairwise comparison questionnaire were volunteers who willingly accepted to offer their opinions on request. The researcher strongly believes that all the ethical requirements were strictly adhered to.

1.10 The Structure of the Thesis

This research report has six chapters. Chapter One which constitutes the introduction to the study provides a detailed background to the research. The various sections give the reader a panoramic view of the research issues. Chapter Two is the literature review that contains statements and arguments advanced by previous researchers in the considered area of expertise. The aim in conducting the literature review was to identify gaps in the research area. Chapter Three elaborates on the methodology used to investigate the issues raised in the five research questions posed earlier. The investigations involved case studies, interviews, and survey questionnaires. Data collected from all three sources were then integrated to address each problem. Chapter Four explains the data collection and analysis processes and reveals the ensuing results. Chapter Five discusses the findings reported in Chapter Four in greater detail and suggests possible areas for improvement. Chapter Six outlines the research assumptions, summarises the research findings, highlights the intellectual merit of this research, indicates the limitations, and makes recommendations aimed at improving the artisanal mining of sandstone in QwaQwa.

1.11 Conclusion

This introductory chapter sets the tone for the research investigation by providing the reader with an overall, integrated view of the research. The chapter has stated the research problem, outlined the research questions, indicated the aim of the research, stated the research goals, foregrounded the importance of the study, outlined the research methodology, indicated the scope of the research, provided an ethics statement, and sketched the structure of the report. In this study, the results were very close to the expectations.

2.0 CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The artisanal mining of sandstone has been covered extensively in literature. However, there has not been much literature linking it to microwave sandstone extraction (Ledwaba, 2016). This chapter discusses the trends in new technology to establish the research gaps. The literature review starts by appraising the viability of the multi-criteria decision making (MCDM) as the instrument underpinning the framework of this research. This technique, whose structural set-up is explained in the next section, is a very popular scientific tool used in model decision-making formulation (Ishizaka and Nemery, 2013). Then, the microwave heating and its associated dielectric basic principles are examined. Subsequently, the activation of the solar energy used to power the microwave as a source of energy is discussed. This section also takes note of the extensive research conducted in solar photovoltaic cell technology, which has now made it affordable for ordinary people to invest in solar energy technology. The drop in solar energy generation cost and its affordability also form part of this study. Recent studies by Saylan et al. (2015) concluded that the comparative price of solar photovoltaic cell has drop to levels on par with the electricity grid cost (MIT, 2016; Snaith, 2013; Solomon, 2016) in most countries. This realisation is good for most South African consumers of solar power, since the sun-rays are available throughout the year, making it easy to adopt solar energy technology.

A discussion of the Analytical Hierarchical Process (AHP) and the MCDM techniques provide an in-depth introduction of concepts and share the opinions of the experts involved in the mining of sandstone. The assessment criterion set by these experts in the evaluation and selection of alternatives – using preferences that will allow for contrasting and competing perspectives in the decision-making processes – is cantered on pairwise comparison. The artisanal mining of sandstone in QwaQwa, the rest of Africa and the emerging economies constitute the additional review that aims to explore and compare these mining activities worldwide. This will enable the researcher to compare the socio-economic impact of artisanal mining in sub-Sharan African countries in particular and the rest of Africa in general. The different areas of knowledge explored in the literature shall enable the researcher to integrate the different techniques mentioned, to synthesise and identify the best methods to adapt to the artisanal mining of sandstone.

2.2 Literature Review-based Themes

The introduction of this chapter provided a basis for the identification of the keywords used to peruse through the databases containing leading journals related to the themes shown in Figure 2.1. These themes form the body of the knowledge integrated to build the theoretical framework for the elaboration of the solar-energy-activated microwave sandstone-mining model. The themes are all associated with the assessment of the practicality and viability of mining sandstone using a microwave-activated solar energy power source. For the microwave to function effectively, it should be energised by solar power. The latter will continuously supply energy for the microwave – through the megaton.

Artisanal mining is a key source of income in most emerging countries. However, related mining activities are generally carried out illegally. Thus, they are often unregulated and present very high risks. This is due to the fact that the illegal miners operate under no legislation and do not adhere to health and safety rules. The introduction of the South African mining legislation as well as health and safety rules emphasise the gravity of the problems related to artisanal mining. Often, the community at large are very resistant to new technology and therefore a study on social acceptability looked at this area, to explore theories and models that could be used to assess the response of the QwaQwa community regarding this emerging technology.

The financial viability covers the income and expenses incurred by artisanal miners to establish whether such a venture would be profitable in the South African market. Preliminary results have shown that most dimensioned sandstone used in South Africa comes from Lesotho, although South Africa has the potential to meet its own demand. The literature review framework is centered on the MCDM and uses the AHP.

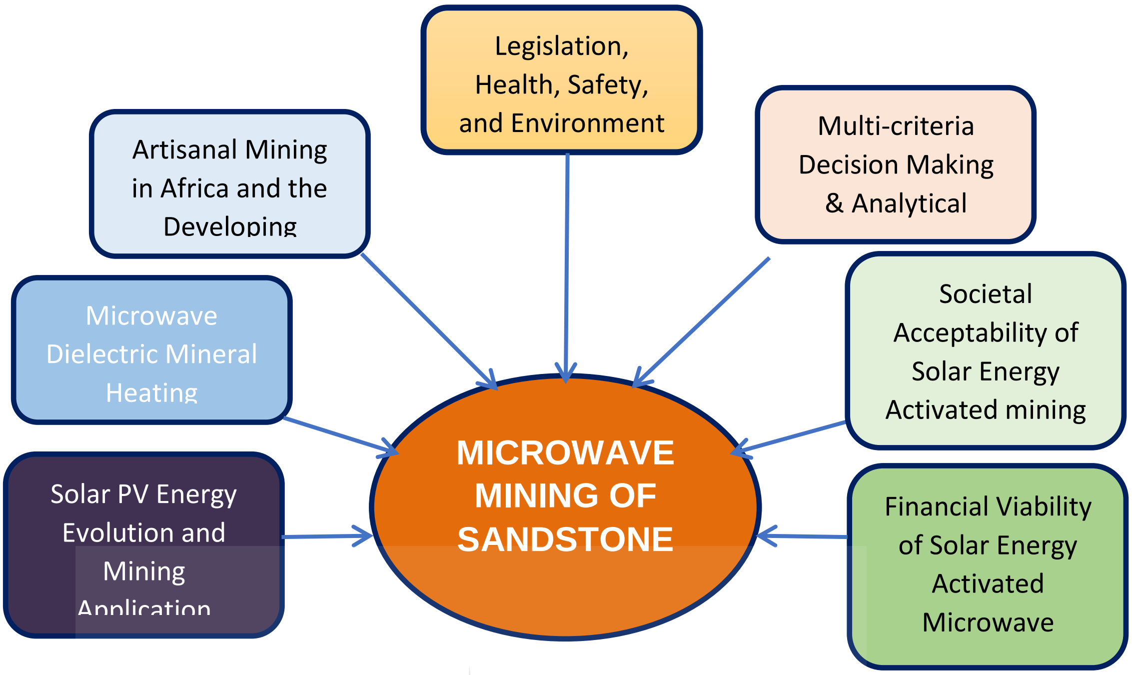

Figure 2.1: The themes reviewed in a number of journal articles and books.

The microwave technology theme explores the basic principles of microwave heating, microwave-assisted rock breakage, and the recent developments in the microwave extraction of materials. Several papers, which included food preservation and the heavy industrial application of microwave technology, have been excluded from this review process and are therefore not referenced in this study. The categories of sources accessed are shown in Table 2.1 below. Additional reading sources included came from the annual reports of a few small and artisanal mines situated in other provinces of South Africa.

Table 2.1: Sources of the literature reviewed

African Mines on Line
AMIRA (Data Metalorganic on-line)
Creamer Media's Research Channel Africa
Emerald
Engineering Village (Compendia)
Lexus Nexis Cases Academic
Research Channel Africa
Sage Journals on-line
Sabinet (UCTD) S.A.
Science Direct (Scopus)
Web of Science Information Science Institute (ISI)
World Wide Web (Google Scholar)

2.3 Analytical Hierarchical Process Theory

The MCDM is a structured technique used in organising and analysing complex decisions – in our daily lives – based on mathematical tools and psychology. This concept was introduced in the early 1970s by Thomas Saaty. It has since been researched and further refined (He Wang and Huang, 2016). Recent advances in MCDM techniques promote the concept that identifies different alternatives based on their advantages and users' preferences to select the best alternative through the judgement of experts with a wealth of experience in the applicable field (Mardani et al, 2015). Intuition plays a part during the decision-making process, as most of these experts have vast experience in their respective fields. Intuition and judgement rest on extensive experience and knowledge gained from both the qualitative and quantitative information acquired from the expert decision-makers during their long time in service. The criteria adopted for the decision-making are normally established by the experts themselves – through consensus – during the preliminary trials. The MCDM may be explained as a tool that assists the mind to organise its thoughts and experiences to bring out the judgements that are normally preserved in the memory. The technique, therefore, offers the expert decision-maker an opportunity to quantify and derive measurements for the intangibles.

In pursuit of the optimisation of sandstone resources in QwaQwa, the decision to mine sandstone has to minimise careless mistakes, or wrong decisions must be avoided altogether. The problem requires the experts to select from among three alternatives. The MCDM has, in the past, assisted researchers to identify certain properties and selection criteria that make it easier to arrive at these decisions (Govindan et al, 2015). These methods have provided an effective tool for the selection of the best alternative. Some researchers who have since used the same technique in their work include Aruldoss, Lakshmi and Venkatesan (2013), as well as Masouleh, Allahyari and Atani (2014). All these researchers emphasised the need for the MCDM in the selection of the best alternative. Jankowski (1995) postulates that the MCDM is a branch of operations research used in multi-disciplinary-decision solutions. Triantaphyllou et al (1998) as well as Montibeller and Franco (2010) used the MCDM in both public and private entities – for making and supporting extremely complex decisions involving policy priorities, trade-offs, and uncertainties. The common working principles of the MCDM, after formulating the principal problem or objective goal, include the following:

- Criteria: These are the attributes that form the diverse measurements from which the substitutes can be viewed (Govindan et al., 2015). Criteria sit on the third level in the hierarchy or structure. In some instances, criteria may be sub-divided into sub-criteria that may represent different dimensions that conflict with each other. It also follows that, in some cases, the units of the attributes may be incommensurate with the results of individual associations with different units of measure.

- Alternatives: These are the options available for decision-making (Yavuz et al., 2015). In most cases, the alternatives are considered to be limited – extending from a little to hundreds. The alternatives are generally selected, prioritised and classified based on the decisions makers' choices.

- Weighing: Weights are attached to the importance of an attribute by decision-makers. Most of the MCDM process requires that the attributes be assigned weights according to the decider's opinion. The ratings given may be subjective or objective, depending on the choice of the criteria. Subjective weights are generally not based on facts or data. The decisions are evaluated in accordance with the experience, knowledge and perception of the decider.

Conversely, objective weights are based on facts and/or data collected by the evaluator.

- Aggregation: This is the summation of the different alternatives available to the decision-makers (Majumdar, 2015). This is attained through a decision matrix where the alternatives are judged or evaluated based on the goals. Calculations may then be made to establish whether the logical transitive property has been followed and the degree of consistency in the subjective judgement minimised.

The most important aspect in the decision process is deciding what factors to include in the hierarchy structure and maintaining the relationship between these elements at all levels. When constructing the hierarchies, decision analysts must include enough relevant details that should cover the problem as thoroughly as possible. In this study, this is the area that required significant effort. This is because the criteria considered are based on five major perspectives or attributes that had to be sub-divided into smaller factors.

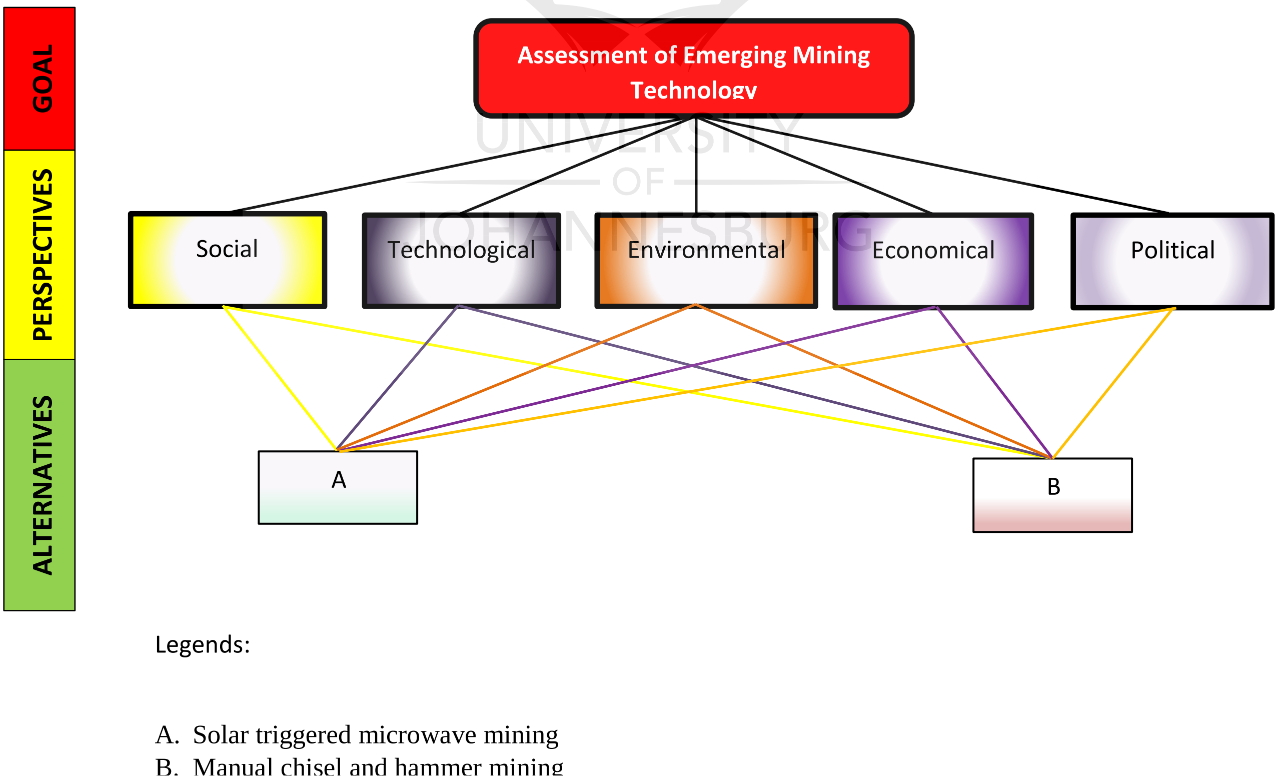

Figure 2.2: The generic analytical decision-making structure.

MCDM models are classified as multi-objective decision-making (MODM) in which the analysis is based on multiple competitive objectives, and multi-attribute decision-making (MADM) in which the analysis is based on set of criteria (Taha and Daim, 2013). This research rests on a multi-attribute judgement technique, as all the elements in the criteria were centered on the five perspectives discussed in the introductory section.The generic process followed in the decision marking used the Analytical Hierarchy Process illustrated in Figure 2.2 above.

MCDM problems using the attribute process are usually further sub-divided into two classes (Majumdar, 2015): (i) Compensatory – various attributes of an alternative are systematically evaluated (e.g. AHP), and (ii) Outranking – outranking seeks to eliminate alternatives which outperform on enough criteria of sufficient importance (e.g. ELECTRE). In this study, the compensatory technique was found to be more acceptable by the team of experts after the preliminary visits to the relevant artisanal mining sites in QwaQwa.

2.4 Multi-criteria Decision Making (MCDM) Applications

MCDM methods like the Analytical Hierarchy Process (AHP) and the Analytical Networks Process (ANP) have been used to enhance the measurement and evaluation of complex event tools of a political, economic, socio-cultural, technological, environmental and legal (PESTEL) nature (Yuksel, (2012). With the integration of AHP and ANP methods, it is now possible to determine the relative importance and positions of PESTEL (factors/sub-factors) in an analytical and systematic manner. This has enabled companies to determine the suitability of their macro environmental alignment to company goals.

The designing and development of an effective e-learning depends on many factors such as instructional, technological and administrative functionalities – making it a complex MCDM problem. This was echoed by Uysal (2012) who evaluated e-learning factors with multi-attributes that needed to be grouped and assessed in a systematic and structured manner. The AHP method was applied and found to be an effective tool in the decision-making procedure. Thus, this method may be used in the selection of e-learning systems. The aim is to optimise e-learning for the individual learner's needs (Kurilovas and Dagiene, 2010).

The MCDM method was tested to assess the mobile payment market (Ondrus, Bui and Pigneur, 2005). These authors observed that it was possible to build evolving scenarios using DSS which enabled market simulations. They also mentioned that the MCDM could assist in developing a structured assessment methodology that could support the selection process of the suitable technology for growing mobile industry. The MCDM method can assist in the decision-making process for mobile application as it enables developers to choose a security type (authentication, authorisation, security protocols, and so on) suitable for mobile application (Gade and Osuri, 2014). ANP and Simple Multi-Attribute Technique (SMART) methods were also used in an application security. The researchers recommended the use of the SMART in the choice of models involving a higher number of alternatives.

The MCDM is also becoming increasingly utilised in spatial decision-making processes. Examples include Geographical Information System (GIS) and policy prioritisation. These applications can be integrated by: (i) file exchange mechanism, and (ii) using a common database (Gade and Osuri, 2014), used it in the MCDM for space-related decision in the web-based analysis of biodiversity conservation and priorities. These authors used the AHP method to identify priority vectors from diverse restrictions and diverging criteria and to provide alternative choices based on these vectors. The ultimate objective was to select the optimum alternative among a set of available options. Aliyu and Ludin (2012) reviewed various spatial multi-criteria methods to determine the most suitable method for sustainable land use planning. The ANP was revealed to be the superior decision-making tool among several approaches reviewed. The ANP uses a network of relationships, compared to the single-direction relationships of the AHP; hence, it is more powerful. Nonetheless, the ANP was not considered in this study – after the preliminary results indicated a preference of the AHP by the expert decision-makers. Other applications of the MCDM in spatial decision making include mapping landslide susceptibility, flood-risk management, site selection (e.g. for locating plants/facilities and landfills), as well as eco-environmental vulnerability assessment (Afshari and Yusuff, 2012).

In recent years, governments have progressively used information technology to share public information and financial transactions with the public. However, serious security threats exist, as postulated by Syamsuddin and and Hwang (2007). These authors developed an MCDM method to convey an information security evaluation framework capable of conducting e-government security strategy. Gangadhar, Pavani and Behera (2012) also developed a similar security evaluation framework using fuzzy logic techniques that produced a validated performance of absolute security parameters.

Different MCDM methods can be used for efficient evaluation and ranking of the technological innovation capabilities (TICs) of firms. Fuzzy Delphi (to screen TICs evaluation criteria), AHP (to compute relative important weights), and VIKOR (to rank the firms) methods were integrated to develop a framework and rank selected Thai automotive parts firms (Detcharat, Pongpun and Tarathorn, 2013). These authors observed that the mix between criteria and TICs influences the model provided – making it a useful solution to assist management in self-assessment and improvement.

The latest version of information technology is a cloud computing which provides computing services anytime, anywhere to customers – on a pay-as-you-go model (Gani et al., 2014). Recently, this service has become increasingly popular with the rise of smart mobile apparatuses. With the variety of services provided on the cloud, the MCDM helps customers to select appropriate services based on their needs which involve various resources such as software, hardware, virtual servers, and database services.

While most researchers applied the MCDM in selecting best information technology applications and solutions, Perera and Karunasena (2008) developed a value-based decision-making framework for best procurement method. They presented the DSS as the most appropriate procurement method and validated it for relevance and usability in real life situations. The examples stated above show the relative success of the MCDM and its effectiveness in minimising flaws in decision-making. These examples have also shown the general trends and growth in the use of the MCDM in individuals' daily lives. The next section discusses the principles and application of microwave energy in the mining of sandstone.

2.5 The Basic Principles of Microwave Dielectric Mineral Heating

The origin of microwave energy usage is communication technology (Jakes and Cox, 1994). In the early 1946, Percy Spencer (1952) carried out scientific experiments that resulted in the heating of materials using microwave technology. Microwave material heat extraction is one of the novel technologies that offer significant time saving – at an effective cost – in a very clean and environmentally friendly work-station (Haque, 1999; Hesas et al., 2013; Mishra and Sharma, 2016).

Global trends have indicated that, to maintain sustainable mining operations, improved and efficient methods have to be introduced in mineral extraction processes. The use of an emerging technology such as microwave heating has shown a very good potential and its use in mineral extraction is increasing steadily (Meisels et al., 2015; Misrha and Sharma, loc-cit). However, microwave mineral heating principles are less understood. To be able to adopt these technologies as soon as possible, researchers have to understand how microwave energy interacts with materials, especially non-conductive materials such as sandstone. Microwave heating through energy absorption depends largely on the type of material specimen being heated. In non-metals such as sandstone, microwave heating is based on the dipolar and conduction losses associated with the electric field effects in the material (Monti et al., 2016). Such a method would alleviate most of the challenges observed in QwaQwa where several of the sandstone mining sites visited revealed a very primitive extraction method. Thus, the introduction of microwave heating would improve productivity. Moreover, the microwave heating of sandstone in South Africa has thus far remained an experiment carried in laboratories.

2.5.1 The fundamentals of microwave material mining

According to Sun et al. (2016), microwaves travel at light-speed – with a wavelength of between 1mm to 1m. This gives a corresponding frequency of 300 MHz to 300 GHz. Microwave may be explained as an electric and magnetic field running orthogonally with wavelengths varying from 1 to 1000mm (Rao, 2015). When these waves' energy interacts with a target-material, their energy is transformed into heat energy – subject to the properties of the material. Microwave heating is the transformation of electromagnetic power into thermal energy. This form of energy, when delivered directly to a target-material such as sandstone, creates a molecular interaction with the electromagnetic field – resulting in extensive heating. Microwave material heating also gives the following additional benefits which apply to sandstone mining:

- Selective heating of the sandstone specimen to allow for dimensioned shapes, since sandstone mining does not desire segmented mining like in other forms of ore extraction.
- The rapid heating of the sandstone – resulting in cracks along the different rock segments.
- The non-contact heating of the sandstone specimen as the microwave gun would be directed towards the target, away from the protected operator.
- The quick start-up and stopping of the sandstone heating action.
- The portability of the equipment and processes. The pieces of equipment are moveable to different locations, when desired, as shown in Figure 2.3 below.

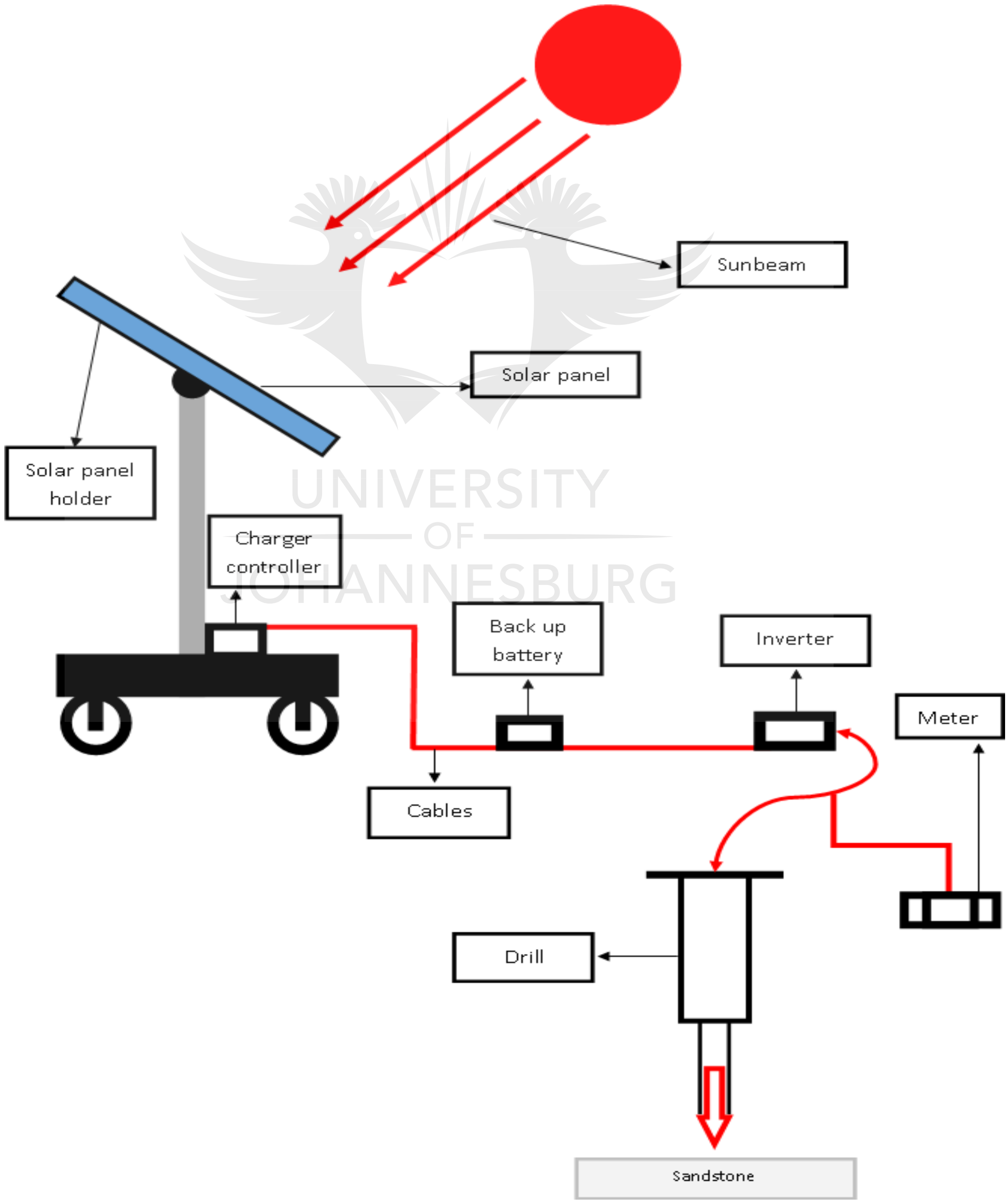

Figure 2.3: Diagrammatic representation of the solar-energy-activated microwave energy driller.

The application of microwave heating involves different temperature ranges for the mining of the targeted material, as shown in Figure 2.4. In QwaQwa, the temperature range is from -4 degrees centigrade to 40 degrees centigrade, although the impact of temperature variations is not very severe. The study by Chandrasekaran categorises the temperature variation for the extraction of minerals into three groups – according to the required application and the temperature grouping – as explained below (Chandrasekaran et al., 2012; Sun et al, op-cit:11).

- A low temperature of 500°C and below is normally used in such activities as food conservation, wood, textile, and rubber transformation.
- A moderate temperature of between 500°C and 1000°C is mainly used for carbon Nano tubes synthesis, ceramics sintering, and glass melting, brazing, drilling on non-metals, as well as the warming and sintering of metallic fine particles.
- A high temperature handling above 1000°C is associated with high-density porcelains and bulk metal linking.

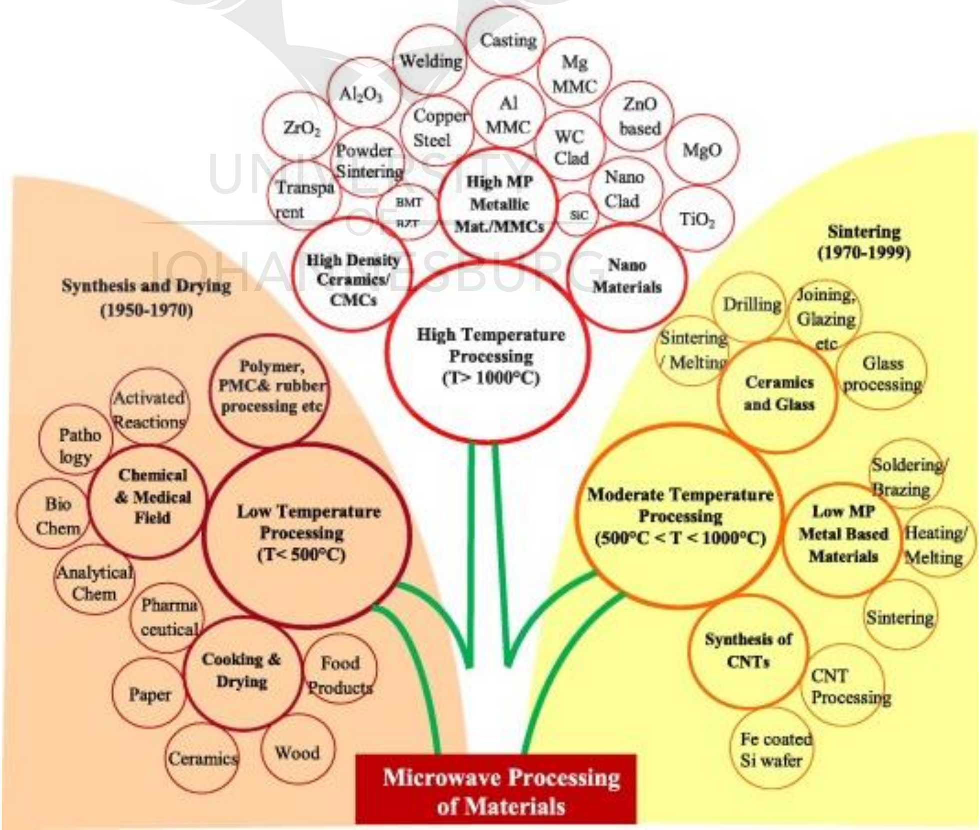

Figure 2.4: The development and grouping of minerals based on microwave heating temperatures (Mishra and Sharma, 2016).

Further work by Mishra and Sharma (2016) categorises sandstone heating as effective at a temperature between 500°C and 1000°C, which is moderate temperature heating. Sandstone mining using microwave energy would therefore be achieved easily within this temperature range – all year around. A recent publication by Beagarba and Penaran (2016) reported on high temperature microwave heating processes. The authors considered the dielectric properties of different materials during the heating through a range of temperatures. Figure 2.5 below depicts the ceramic properties of a sample subjected to a temperature of up to 1200°C. The results indicated a noticeable increase in sample height at heats exceeding 450°C as the water content in the tester changed to a gaseous state and tried to escape, causing the sample to expand. A similar study, by Makul et al. (2014), on cement and concrete composites also noted the same changes at temperatures above 400°C. The results from Beagraba's experiment show that at temperatures above 900°C, the sample size contracts – as the sample melts. The sample dielectric properties increased slightly from temperatures up to 700°C. During the melting of the sample, a more pronounced increase was evident in the dielectric constant and values of the loss cause. The extraction of sandstone requires heating only on the target specimen, to achieve sufficient expansion for the deposits to crack from between the different constituent layers. The temperature variation in QwaQwa ranges only from -04°C to 40°C. Therefore, the above findings indicate that the proposed microwave equipment would work efficiently in QwaQwa.

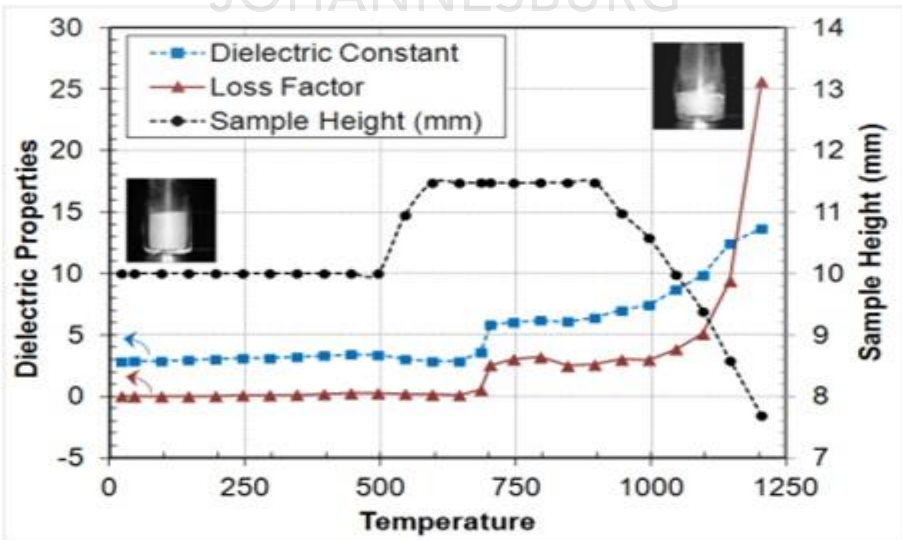

Figure 2.5: The high-temperature heating process of microwave energy on a ceramic sample (Beagarba and Penaran, 2016).

The researchers further emphasised that the physics of electromagnetic waves is of primary importance in the heating of any sandstone specimen. The electromagnetic fields in the microwaves play a major part in the heat generation – at an atomic level (Chen et al., 2013; Binner et al., 2014; Monti et al., loc-cit). When the electromagnetic wave encounters a material specimen, the waves behave in four possible ways – depending on the classification of the material. It may either be redirected, absorbed, conveyed, or be an amalgamation of all three interactions (Chen et al., loc-cit; Kingman et al., 2013; Mishra and Sharma, op-cit: pp82), as illustrated in Figure 6 and Figure 7, respectively.

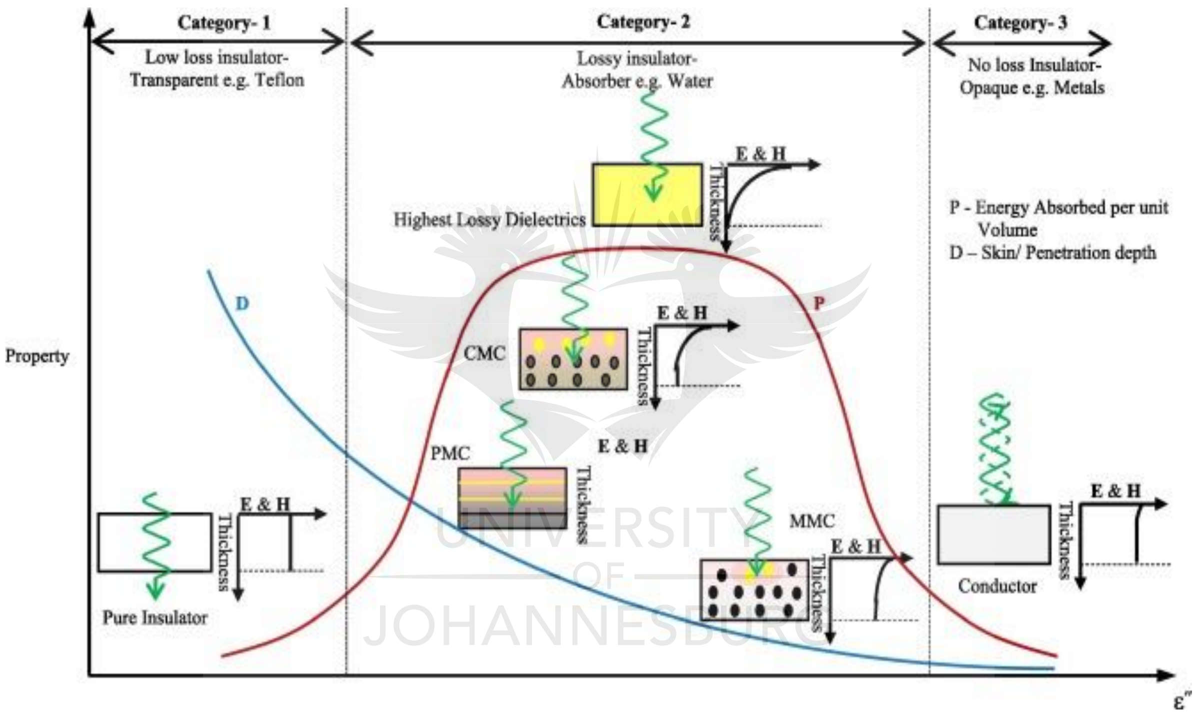

Figure 2.6: The category and behaviour of materials subjected to microwave energy (adopted from Mishra and Sharma, 2016).

- The first-group materials are opaque and therefore cannot be penetrated.
- The second-group materials are transparent or have a low dielectric loss of materials that causes the radiation to be transmitted through the material with little resistance.
- The third-group materials are mainly absorbent. This is where sandstone is anticipated to belong.

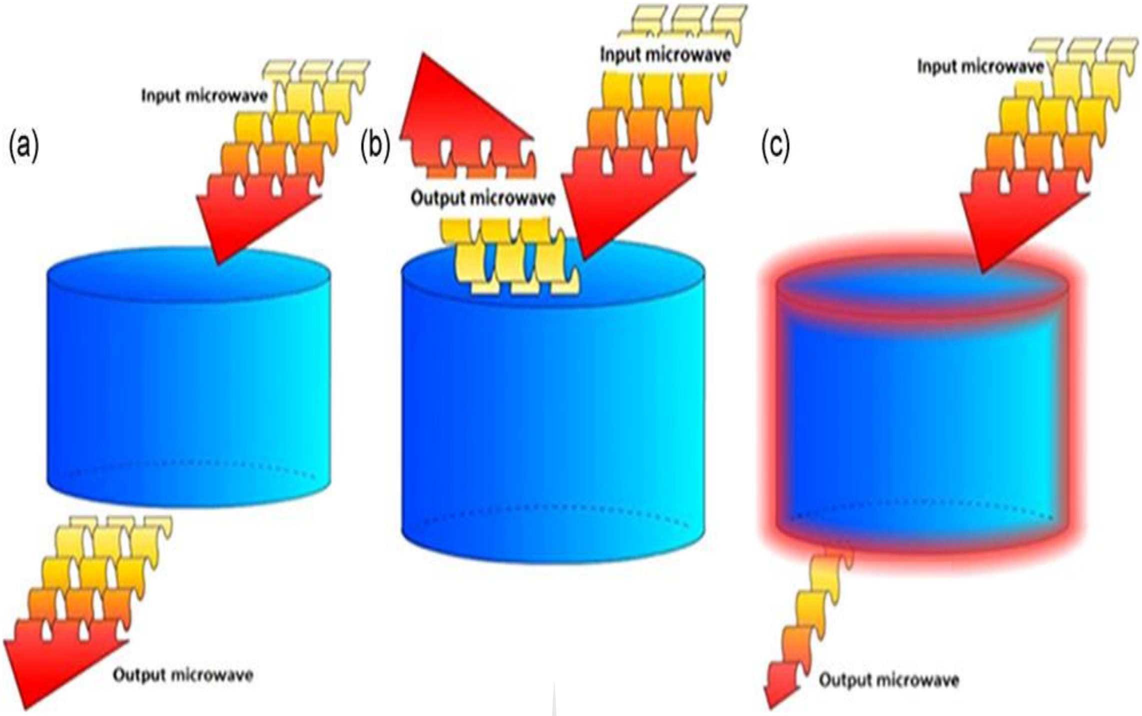

Figure 2.7: The different types of material arranged according to their interaction with microwave energy (Oghbaei and Mirazaee, 2010).

The above-represented phenomena can only be explained based on the modelling of Lambert's and Maxwell's laws (Ramos et al, 2017). The in-depth formulation and calculation of these models will not be considered in this study, although the framework of the models can be used to predict the effect of resonance on microwave absorption.

2.5.2 The Microwave Dielectric Heating Process

Knowing the dielectric attributes of materials is crucial to understanding their ability to absorb microwaves and store energy. The dielectric heating process in the electrical component of the microwave is mainly caused by dipolar polarisation and the ionic conduction of molecules within the heating material (Meisels et al., loc-cit).

In polarisation phenomena, the dipolar reacts to the external electric field and attempts to align itself to the field by rotating. As the alternating electric field varies at very high frequencies, the dipoles will tend to lag behind the oscillating field. This results in their collision with each other – in an attempt to follow the field. This produces a collusion-generated heat in the material. In the conduction mechanism, the electrons and ion carrying charges move up and down through the material, creating an electric current that follows the microwave E-field. The induced currents generate heat due to the resistance between molecules and atoms (Mishra and Sharma, op-cit: p85). The dielectric material's ability to absorb microwave heat energy and store it in the form of heat is given by the permittivity value **Ɛ*** denoted by the equation below (Chandrasekaran et al., op-cit: p330):

$$\varepsilon^* = \varepsilon' - j\,\varepsilon'' \quad (1)$$

Ɛ' above represents the capacity to store energy.

Ɛ'' denotes the energy absorption capacity of the material converted into heat energy.

The formula for the dielectric loss tangent (tan ∂) is given by the ration of the dielectric loss against the dielectric constant, as shown below (Chandrasekaran et al., loc cit)

$$\tan \partial = k''/k' = \varepsilon''/\varepsilon' \quad (2)$$

where k' and k'' represent the comparative dielectric constant and loss correspondingly, since $k' = \varepsilon'/\varepsilon_0$ and $k'' = \varepsilon''/\varepsilon_0$.

The power adsorbed per unit volume during dielectric heating is directly dependent on the depth to which the target material is penetrated and is reliant on the dissipated energy. This energy is represented mathematically as P.

$$P = \omega.\varepsilon''_{eff}.\varepsilon_0.E^2_{rms} \quad (3)$$

P embodies the power concentration in the sample. (W/m^2) and $\omega = 2f$ (Hz) and f denotes the frequency of the incident microwave; ε''_{eff}: denotes the effective dielectric factor; ε_0 is a symbol for the permittivity of free space that is numerically given as (0.824); E^2_{rms}: represents the electric field strength (V/m) at a specific local position.

The loss factor ε''_{eff} is therefore given comprehensively by the equation below (Chandrasekaran et al., loc-cit).

$$\boldsymbol{\varepsilon''_{eff} = \varepsilon''_{polarization} + \varepsilon''_{conduction} = \varepsilon''_{dipolar} + \varepsilon''_{interfacial} + \sigma/\omega\varepsilon_0} \quad (4)$$

Where σ represents the power concentration around the measurable and the other symbols remain the same, as already explained above.

The magnetic field component heating (H-field) is based on three interactive phenomena. The first is the magnetic loss resulting to heavy microwave heating. However, this is limited to a range of materials that are either magnetic, conductive or semi-conductive. In most cases, the microwave magnetic heating is superior to the electric field heating. In some materials, the magnetic loss is four times greater than the electrical dielectric loss (Wang et al, 2014). The principal phenomena for microwave magnetic losses resulting from the H-field are as stated below; based on the following interactions that are in addition to the first interaction mentioned above:

- Eddy currents losses from alternating magnetic fields.
- Hysteresis losses from irreversible magnetisation.
- Magnetic resonance losses caused by electron spin.

Based on the understanding that sandstone microwave heating may not be done magnetically due to the characteristics of sandstone, the details of microwave magnetic heating are not be discussed further.

2.5.3 The Penetration Depth for the Microwave Heating Process

The formula used to assess the penetration depth is provided mathematically as indicated below. This formula provides guidance as to the level of interaction between the microwave and the materials – especially the heating efficiency and uniformity in the material. The depth Dp is a notable indicator of the level of penetration. The latter is conceived as the distance from the surface of a material to a point in it, where the field strength drops to e^{-1}.

$$Dp = \frac{1}{\sqrt{\left[0.5\mu_0 \mu' \varepsilon \varepsilon' \left\{\sqrt{\left(1+\left(\frac{\varepsilon''_{eff}}{\varepsilon'}\right)^2\right)}-1\right\}\right]}} \tag{5}$$

2.5.4 The Microwave-assisted Rock Breakage Technology

Most mineral and metal heating is usually accomplished through conduction and convection. The heat source is usually concentrated at the surface of the material – at a temperature as high as possible – to enable the temperature gradient to transport the heat across the remaining areas, resulting in the rapid heating of the material. Contrary to the above, the microwave dielectric heating generates heat directly inside the exposed mineral; as such, heat travels from the inside out to the surface of the material (Lu et al., 2016). Dielectric heating mainly occurs in both liquids and solids, especially poor conductors that are able to sustain an electrostatic field. Materials ability to support an electrostatic field is linked to the dielectric constant that measures the extent to which any substance is able to concentrate the electrostatic lines of the flux (Mishra and Sharma, op-cit: p83). Sandstone is believed to have a moderate dielectric constant and is therefore a good candidate for microwave dielectric heating.

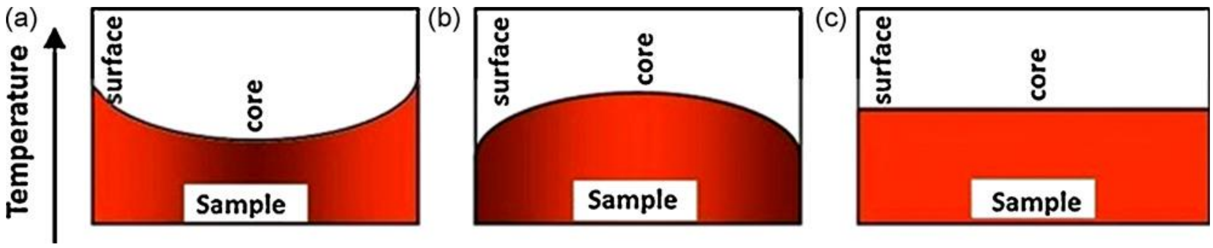

Figure 2.8: Temperature variation within a material sample (Oghbaei and Mirazaee, 2010).

The idea of using microwave power to produce the heat that would assist in the extraction of minerals was first introduced in the 1960s. Nevertheless, it had to be abandoned because of technical issues and economic unviability at the time (Osepchuk, 1984). In recent years, however, Hassani et al. (2016) from the Geo-mechanics Laboratory of McGill University have made a progressive discovery into microwave-radiation-assisted rock breakages. These researchers have conducted an actual microwave-assisted automated rock breakage using tunneling apparatuses and drills. The geo-mechanics researchers reported on the effect of microwave radioactivity on the thermic profiles of several hard rocks. They focused particularly on their strength reduction for an array of radiation contact times and microwave energy intensity levels. Preliminary results indicated that the ductile and uniaxial compressive powers were diminished considerably by augmenting radiation exposure time as the energy levels increased. A similar observation was published by Norambuena-Contreras (2016) who compared the effect of heating asphalt using both induction and microwave in an attempt to heal the cracks on asphalt roads. This researcher noted a decrease in the healing power of asphalt each time the cycle was repeated, until the tenth time when the bitumen was degraded. He concluded that microwave heating was very effective in healing the cracks in asphalt roads due to its ability to heat from the inside out. A further study by Monti et al (op-cit: p9) discusses the interrelationship between microwave energy and rocks as a way of understanding the fundamental physical processes that illustrate the phenomena occurring during the microwave heating process. The latter was described as related to electrical, thermal and mechanical forces that act concurrently. These researchers noted that microwave energy heated the material comprehensively. They concluded that in heterogeneous materials, only the loosely cemented parts absorbed the electromagnetic energy – resulting in rock breakage.

2.5.5 The Recent Developments in Microwave Mineral Extraction

The use of microwave in mineral extraction is improving continuously worldwide. This is because of intense technological research and the unique advantages of microwave heating technology over other heating methods. Indeed, microwave heating remains the fastest and most efficient way of heating (Kingman, 2013; Singh et al., 2016; Xu et al., 2017). The problem, however, remains with the non-uniformity heating of its specimens. Hence, researches have directed their efforts towards methods that would complement microwave heating, in an attempt to solve this problem (Zafar and Sharma, 2014). By combining microwave heating with other heating methods, heat is also introduced at the surface. This results to a more evenly distributed heat source (John et al., 2015). The common methods currently used to improve uniformity in microwave heating technology include:

- Phased control microwave heating.
- The variable frequency technique that allows for different heating patterns within the specimen sample.
- The cycling microwave power methodology that applies the continuous use of microwave power at lower levels.
- The magnetic resonance coupled with thermal imaging.

A brief description of the above techniques will highlight how important they are in the moderation of microwave heating. Phased control microwave heating offers an opportunity of enhanced heat transfer, as discussed by Kosterev et al. (2015). These researchers explained this concept by using a hyperthermia applicator in which controlled dosages of both microwave radiation and heating are administered simultaneously. This process also incorporates a dosimetrist feedback mechanism that helps in monitoring the treatment process. In some incidences, Kosterey et al. (2014) explained that an array of applicators may be used for differential frequencies. For example, tumours near the surface or moderately deep had a frequency of 434 MHz. The latter is used to carry out the treatment, as opposed to the 70 MHz frequency that would be directed to deep-seated tumours. Selected heating by microwave was also used in removing water from oil emulsions, as revealed by Binner et al. (2014).

The cyclic frequency technique relies on temperature control and therefore works by running the microwave energy at a less than full power, to enable the heat to travel from the heat concentrated areas to the cool parts of the specimen – in a given time span

(Chumha et al., 2016; Zafar and Sharma, 2014). This action would contain most changes – in the dielectric properties of the sandstone – that are normally engendered by the inherent variability of natural rocks. In addition, cyclic frequency allows homogeneity in heating, which is very vital in attaining the desired effects during the production on dimensioned sandstone samples. Magnetic resonance imaging is a technique used in mapping thermal changes (Behnia et al., 2002).

2.6 Solar Photovoltaic Technologies

This section discusses the evolution of Solar Photovoltaic Technology and demonstrates how rapidly solar energy technology has improved over the years. Furthermore, the section expands on the potential of solar power in improving the generation and capture of the electrical energy that could be used in other forms of technology, such as the microwave technology proposed for the mining of sandstone.

2.6.1 The Solar Photovoltaic Technology Evolution

Solar photovoltaic (PV) technology, one of the few low-carbon energy technologies, converts sunrays and sun heat into electrical energy. Solar PV is one of the new technologies drawing the most favourable attention of renewable technology solutions researchers, given that it is readily available. As per its architecture and working process, solar energy is the most publicly known, easily understood and accepted renewable energy technology (Green, 2002). However, the first commercially manufactured solar cell was conceived only 100 years later, when the crystalline silicon(Si)-based cell was invented and publicly disclosed for the first time by the Bell Labs scientists in 1954 (Hui, 2011).

A fundamental question remains why Si is the most used material in the absorption of solar energy. This is because Si constitutes the next most-available and abundant component in the earth's crust, which makes it a relatively cheaper semiconductor. Today’s Si technological stride is made through the development of Si-based solar technologies. This is enabled by the success of a strong technological base for the electronic industry that applies a mass production of Si-based solar applications. Nevertheless, the produced Si is not as pure as natural Si and does not fully meet the requirement of the electronic industry. The first publications on solar cell emerged after the Bell Labs’ demonstration on how the Si cell converts sunrays energy with an efficiency of 21.6%. Later, in 1961, Shockley and Queisser demonstrated –

theoretically – that a solar cell's efficiency could be estimated at 31% (Krogstrup et al., 2013). Further recalculations and additional considerations – taking into account Auger's recombination – brought the efficiency of the Si solar cell to 29% (Tsakalakos, 2008).

Today, the crystalline silicon (c-Si) cell is the most commercially available solar PV that accounts for 90% of the global solar system installation. The PV-thin-film technology, however, covers 10% of the rest of the solar market. It must be noted that c-SI technology is still developing and will still require much improvement in terms of efficiency enhancement, although making it cost-effective remains a challenge. The PV solar technology system components are divided into two main categories – when analysed based on cost (MIT Energy Initiative, 2015).

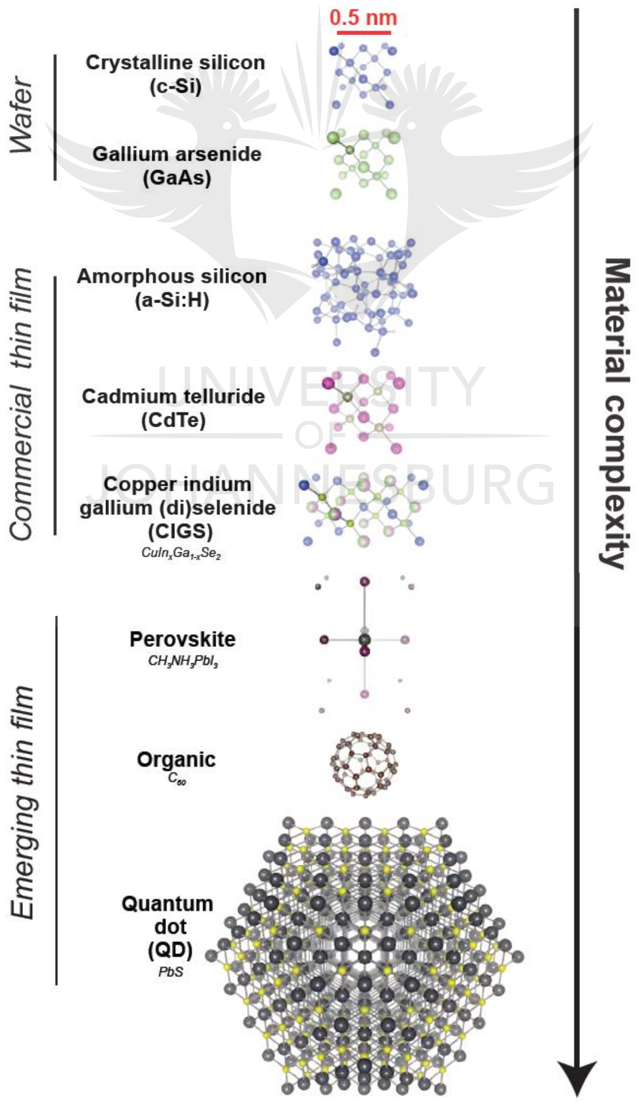

Figure 2.9: PV technologies classified on material complexity based on molecule weight or repeating crystal unit (MIT Energy Initiation, 2015).

The building blocks emphasising solar PV technologies and their respective molecular complexity are shown in Figure 2.9. Wafer-based technology relates to one of several atomic units. Thin-film technology refers to a highly complex structure ranging from amorphous silicon to building to thin polycrystalline films. The cost of solar panels has since dropped by 85% since 2006, despite the fact that the cost of BOS has not changed much. This makes comparing the cost of BOS to that of silicon challenging, as the latter does not absorb the sunrays effectively given its thickness. In addition, this material is frangible and generally mounted on heavy piece of glass. Improving silicon-based solar cell technology would necessitate that it be lightweight, flexible and thinner, for easy transport and installation (IRENA, 2016).

2.6.2 The Solar Photovoltaic Technology beyond Silicon

Silicon researchers have now discovered better semiconducting materials such as gallium arsenide and phosphide. These materials are superior to silicon but very expensive. The absorption of solar cells has since increased immensely following a change in the manufacturing set up whereby different layers of semiconducting materials are superposed, giving researchers the fine-tuning needed for the electromagnetic spectrum of a theoretical efficiency of up to 50%.

2.6.3 The Solar Photovoltaic Technology Availability of Materials

The improvement of solar energy generation or production, by up to 100 times, raises a new issue, namely, raw materials availability. This suggests that the extensive generation of solar power may be limited by the unavailability of the critical materials for the industrial production of solar cells (National Research Council (US) Chemical Sciences Roundtable, 2012).

Researchers have striven to determine the material requirements of the PV technology. They have established the amount of materials needed if solar PV technology is to be used to meet the expectation of the global demand for electrical power in 2050. The projected installation requirements of 1,250; 12, 500; and 25,000 gigawatts, dwarfs the current PV energy capacity of only 200GW worldwide. Finally, these researchers have looked at the current materials used for PV production and have evaluated the additional worktime required to meet the generation targets, as shown in Figure 10 below (OECD/IEA, 2010).

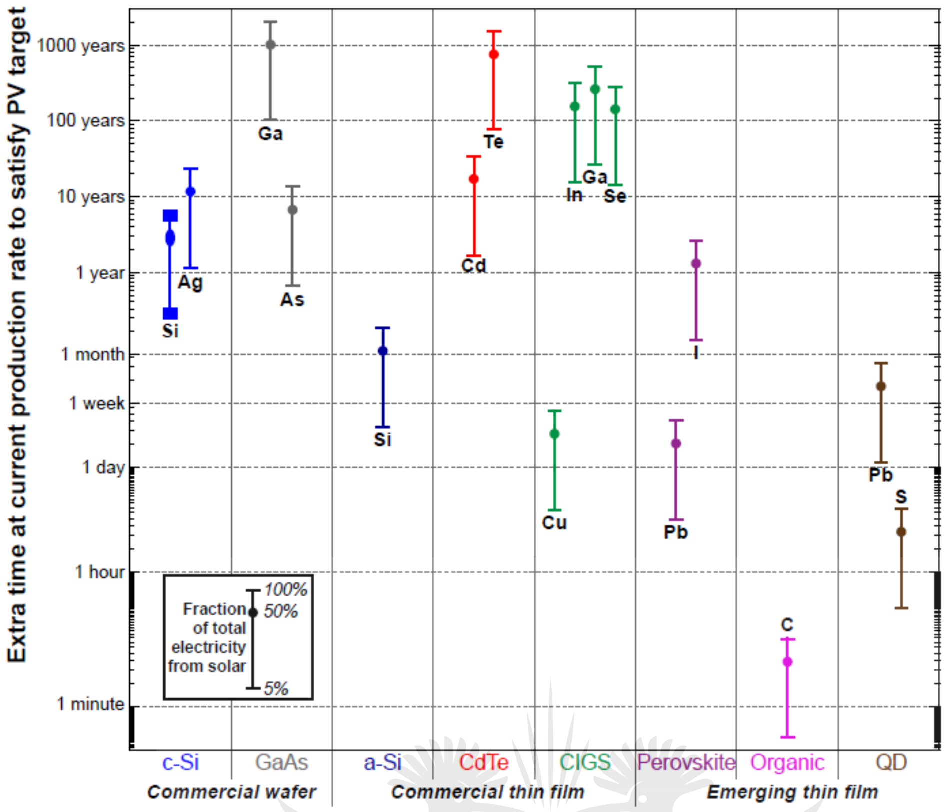

Figure 2.10: The availability of critical materials required to improve the capacity-generation of PV solar technologies (MIT Energy Initiative, 2016).

The 100% meeting of the global demand in electricity is estimated in 2050 – using crystalline silicon solar PV. This is likely to take six years of current silicon production. The estimated increase in production is feasible by 2050. Material constraints would not be a problem for silicon production (OECD/IEA, 2010; OECD/IEA, 2014; Global CCS institute, 2014). However, such a record-time production cannot be claimed of the thin-film technologies today. By illustration, if cadmium telluride may be considered, the raw material tellurium can only be found as a by-product primary of copper refining in tiny quantities. Supplying the tellurium to produce cadmium telluride-based solar cells for meeting all energy demands in 2050 would require approximately, at the current tellurium-mining rate, an equivalent of 1,400 years (Jean et al., 2013). The same applies to gallium, Indium and selenium that are also mined as by-products of main and basic metals. Thus, using copper indium gallium selenide (CIGS) solar cells for meeting all energy demands in 2050 would require the current production rate to last for over 100 years. The preceding shows that the new technologies do not have a promising future, since they can only produce some hundreds of gigawatts of power (MIT, 2015; Jean et al., 2015). Considering the challenge with CIGS, these solar energy production types seem unlikely to dominate solar technology.

2.6.4 The Improvement in Solar PV Technology Cost

The most recent solar Innovation is the new tandem solar cell resulting from a research carried at the Massachusetts Institute (MIT, 2016). This novel solar component is more effective and cheaper than its equivalents (Solomon, 2016). The cost of solar PV modules is characterised by an exponential downwards movement to the extent that price parity with grid electricity generation in some parts of the world will soon be attained. Nevertheless, clean energy sources remain just slightly more expensive in all the energy mix (MIT, 2016). The researchers concluded that a significant reduction of the cost of solar energy generation lies in increasing conversion efficiency. This may only be achieved through reduced use of manufacturing materials and the simplification of the process. Currently, no single technology insight promises to be best in handling all three measures (Sadatian and Abolqhasemi, 2016).

2.6.5 Cost Reduction Potential for Solar PV Technology on c-Si Pv

The progress in science, coupled with the latest discoveries and innovation, has resulted in PV costs progressively dropping in the short-term (IRENA, 2016). The uncertainty in the global economic context has resulted in many investment decisions in solar-powered generation being delayed or postponed indefinitely, slowing its deployment and growth rate.

The attainment of cost effectiveness might likely result from technology innovation and economies of scale. Both high- and low-cost PV manufacturers would have halved their production costs from those of 2015. Figure 5.1 depicts how the c-Si PV cost has decreased from 2010 to 2015 and has helped to increase the PV manufacturing plant size. Table 2.2 and Table 2.3 below respectively show in-depth usage projections and c-Si PV modules cost breakdown. The costs of producing wafer and polysilicon could have declined considerably by 2015 considering the growing production and progressive engineering innovations on PV solar modules.

Table 2.2: Crystalline silicon PV module prices for European, North American and Japanese manufacturers from 2010 to 2015 (adopted from Mehta and Maycock, 2010).

High-cost producers	2010	2011	2012	2013	2014	2015
Production scale (MW)	150	400	650	900	1 150	1 400
Polysilicon production (USD/W)	0.43	0.33	0.23	0.18	0.15	0.13
Silicon wafer production (USD/W)	0.46	0.37	0.33	0.29	0.27	0.25
Solar cell production (USD/W)	0.36	0.29	0.25	0.23	0.20	0.19
PV module production (USD/W)	0.50	0.42	0.37	0.33	0.31	0.29
Total PV module cost (USD/W)	**1.75**	**1.41**	**1.18**	**1.03**	**0.93**	**0.85**

Table 2.3: Crystalline silicon PV module prices for low-cost manufacturers from 2010 to 2015 (Mehta and Maycock, 2010).

Low-cost producers – China, etc.	2010	2011	2012	2013	20 14	2015
Production scale (MW)	350	600	850	1 100	1 350	1 600
Polysilicon production (USD/W)	0.47	0.39	0.25	0.20	0.16	0.14
Silicon wafer production (USD/W)	0.34	0.28	0.26	0.24	0.22	0.20
Solar cell production (USD/W)	0.24	0.21	0.19	0.18	0.16	0.15
PV module production (USD/W)	0.36	0.31	0.29	0.27	0.25	0.23
Total PV module cost (USD/W)	**1.41**	**1.20**	**0.99**	**0.87**	**0.73**	**0.73**

2.6.6 Use of Solar Energy in the Extraction of Minerals

Research has shown that up to 30% of the global energy produced is consumed by the mining industry, with 20% used by mining operations and 10% by mineral resources processing operations (Hillig and Watson, 2016). These figures clearly show that power supply in the mining sector should be part of the search for regenerative technologies solutions like solar power, in an effort to ease the use of carbon emitting energy resources. Substitution might occur slowly, starting with mining light-energy-consuming systems' equipment until solar systems and other renewable energy technologies and their infrastructures have improved sufficiently to drop the use of crude fuels. However, it might be possible to use solar energy for a series of industrial devices and apparatuses. Some examples include the use of solar energy to power microwaves and light vehicles like forklifts and so on.

2.6.7 Renewable Energy Prospects as an Alternative for Mining

Solar PV regenerative technology has the highest prospect for a large number of mining companies in South Africa. The original venture costs for solar PV technologies are relatively low compared to those of other renewable energy equipment – with the exception of wind energy that remains three times more expensive than the current solar PV sources (Votterler and Brent, 2016). Solar energy is abundantly available in South Africa where it is generally received with an ardent steady intensity throughout the day. This gives a clear advantage of solar technology compared to other renewable energy technologies – depending on the availability and exploitation of its energy resource (Ramayia, 2012).

Solar energy service infrastructure is developed in South Africa. This is evidenced by the existence of solar energy infrastructure in numerous local companies (Maphelele et al., 2013). Wind energy constitutes the second-best renewable energy option, followed by the geothermal technology (Ramayia, 2012).

When referring to solar energy in the mining domain, especially in the case of artisanal mining in South Africa, researchers have reported that mining operations and the service infrastructure are very low. The technology, in terms of equipment, would still need to mature. The need for energy use might be so significant that solar systems could be adopted in the future mining operations – probably with the use of concentrated solar power (CSP) and the incorporated molten salt power storage (Parrado et al, 2016).

Figure 2.11: The use of CSP with molten salt energy storage to supply power to a mining site (Parrado et al, 2016).

In their annual reports, South African mining companies have disclosed economic plans aimed at creating mining corporation opportunities for energy sustainability with reference to renewable energy sources, to support their long-term achievements. Considering the affordability of solar systems such as CSP technology, the key challenge would probably be to find investors. Solving this will ensure the shift from operational to capital expenses so that such a project may be realised. Therefore, education in decision-making for the future of mining should involve knowing the emerging opportunities presented by the renewable electricity associated with their specific future needs (Ndebele, 2015). In principle, such an endeavour would be the apanage of mining leaders who should take initiative and work on more plausible knowledge and accessibility.

2.7 Societal Acceptability of New and Emerging Innovations

The changes in global energy demands and environmental targets are introducing new energy systems worldwide. However, this introduction of new infrastructure and technologies is quite challenging, as it must ensure both sustainability and public acceptance (Upham et al., 2015). The development and successful application of new equipment depend on a positive response from and acceptance by society. A proper coordination among all stakeholders and specific planning are required to secure acceptance and widespread distribution of a new technology. The ratio of perceived risk (closeness of technology to the user) to benefit (need of technology) indicates the acceptance of a new technology.

While new technologies are designed to deliver benefits to society, the new risks and unpredicted events associated with certain technologies may lead to public concerns and controversies. In many instances, the establishment of new energy systems may face resistance from local communities. Societal controversies often delay and have sometimes lead to the public's rejection of many technologies in the past (Gupta et al., 2011). In the Netherlands, a case involving a carbon capture storage (CCS) initiative received a low level of social acceptance and was abandoned. This was due to a lack of or poor communication on the necessity of CCS among the key stakeholders (van Os et al., 2014). It becomes imperative to understand the factors driving the public's reactions to new energy systems, both infrastructure and end-user applications.

Social acceptance is increasingly becoming one of the major challenges in implementing new energy systems and policies successfully (Jung et al., 2016). Studies on the social acceptability of technologies are becoming increasingly popular (Yuan et al., 2011; Fast, 2013). The social approval of innovative technologies is becoming frequently investigated in developed countries, although it remains unexplored in developing countries (Hanger et al., 2016). While some studies on social acceptance focus on general acceptance and communication, others investigate economic and political perspectives, as is the case with those on sandstone mining in QwaQwa. However, different perspectives on social acceptance coexist and can interact with one another. Hence, an integrated approach accounting for all perspectives will be an appropriate method to conduct such studies (van Os et al., 2014).

A "triangle of social acceptance" is categorised by three corners of the triangle, as shown in Figure 2.12 below (Wüstenhagen et al., 2007; van Os et al., 2014; Caporale and De Lucia, 2015). The corresponding three perspectives are:

- socio-political acceptance which covers the technology and policies, and include stakeholders in the public;
- market acceptance which deals with prices, investments and profits made by investing companies – based on consumer demands; and

- community acceptance which normally involves support by local stakeholders and the surrounding community. It is essential to constantly engage local stakeholders as a way of accelerating the public's involvement in the introduction of potential technological advances.

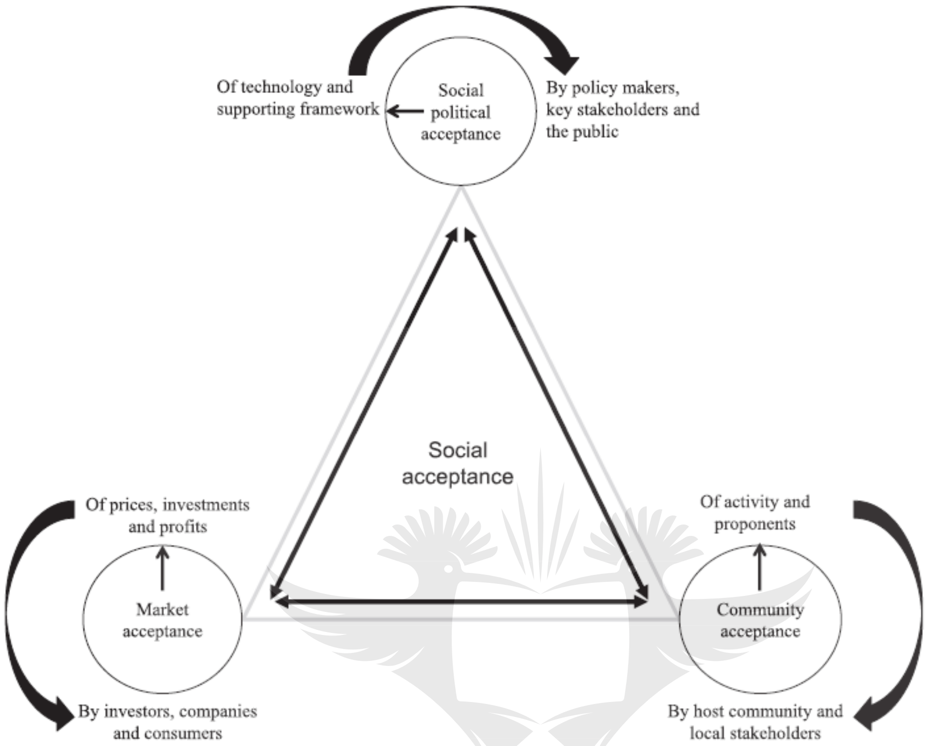

Figure 2.12: The three-dimensional triangle representing the social acceptance of renewable energy (van Os et al., 2014).

2.7.1 Social Acceptance of New Emerging Technologies

Economic, ecological and social implications are three major dimensions of sustainable technology development (Assefa and Frostell, 2007). These authors found it difficult to involve the local community in basic discussions about replacing existing energy technologies with new ones. They believe that the absence of information and expertise about novel energy technologies discouraged the participation of the community in the discussions. Therefore, it is necessary for developers and policymakers to introduce new technologies to the public first and hear their opinions from the outset. Once the public becomes comfortable with the new technologies and their concerns have been addressed, it becomes much easier to implement new technologies without any delays. But, in some specific cases, the respondents preferred to continue with established technologies.

Human behaviour is too complex to understand, which makes it difficult to recognise patterns of acceptance and adoption of innovative energy technologies (Alomary and Woollard, 2015). To understand social acceptance, it is important to address the psychological determinants used in the new energy technologies, as explored by researchers (Gupta et al., 2011). Several models and theoretical frameworks have been developed and are being practised to study the social acceptance of technological innovation. Examples include the Theory of Reasoned Actions (TRA), the Technology Acceptance Model (TAM), the Social Cognitive Theory (SCT), the Innovation Diffusion Theory (IDT), the Unified Theory of Acceptance and Use of Technology (UTAUT), and so on. The most important variables in the TAM are the supposed usefulness and the seeming ease-of-use. These two factors explicate 40% of an individual's intent to use a technology, whereas the UTAUT model uses two additional variables, namely, the facilitation conditions and the social influence. In addition, the above researches require four more tempering factors (gender, age, experience and voluntary usage) to explain up to 70% of the individual's intention to the use any technology (Peek et al., 2014). Assefa and Frostell (2007) developed an approach to assess social indicators of new technologies, using a Swedish computer-based tool known as ORWARE. The latter is a short form of Organic Waste Research that includes economic and ecological indicators. The authors added three social indicators (knowledge, perception and fear) in their tool, which provided a local setting and relevance to the ecological sustainability and economic viability of technology advancement.

Gupta et al. (2011) studied social acceptance using peer-reviewed articles on technologies, social science and psychology. These authors selected 292 peer-reviewed articles published in 39 different countries between 1997 and 2008 – using the Scopus database. The technologies and socio-psychological determinants of technology acceptance used in the research are enumerated in Table 2.3 below. The authors reported an increase in the scholarly attention paid to the public's acceptance of technologies, as well as an increase in the wider coverage of socio-psychological determinants. In the past, research on the acceptance of new and emerging technologies was conducted post-commercialisation, leading to negative responses. However, recent studies have noted a shift towards identifying the public's opinions and views prior to commercialisation, leading to societal acceptance. The authors also found that most of the reviewed articles originated from North-West Europe and North-America while fewer of the articles investigated the social acceptance of new technologies in Latin America and Oceania countries.

Table 2.4: List of new technologies and socio-psychological determinants (Gupta et al., 2011).

Technology	No. of Articles	Socio-psychological determinants	Region
1. Genetic modification	210	Effect (broad, positive and adverse) Professional vs general knowledge Effect (overall, positive or harmful) Impact on wellbeing (positive and destructive) Effect on environment (positive and deleterious) Expected heuristics Values (common and positive) Perceived risk Perceived benefit Perceived cost and risk management. Risks assessment Possible attitudes (generally, positive or negative) Technological ethics and values Role of society in promoting confidence and accountability. Citizen knowledge linked to individual dissimilarities and communication costs. Technological features	North-West Europe North America Asia Southern Europe Latin America Africa Oceania
2. Nuclear technology	99		
3. Information and communication technology (ICT)	93		
4. Chemicals used in agricultural control.	50		
5. Nanotechnology	30		
6. Cloning	21		
7. Mobile phones	20		
8. Hydrogen technology	11		
9. Genomics	14		
10. Radio frequency identification technology (RFIC)	10		

Gupta et al. (2011) observed that certain determinants of social acceptance were associated extensively with specific types of technology (Figure 2.2). Clusters one and two include one technology with one or more associated determinants, whereas clusters three and four include more than one technology with two or more associated determinants. About 60% of the reviewed articles focused on elements initially discussed above. Few determinants were observed to have a weak association with any of the technologies. The authors believe that the association of public acceptance determinants and new technologies will aid in understanding and predicting the factors, while discussing new and emerging technologies in the future.

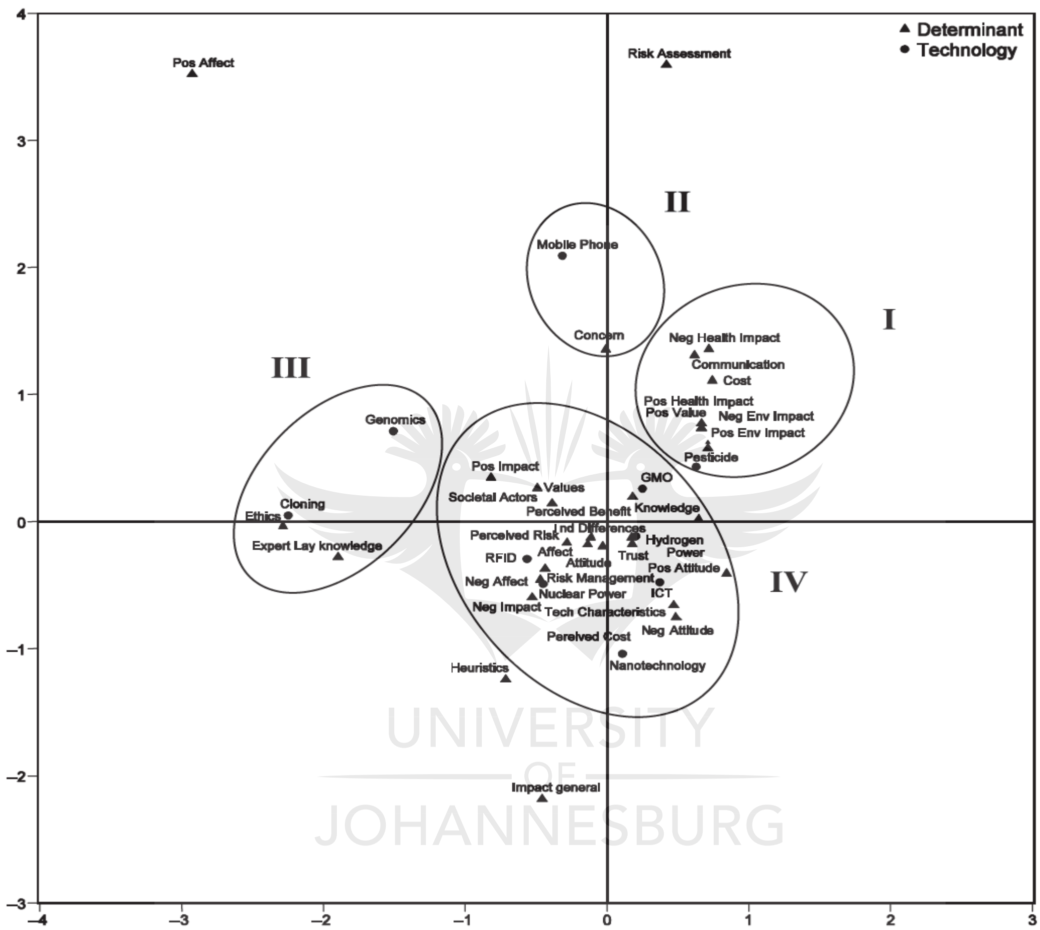

Figure 2.13: Correspondence analysis of categorised socio-psychological determinants and technologies (Gupta et al., 2011).

Peek et al. (2014) reviewed original and peer-reviewed articles in probing the factors swaying the approval of the integration of new electronic technologies to support the independence of aging (60 years and older) in the community dwelling of older adults, for both pre- and post-implementation stages. The factors prompting technology acceptance at the pre-rollout phase are shown in Figure 2.13 and generally include:

- such concerns about technology as cost of implementation, privacy repercussions, and usability problems),

- such advantages of technology as augmented users' protection and usefulness),
- requirement for technology, for example, application of technology to help from a family member,
- social influence such as that from family and friends, and
- characteristics usually required by older adults such as aging in a particular way and place.

The factors influencing post-implementation acceptance include:

- privacy implications,
- perceived need of technology,
- safety,
- availability of home care centres, and
- level of satisfaction when using new technology.

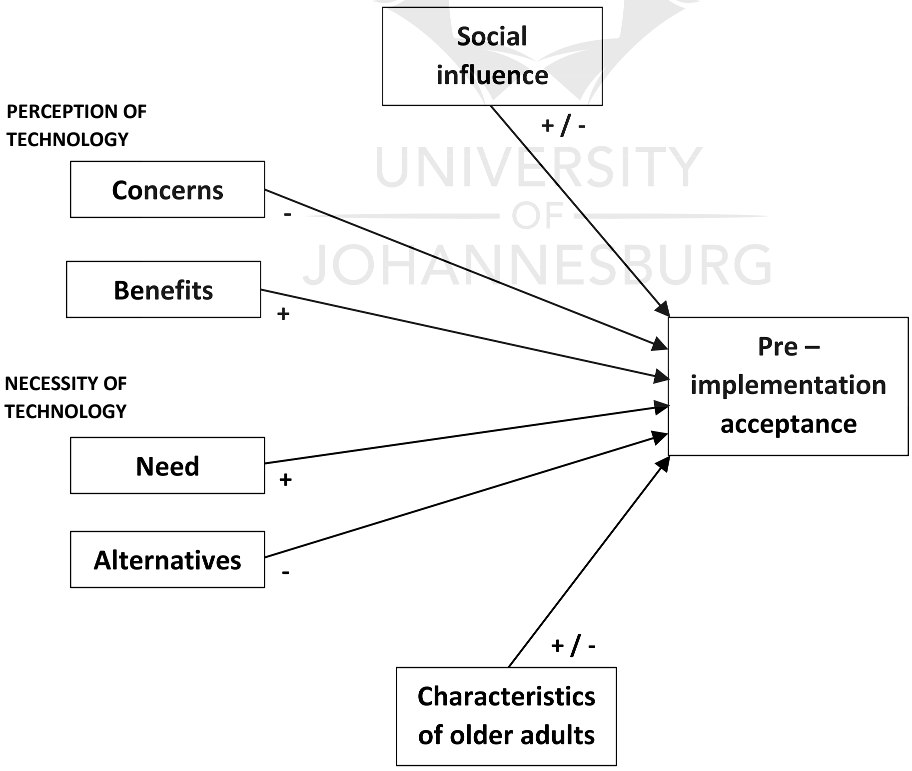

Figure 2.14: Pre-implementation acceptance model (Peek et al., 2014).

Although available technology acceptance prototypes can analyse the effects of social sway on technology acceptance, they do not incorporate the influencing role of social networks (Kate et al., 2010). The analysis of social systems, which is characterised by individuals' trust, opinions and behaviour, may provide a useful insight into technology acceptance. The authors studied the influences of social networks on technology acceptance using three social network characteristics of subjective norms (Figure 2.4): (i) core elements (tie strength), (ii) key individual measure (network uniqueness), and (iii) main collective measure (network concentration). Since individuals tend to be influenced by their social network and adopt the attitude of the group (also known as subjective norm), the authors investigated the behaviour at the individual level (e.g. TAM) and then extended it to the group level (social network). The subjective norm concept, when introduced in TAM (this extended version is known as TAM2), provided a means of linking the characteristics at group level to those at the individual level. An effective way of utilising social networks is to disseminate the information regarding the new tool within the network, using highly central persons. Then it becomes important to increase the network's density to enhance unity, trust, commitment and cooperation within the group – to increase the flow of information. Instead of approaching large numbers of stakeholders, social networking can be effectively used to ensure the positive social acceptance of technology.

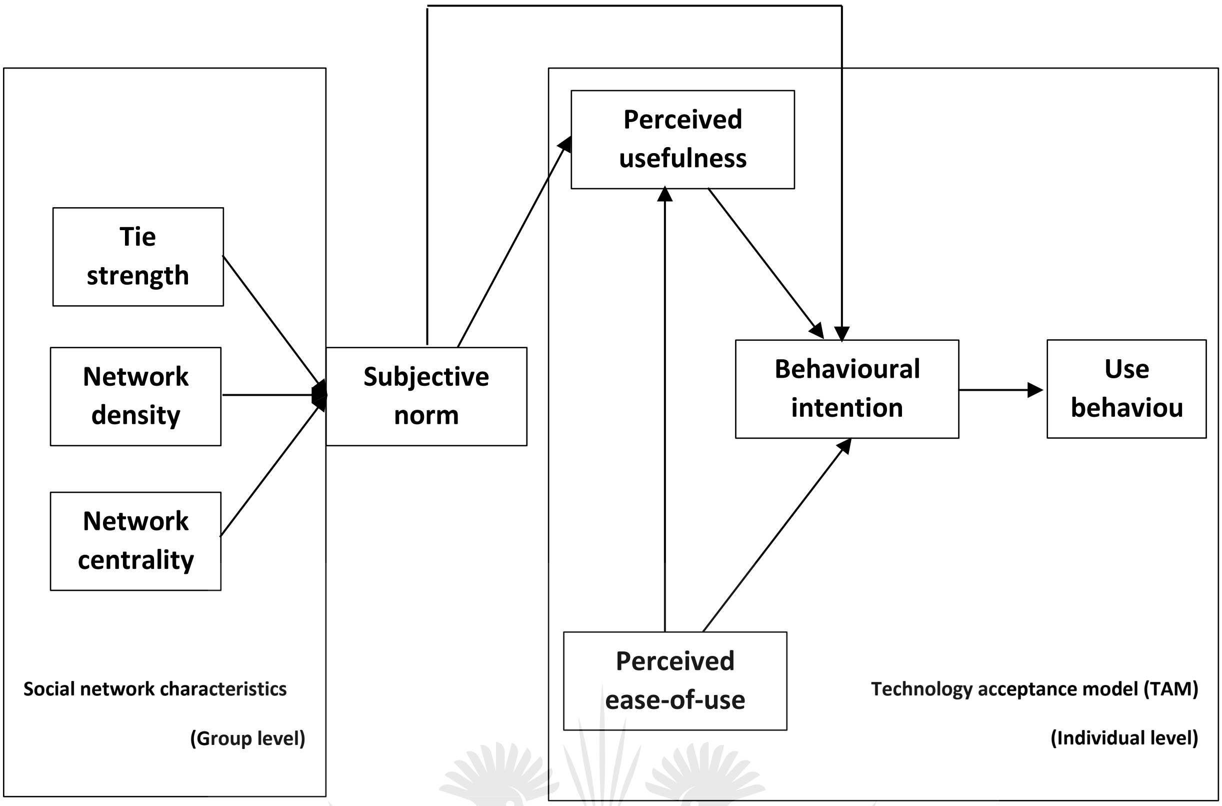

Figure 2.15: Influences of technology acceptance on social networks - based on subjective norms (Kate et al., 2010).

2.7.2 Renewable Energy Social Acceptance Systems

A shift has occurred in renewable energy research areas – from market and socio-political measures towards the social acceptability (support or opposition) of the renewables by the community (Fast, 2013). The increased adoption of renewable energy and the ambitious setting of targets require an investigation of social acceptance. This will ensure widespread adoption and will help with the planning, because social conflicts and a low level of social acceptance may pose a serious threat to the achievement of the set targets (Wüstenhagen et al., 2007; D'Souza and Yiridoe, 2014). For instance, the generation of wind power in several countries has been questioned, due to its acoustic and aesthetic impact on landscapes. Researchers, worldwide, have explored the social and public reception of the implementation of renewable energy equipment; however, they have not yet elaborated tangible solutions (Zoellner et al., 2008; Yuan et al., 2011; Fast, 2013; D'Souza and Yiridoe, 2014; Hanger et al., 2014; Stigka et al., 2014; Toft et al., 2014; Caporale and De Lucia, 2015; van Rijnsoever et al., 2015; Rosso-Cerón and Kafarov, 2015; Jung et al., 2016; Sheikh et al., 2016).

Caporale and De Lucia (2015) conducted a study to understand the social approval of an on-farm wind energy in the Apulia region of Southern Italy. Because of poorly developed electricity transmission in the Apulia region, the focus was shifted to alternative cleaner sources of energy. The Apulia region presents favourable climatic and territorial conditions for on-shore wind energy development. However, the high concentration of wind farms poses serious problems concerning landscape preservation over time. The public awareness on the sustainability of the territory has halted the expansion of the existing wind farms. The authors reported a positive consumer attitude towards wind energy, which closes the gap between institutional requirements and consumer needs. Nevertheless, consumers were found to lack the information on the energy market and were unaware of their role in subsidising renewable energies through their electricity bill.

A study conducted in Australia found three major determinants of social acceptance that impede the development of wind farms in rural communities: (i) concerns about wind turbines, (ii) annoyance with wind turbines, and (iii) lack of consultation with stakeholders (D'Souza and Yiridoe, 2014). While the local respondents were aware of the economic benefits derived from wind farms through employment, about one-fourth of the respondents were unaware of the negative environmental impacts caused by fossil sources of electricity. Despite the fact that the indigenous community participated fully in the wind-farm project development from the inception, only 15% of the respondents agreed to participate or contribute actively to the wind energy development and planning. The authors observed that about one-fourth of the respondents reported the lack of transparency while only about 20% of the respondents were allowed to express their views. The concerns about the possible negative impacts of wind farm development on the landscape and its visual aesthetics were also raised in the study. The benefits of wind energy development such as optimum usage of less productive lands, and the economic benefits linked to employment and land leasing or renting must be well communicated to local stakeholders.

Hanger et al. (2014) studied the importance of societal acceptance in the large-scale solar power project in Ouarzazate, Morocco. These authors investigated the impacts of solar power installation in the region – using a theoretical model (Figure 2.5) with several levels of social acceptance elements. These included (i) factors linked to the project development phase, e.g. awareness (information), procedural justice (public participation), as well as trust in developers and investors; (ii) factors associated with the possible project outcomes, e.g. socio-economic impacts, environmental effects, distributive fairness (equity); and (iii) geographical factor, e.g. the distance separating respondents' residence and the project site. The authors observed an almost unanimous acceptance (91% of the respondents supported the project) of the solar energy project by the community. They believed that this was due to the fact that the community was well aware of environmental benefits of solar energy and the low level of awareness (45% of the respondents were poorly or not informed at all) about the project. The community expected (75% of the respondents) positive socio-economic benefits, namely, job creation and reduced electricity prices.

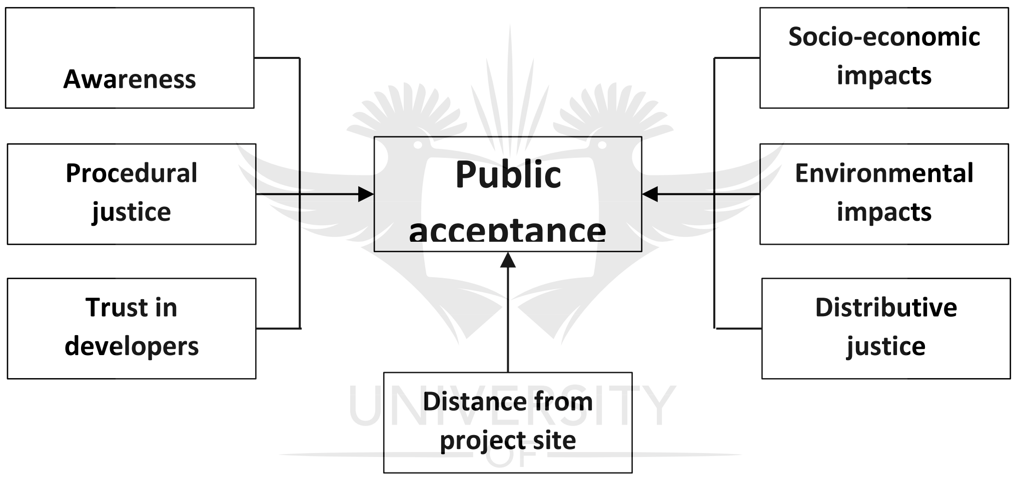

Figure 2.16: Social acceptance model (Hanger et al, 2014).

A similar study on the social tolerability of solar power technologies was conducted in Shandong province, China (Yuan et al., 2011). The authors investigated the social acceptance of the solar water heater (SWH) and the solar photovoltaic (PV) in the rural and urban areas of Jinan City. They found that SWH achieved a higher status of social acceptance and public consciousness than solar PV. The awareness level and resolution to implement solar energy equipment at home were found to be influenced by the income, age and education levels of the respondents. However, urban respondents than their rural counterparts showed a higher level of mindfulness of solar power technologies. While the important factors for the installation of SWH included convenience and economy, energy conservation and environmental protection were highlighted as the important factors in installing solar PV. The high initial cost and the lack of PV awareness were reported as the reasons for the low level of social acceptance of solar PV.

Zoellner et al. (2008) studied the public's reception of renewable power technologies using a multi-model research design. They investigated the social aspects responsible for the public's acceptance of the implementation of the grid-connected solar PV, the biomass and the wind power in four different regions of Germany. They found a general public support of renewable energies. However, further consideration of the social factors influencing the local acceptance is required for the widespread adoption and utilisation of renewable energy systems. The economic consideration was observed to be the strongest predictor of the societal acceptance of renewable power systems. A positive cost-benefit output of the renewable energy system improved the overall evaluation of that energy form. The other factors which seemed to be influencing the public's acceptance of renewable energy systems included: (i) impacts on the landscape (e.g. presence of biomass plants deemed unpleasant by some respondents), (ii) procedural justice (e.g. fairness, transparency), and (iii) involvement (e.g. dissemination of information, including in scheduling and decision-making procedures – from the early stage of project development).

Jung et al. (2016) examined the status of social perceptions and the implementation of renewable energy technologies (RETs) in Helsinki's, Finland, and residential building sector. The European Union (EU) has identified building stock as one of the sector that can assist it in achieving its climate and energy objectives through improved energy efficiency – using RETs. The authors investigated such social and economic factors as investment cost, payback period, housing types, national incentives, and perceived reliability of building-integrated RETs. Furthermore, these authors used a Stochastic Multi-criteria Acceptability Analysis (SMAA) to conduct the preference assessment of the available RETs ranked by the respondents. They observed that the Finnish residents preferred multiple RETs than a single option. These residents rated solar power and ground source-heating pumps as the most reliable whereas wind technologies as well as joint heat and power were rated the lowest. The participants were aware of the reduced carbon footprint and were eager to invest (43% of the respondents were prepared to inject over 6000 euros) in RETs – with investment grants and tax deductions as preferred incentives. Most of the respondents were observed to be comfortable installing RETs within their property (roof, backyard). The authors suggested to the government to choose suitable RETs in a balanced manner, based on the local conditions and the public's preference.

Van Rijnsoever et al. (2015) realised that most social acceptance studies conducted in the past were limited to particular technologies and excluded the effect of time. To address these concerns, the authors classified public acceptance into three forms: (i) socio-political acceptance, (ii) market acceptance, and (iii) community acceptance. They used two identical discrete choice experiments (DCEs) in 2010 and 2012, to assess the public's preferences for renewable energy equipment. They used nine prominent renewable technologies and classified the experiments into labelled and unlabelled conditions in both 2010 and 2012. It was observed that the respondents preferred labelled renewable energy technologies, which indicated that the labelling had a profound influence on preference. The public's energy preference was stable over time, suggesting limited temporal impact. Furthermore, they used latent class model (based on the respondents' characteristics and their extent of making similar choices) to investigate the impacts of heterogeneity. They established that preferences of technological attributes changed with the classes of the respondents and that the extent of the influence differed from one class to another. Therefore, the public's acceptance of technology is influenced by class or population sub-group.

Rosso-Cerón and Kafarov (2015) also investigated the impacts of three dimensions of social acceptance on the penetration of renewable power systems in the Columbian market. These authors identified the potential barriers to the public's acceptance of renewable energy technologies and evaluated the importance of each barrier, as shown in Table 2.5 below. Market acceptance was observed to be the most important barrier to the successful operationalisation of renewable energy technologies, with socio-political acceptance coming second and community acceptance last. The respondents indicated their awareness of the environmental benefits of renewable energy systems but seemed reluctant to adopt them (e.g. solar) due to the high initial capital cost. Despite the positive attitude towards renewable energy, the respondents showed a low degree of confidence because of the absence of supportive policies on the part of the government. The authors also observed financial institutions' lack of proper knowledge, the non-diffusion of information, and the lack of interaction among the interested parties.

Table 2.5: Dimensions and potential barriers to social acceptance (Rosso-Cerón and Kafarov, 2015).

Dimension	**Barriers**	**Ranking of the barriers by the respondents**
1.Socio-political acceptance	• Regulatory framework • Government standards	Very elevated barrier level: • Absence of governing legal framework • Lack of government standards
2. Market acceptance	• Unfavourable electricity prices • Elevated initial capital cost • Trade taxes • Fossil fuels subventions • Lack of access to credit and funding • Emerging markets	Very high level of barrier: • High initial investment cost • Non-access to credit • Financing trade tariffs
3.Community acceptance	• Cultural dismissal of transformations encompassing the use of renewable power systems • Non-acceptance by consumers	High level of barrier: • Cultural rejection • Non-acceptance

While the positive impact derived from the social perspective on renewable energy technologies can be enormous and may lead to acceptance and support of certain technologies in the long-run, the negative impact may reduce these potential benefits, or may even lead to the rejection of promising technologies (Sheikh et al., loc cit). The authors identified four main criteria and twenty-seven sub-criteria of the social perspective: (i) public perception (e.g. aesthetics, lifestyle, convenience to use), (ii) employment (e.g. job creation, availability of workforce), (iii) public health and safety (e.g. work safety, welfare of firmly), and (iv) infrastructure development (e.g. development of infrastructure, regional or local empowerment). It was observed that no single criterion or sub-criterion was to be disregarded during the evaluation of the impacts of the social approval of regenerative energy. The importance of incorporating comprehensive sets of criteria while conducting decision-making analyses and assessing the market potential of renewable energy technologies was confirmed.

Stigka et al. (2014) investigated the public's preferences and attitudes towards the acceptability of renewable energy, in the production of electricity, as a substitute for traditional fossil fuels – by means of the contingent valuation method (CVM). This method is a non-market assessment method that uses data provided by persons or households to calculate the pecuniary contribution people are prepared to give to reduce the environmental impact. The authors observed that well-educated consumers – those with good knowledge on renewable energy and its environmental benefits – paid for the development of regenerative energy technology. The challenges to the acceptance of renewable energy sources were identified as: (i) economic and institutional factors (e.g. high investment cost, lack of financial incentives, bureaucratic problems), (ii) technical and planning factors (e.g. local geography, planning problems), and (iii) public perception factors like absence of information and mistrust. The acceptance of completed projects by the public depends on economic (e.g. job opportunities, sharing of profits), environmental (e.g. visual impacts, noise pollution), and energy (e.g. reliability of energy supply, energy independence, reduced emissions) impacts. The social acceptance of new technologies can be achieved and accelerated through friendly policy, financial incentives, building trust, and better coordination among the stakeholders.

Likewise, Toft et al. (2014) investigated the social reception of the installation of smart grid equipment in private homes in Denmark, Norway, and Switzerland. The reduced control over the use of electricity and the violation of privacy were perceived as risks, whereas the reduction in electric bills and environmental impact were regarded as the benefits of adopting smart grids. However, monetary savings from smart grid technology are too small, compared to the societal (resource conservation) and environmental benefits. The authors analysed the acceptance of smart grid technology by applying the Norm Activation Model (NAM) to the TAM framework. Since the TAM evaluates perceived usefulness as well as ease-of-use and the NAM proposes individuals' moral obligation to accept the technology (Figure 2.17), the authors referred to the combined model as the Responsible TAM (RTAM). Their study confirmed that the ease and usefulness of technology as well as the individual and societal/environmental benefits are the key drivers of the acceptance of smart grid technologies.

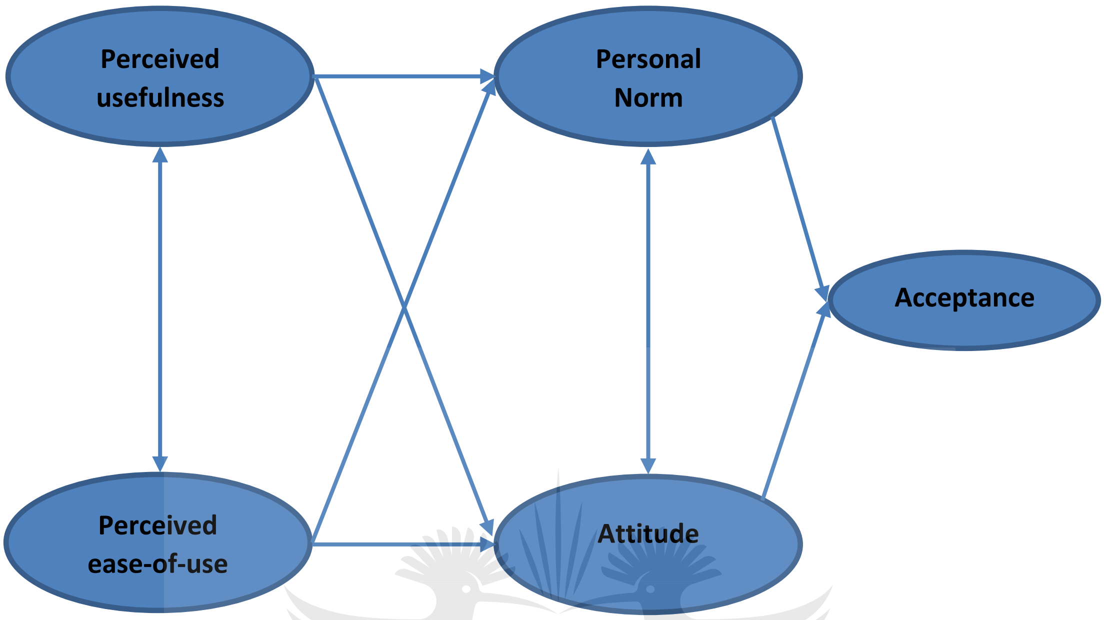

Figure 2.17: A responsible technology acceptance model (RTAM) (Toft et al., 2014).

A wider spatial distribution of renewable energy sources exist around the world; hence, the production and distribution of renewables should adapt to the geographical setup of the world (Fast, 2013). Therefore, geographical notions like place, scenery, space, distance, and territory are some of the essential elements of social acceptance that can help interpret the findings of public discussions on technology acceptance. However, previous discussions have been limited to the influence of geographies on the social acceptability of renewable energy technologies. The author studied 159 peer-reviewed articles regarding the public acceptance of renewable power and investigated the significance of geographical contribution. He found that geography critically addresses human environment relations and accounts for the spatial placement and organisation of renewable energy including various roles for persons and communities. He observed that geographical concepts helped interpret the behaviour of individuals or society towards the impacts of renewable energy technology. For instance, he noted protestors' attachment to specific spaces or places (e.g. sighting wind turbines in certain places can become more controversial). Moreover, he pointed out the visual impacts of renewable energy infrastructure on the landscape (e.g. influence of wind farm on the aesthetic or attractiveness of landscapes). Lastly, he highlighted the distance between individuals' homes and the renewable energy infrastructure (e.g. individuals whose homes are far from the renewable energy infrastructure tend to oppose it less).

2.7.3 Social Acceptance in Mining Industry

The social acceptance of mining projects mostly depends on the societal and ecological impacts of the quarrying operations on the community (Franks et al., 2010). Serious social or environmental harm to the community may result in financial and reputational losses that may lead to the closure of mining operations. The public's acceptance of mining projects is enhanced by appropriate technological innovation that improves efficiency and meets sustainability goals. An ill-fitting technology may cause significant harm to the society, personnel, and the environment – leading to rejection by the community. Technology assessment during technology development, however, can reduce the potential embedded-conflict and enhance the ecological and social performances of the technology thus enhancing the chances of its social approval.

The World Bank (2005) reported that environmental degradation and health hazards contributed to the majority of social conflicts in the mining sector in Peru. The main factors influencing the social acceptance of informal mining (i.e. artisanal and small-scale quarrying) sector were reported to be: (i) health hazard due to the mercury pollution of air and water, (ii) child labour, (iii) conflicts over land contracts, and (iv) lack of basic public services for miners and their families. The most common factors influencing the social acceptance of formal mining sector (i.e. medium and large-scale mining) were identified. The first is the non-fulfilment of expected employment and benefits. The second is the impacts of land acquisition and resettlement. The third is inadequate communication. The fourth is poorly enforced regulations. The fifth is weak negotiation and management capacity. The sixth and last is the negative environmental impacts on water resources, air quality, and public health. To mitigate social conflicts, these issues must be addressed properly among relevant stakeholders (e.g. local communities, industry, and government) from the onset of mining projects (i.e. from the consultation phase).

Wang et al. (2016) studied the literature to investigate the link between the sustainable development of mining projects and community engagement. These authors identified 17 factors affecting the community's perceptions of mining projects. They grouped these perceptions into five categories: (i) environmental, (ii) economic, (iii) social, (iv)governance, and (v) demographic. Increased job opportunities and income, as well as improved infrastructure were perceived as positive (+) impacts. Conversely, the following were identified as negative (-) impacts: increased pollution (air, land, and noise), high housing costs, traffic and crime, as well as reduced labour market. The framework of these impacts is illustrated in Figure 2.17 below. In addition to these impacts, mining projects were also perceived to cause population increases and to have negative cultural impacts. Mine buffer, mine life, governance, and local demographics were also observed to influence individuals' perception of mining projects. As a result of these factors and based on the discrete choice theory, the authors proposed a cost-effective and timesaving two-stage community engagement approach that can easily improve the acceptability of emerging technology.

A successful acceptance of mining projects by local communities depends on a good, stable operating environment (Que et al., 2015). Effective community engagement is key to increasing the social acceptance of emerging technology, which can be enhanced through discrete choice models. The authors used discrete choice experiments to investigate the factors influencing individuals' acceptance of mining projects in the United States of America (USA). They identified and grouped mining projects' characteristics and demographic factors into possible determinants of social acceptance. The identified mining project characteristics included 17 determinants that were classified into four categories (social, economic, environmental, and governance and others), whereas demographics comprised 6 factors (same as in Figure 2.17). The researchers observed that all mining project characteristics, including the four demographic variables (age, gender, income and level of education), key forecasters of the individual's acceptance or rejection of mining projects. Thus, it was recommended that all these determinants, including the discrete choice experiments, be incorporated in the mining sector's community engagement documents. The most important predictors of social acceptance for any mining project were identified as job opportunities, clean water availability, as well as air and land pollution.

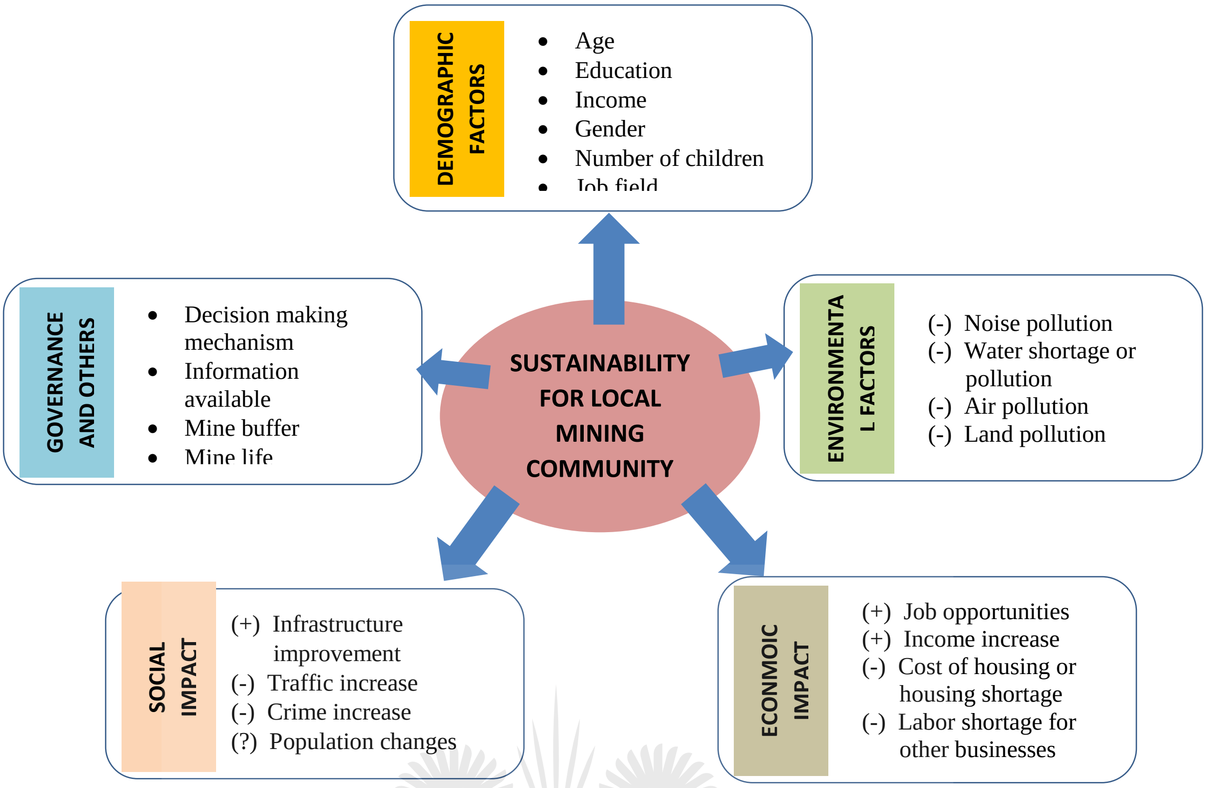

Figure 2.18: Factors for effective community engagement (Wang et al., 2016).

The diffusion of information over a social network changes the public's perception of a mining operation and its overall impact on the community (Boateng and Awuah-Offei, 2017). Demographics, engineering design choices, and environmental attributes of a mine change over time; hence, the diffusion of new information changes the public's perception of a mine's impacts, which influences the acceptance levels of mining projects. The authors developed a framework – using the agent-based modelling (ABM) – to study the impact of information dissemination on social approval as applied to mining projects. The ABM consists of a system of agents and their interactive relationships. The authors implemented the discrete choice model using Mat lab and tested the model using demographic (e.g. age, gender, education) and non-demographic (e.g. job opportunities, income increase, noise pollution) data sets from Salt Lake City, Utah, USA. It was observed that the acceptance of mining is highly influenced by variations in individuals' view of air pollution, whereas no significant influence was found for demographic factors. They also established that civic engagement and other involvements define the rate of information diffusion in the community and its effect on social acceptance.

Managers of mining companies like to predict and act proactively to address the conflicts that arise in mining operations, using various scientific tools applicable to the cultural realities of a mining framework (Nakagawa et al., 2013). This requires a comprehensive understanding of the mining ecosystem, including all relevant stakeholders – notably the communities – and the environment. The authors developed a framework for scientific modelling and then used the ABM approach to evaluate existing case studies to establish stakeholders' behaviour towards conflicts in the mining community. It was found that the local community will not always reach a consensus and that community members change their attitudes (acceptance or rejection) over time. The model can predict the relative number of times and steps required before the community can reach a consensus.

Mining companies need to establish a good rapport with local communities to secure the issuance and maintenance of their licence to do business in Australian mining industries (Bice, 2014; Moffat and Zhang, 2014). This social licence to operate (SLO) ensures acceptance and approval by local stakeholders of a mining development in the region – without any costly conflicts and business risks. Australian mining companies confirmed their awareness of the necessity of the SLO for successful mining operations and included environmental impacts, social and community issues, as well as employment practices in their sustainability reports, as a means of communication with local stakeholders (Bice, 2014). The state of a SLO is closely linked to stakeholders' behaviour and the issuance of the SLO depends on the conduct (i.e. trust, credibility, and legitimacy) of the project/company and associated technological, social, and environmental impacts (Franks et al., 2010). According to Moffat and Zhang (2014), the social acceptance of a mining development was dependent on: (i) building trust with the local community, (ii) impacts on social infrastructure (local employment, training and development), (iii) high-quality engagement of the local community (sufficient interactions and contracts), and (iv) procedural fairness (community involvement in decision-making processes). While the negative impact of mining development on social infrastructure (e.g. impacts on housing availability/affordability) was found to diminish public trust, the positive contract quantity and procedural fairness resulted in establishing trust in a mining company.

The development of mining projects in dynamic environments is often determined by the factors leading to the granting/declining of a SLO (Prno, 2013). The author reviewed case studies (from mines in the USA, Canada, Peru, and Papua New Guinea) to investigate the outcomes of SLO determinants in the mining industry. The framework included three types of variables: (i) system characteristics (including socio-ecological context, change, uncertainty, feedback and so forth), (ii) local variables (such as the relationship between the local community and the mining fraternity), and (iii) multi-scale factors (including regional, national and international, governance, socio-economic, and biophysical conditions). Water-related issues caused a major public concern while trying to revive the mining industry in Finland (Wessman et al., 2014). The poor management of water during a mine's planning phase (i.e. the initial phase of a mine's lifecycle, see Figure 2.18) attests to the ineffective ecological, cultural, and economic relationships between the mining company and local stakeholders. An improvement in local trust and practices resulted in reduced social disputes at the Kittilä and Pampalo mines in Northern Finland, whereas a failed management of environmental issues (water discharge containing sulphate, sodium, and manganese) and inadequate communication with locals led to social conflict at the Talvivaara mine. The mining industry in Finland is required to perform a social impact assessment (SIA) to gain and maintain a SLO. A SIA evaluates environmental impacts and improves the general-public's access to data and participation in decision-making processes. SIA encompasses Finland's Environmental Impact Assessment Act (EIA). However, limited harmonisation has been observed in practice.

Figure 2.19: Life-cycle analysis of a typical mine (Wessman et al., 2014).

Wessman et al. (2014) reviewed the sustainability issues of water management and social acceptance in the Finnish mining sector. It was observed that efficient water management (e.g. reduced water use, use of lower quality water, recycling and reusing of water, desalination of mine water) could increase the social acceptance and improve the SLO of mining. The use of efficient and effective social communication processes (such as face-to-face dialogue, partnership, and conflict resolutions at the local level) could improve social sustainability and enable mining industries to obtain and maintain their SLO. The authors recommended a dynamic water management system to tackle water fluctuations and value-chain-based ecological apparatuses to address water usage and its environmental effects on mining. It is hoped that this would increase the general-public's trust and acceptance.

2.8 Mining Legislation, Health and Safety, and the Environment

This section discusses the details pertaining to mining legislation, health and safety as well as the environment.

2.8.1 Mining Legislation

The South African mining law is regulated by a government agency (MPRDA Act 28 of 2002; MPRDA, 2002). These legislations deal with the acquisition or right to conduct reconnaissance, prospecting, and mining. The custodian of these laws is the Department of Mineral Resources whose head office is in Pretoria – the administrative and political capital of South Africa. This department has branches all over the country. The abovementioned laws cover such issues as royalties, title registration, as well as health and safety in the mines. The procedure that governs prospecting in South Africa is the same for all minerals, including sandstone. The only difference relates to petroleum exploration, which requires a slightly varied set of rules.

The ownership of mines by indigenous persons or entities requires that at least twenty-six percent (26%) of the attributable units of production in any prospecting or mining project in South Africa be held by previously disadvantaged South Africans (Harmann, 2004). In the case of surface usage, the native title allows for reconnaissance and exploration or mining operations. The holder of such land would normally have to negotiate for compensation in case of damage or loss. The only exception is that the minister may impose certain conditions that can promote the rights and interest of the community (MPRDA Act 28 of 2002). The owner of a prospecting right is required to allocate sufficient funds to the rehabilitation of the mine after its closure. The Department of Mineral Resources (DMR) normally accesses and verifies these funds annually. Usually, the Department holds a bank guarantee or a trust-deed, in case of an unexpected or premature mine closure. The closure of mines or the rehabilitation of any former mine sites is handled by a separate legislation which conforms to the international expectations and is closely linked to global best practices (Alberts et al, 2017). This author suggested that governments' create a complicated interconnection based on sound provisions and expectations, when dealing with mine closures.

The amendment of the South African legislation by the DMR in December 2014 attempted to untangle the networks of complexities mentioned by Alberts. Nevertheless, governance-capacity constraints remains. This has made it very difficult to implement South African legislative frameworks regarding mine closures smoothly (Morrison-Saunders et al., 2016). Governance is a major issue in sandstone mining. One fact to remember is the constant uncertainty in sandstone pricing due to volatility. Hence, various mining companies and communities involved in artisanal mining are always vulnerable to unexpected or unplanned mine closures. The South Africa government has therefore sought to incorporate a mine-closure mitigation plan right at the beginning, during the business feasibility study. As a result, financial commitments are made by companies – in the form of reserves that also demonstrate that these companies have adequate funds to meet their obligation during both the operation and closure of the mines (McHenry et al., 2015; Morrison-Saunders et al, 2016).

In 2012, the African Union Commission (AUC) attempted to set sound positive goals regarding mining sustainability (Campbell et al., 2012). A very small advancement has been made, according to its report that included the following goals:

- The creation of a balanced mining-sector information and knowledge centre aimed at being the engine of growth and international competitiveness.
- The creation of sustainable and well-governed mines with inclusive and much-appreciated objectives endorsed by stakeholders – including all the surrounding communities.
- The establishment of a commission that will ensure the creation of an attractive mining sector that will be able to increase investment levels and cash flows into the mining community, which should result in increased infrastructure projects aimed at supporting the broad social-economic development.

2.8.2 Health and Safety

Sandstone exists in nature – with no health hazard; however, in some human processes, sandstone has been associated with dust production from the breaking of rocks. Other hazards related to sandstone activities may be accidents associated with an artisanal sandstone miner's working conditions (tools used), unregulated working hours, weather conditions, and so on. Although we proposed the use of new technologies in the mining of sandstone, precautionary measures must still be taken to protect the miners from the microwave X-rays emitted during the heating of the sandstone that result to differential expansion.

2.8.2.1 Sandstone Dust Hazards and Toxicology

The sandstone aggregate is used in the manufacturing of cement, mortar, concrete, bricks, paving materials, and other construction materials (Hanson, 2012). Massive mechanical breakdowns result in dust production during the processing of the raw stones through the crushing caused by the friction between rocks. In this case, the risk of exposure of the human body to dust particles penetration and deposition is higher, unless miners are protected. Possible dust hazards related to sandstone production include carcinogenicity, skin irritation, and eye irritation or damage. A prolonged or recurrent inhalation of dust containing respirable crystalline silica can result in lung cancer. Sandstone mining may lead to organ damage and there is always a substantial expectation of acute toxic effects during sandstone extraction (Fotolia, 2017). A sandstone miner may be exposed to toxicological effects such as corrosion or irritation of the skin y dust, which is likely to cause irritation through mechanical abrasion, although this is not a predictable skin hazard. Direct contact between dust and eyes may temporarily irritate the latter in the course of mechanical abrasion. A continual dust-inhalation of quartz can lead to silicosis, that is, a fibrosis or damaging of the lungs. Silicosis might likely lead to pulmonary tuberculosis (Colinet, 2010).

2.8.2.2 Dust as an Occupational Hazard

A more in-depth understanding of dust particles deposition and penetration in the human respiratory tract may be represented as in the diagram below.

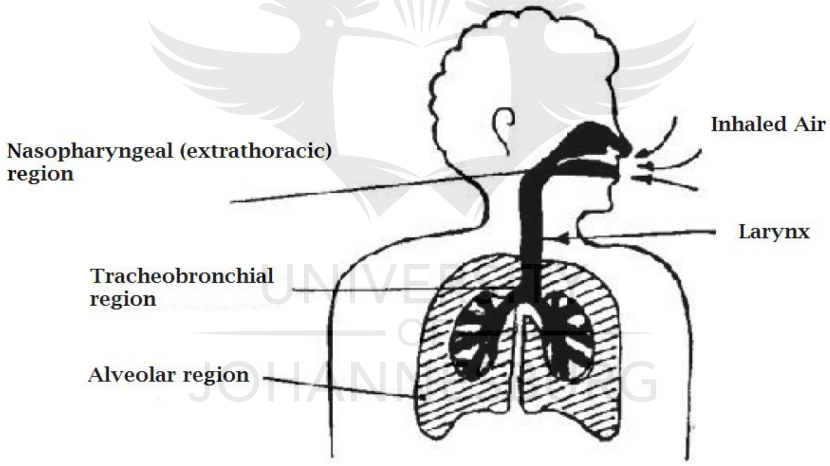

Figure 2.20: Human respiratory tract (Pfister, 2004).

Tiny particles of 0.5µm in size have a high probability of being inhaled through the nostrils or being ingested. Miners working in a more dust-producing environment have a significant exposure to dust particles, which – with time – may result in deposition. We identify five deposition mechanisms, namely, diffusion with tiny microscopic dimensions, sedimentation, impaction, and inertial impaction. It must be noted that the largest particles that humans can inhale are those with a diameter bigger than around 30µm. These particles are deposited mainly in the airways of the human body, the nares, and the lips (Pfister, 2004).

A number of scholars report that repeatedly breathing crystalline silica may cause adverse health effects such as kidney and lung cancer (Naspierka et al., 2010). Dust respiratory sensitisation results to coughing, short breath, and discomfort in the chest. Sandstone emission is mainly dust that is not expected to be harmful to aquatic organisms. However, it should be avoided as discharges of such dust and fines in the waters might increase the levels of total suspended particulate (TSP), which would be harmful to some aquatic organisms (Thompson et al., 2016). Dust from quartz has no proven harmful effect during extraction; however, many disturbances in human life are observed when a concentration of dust is suspended in air. This causes air pollution that impairs sight, unclean air-breathing that induces respiratory diseases, as well as the blocking of water pours in the soil (Tripple green, n.d.).

2.8.2.3 Preventing and Controlling the Risks of Airborne Dust in the Working Environment

The control of dust risks and attacks can be achieved through certain known ways. It must be noted that there are two types of particle taken into the human body. The first type of dust is soluble dust-particles that may dissolve if deposited anywhere in a person's respiratory tract. The second type is insoluble dust-particles that may be contained in certain ways (Gizurarson, 2015):

- *The mucociliary clearance*: The terminal bronchioles, the cilia, have a synchronised motion that can cause an upward continuous movement of mucus layers, naturally. Consequently, insoluble particles can move upward less than 10 mm per minute and can be spat out or swallowed to clear the respiratory system. However, the degree of clearance of insoluble dust can be seriously impaired if exposed to cigarette smoke.
- *The Bronchiole movement*: This clearance of the intermittent movement of the peristaltic of bronchioles results in discomfort coughing and then sneezing. This may impel particles in the mucus towards the larynx and out of the respiratory system.

2.8.2.4 Workers' Risk of Sun Exposure

In 2014, the USA Occupational Safety and Health Institute (CAL/OSHA Consultation Services) published a report on the protection of workers from sun spectrum exposure – notably from the invisible UV rays – and enabled researchers to understand that this damages the connective tissues that are susceptible to enhance the risk of developing skin cancer. Sandstone miners in QwaQwa normally extract dimensioned stones for the whole day; yet, the effects of sun exposure is generally ignored. Exposure for a period of approximately 4 hours or more can cause blisters, fever, headache, unsettled stomach, exhaustion, as well as tender and swollen legs. Sun exposure also has an effect on eyes in that it may lead to serious sunburns that result in the affected miners turning red, feeling gritty, and experiencing great pain. Prolonged exposure of eyes to the sun can cause a permanent damage that may result to blindness. As precaution, workers should use a sunscreen with a minimum of SPF 15 (CAL/OSHA Consultation Services, 2014).

2.8.2.5 Health Risk of the Manual Lifting of Heavy Stones by Miners

A continual exposure or frequent lifting of heavy-weight materials (dimensioned stones in this case) may lead to fatigue, discomfort, and injuries of different kinds to active parts of the body such as the back, hands, shoulders, and wrists. These injuries may include damages to muscles, ligaments, blood vessels, nerves, and tendons. These kind of injuries are call musculoskeletal disorders also known as MSDs (CAL/OSHA Consultation Services, 2014).

Researches on epidemiology established that the risk of injuries increases when lifting heavy loads, especially while twisting or flexing, or holding these loads away from the body. Researches in biomechanics concur with these epidemiological findings as they indicate that the strains in the spine increases under the abovementioned conditions. In this regard, intervention studies found that the use of lifting hoists, the splitting of these loads, and the use of other engineering interventions can help reduce injuries among workers (Choi et al, 2017). To prevent health injuries, ways of mechanising heavy weight duties should be identified so that the human potential be used for activities requiring less muscle intervention. Workers' abilities to perform tasks should be considered in conjunction with such factors as physical conditions, gender, age, stature, strength, and other elements involved in the interaction between a worker and the working environment.

Workers carrying heavy stones or loads at a stone quarry can experience health problems caused by heavy work. Such health problems engender severe pain in the vertebral column to the extent of rendering these miners unable to work. A risk of back injury may increase if the load is as follows (European Agency for Safety and Health at Work, 2017):

- Too heavy: weight limit should be kept minimal for safety — Normally a 20 – 25 kg weight is believed to be heavy for most people;
- Too large: loads which are too large may not be managed well as the lifting process cannot be brought close to the body; thus, the muscles will become very tired very rapidly; and
- Unbalanced or unstable loading: uneven loading causes muscle fatigue, since the centre of gravity would be away from the worker's body.

2.8.2.6 Ergonomic Interventions against Health Hazards of Mining Sandstone

In general, ergonomic interventions can improve the fit and ability of a worker to cope with mining tasks. Many techniques and considerations exist that would help to this end. Ergonomic interventions are grouped in two types:

- Engineering improvements
- Administrative improvements

Engineering improvements involve modifying or rearranging tools, redesigning and providing or replacing engineering gadgets. Engineering improvements enhance workstations, processes, packaging, assembly parts, and products or materials. Conversely, administrative improvements focuse on how workers as individuals perform the same tasks and get ideas on the way of organising work practices to improve the work experience. The following are possible improvements in this regard:

- Substitute any heavy jobs with light ones.
- Eliminate or reduce duplication by providing various jobs to individuals (avoid utilising the same muscle set).
- Adjustment of work schedules, work practices, and work pace.
- Provide recovery time (slight breaks for rest).
- Rotate workers in jobs that involve using different postures, body parts, or muscles.

2.8.2.7 Health Risk from Workers' Lack of Skills and related Factors

Workers' lack of skills is often a source of health risk for them. Some individual factors associated with these risks and injuries can relate to the following findings reported by the European Agency for Safety and Health at Work (2017):

- Inexperienced workers, not properly trained and unfamiliar with the job;
- Back injuries normally increase with age and are directly proportional to the number of years at work;
- Physical built of the worker e.g. weight, height and strength; and
- Past health history.

2.8.2.8 Workers' Health Risk from Extensive and Long Working Hours

Studies have shown that long working hours and extended work schedules involving overtime adversely impact on the health of workers. This increases the possibility of the following conditions: hypertension, circulatory disease, exhaustion, stress, melancholy, musculoskeletal disorders, protracted infections, diabetes, and common health complaints (Dembe, 2005). Although new inconsistent views regarding long working hours have emerged, methodical analyses have determined that extended working hours are detrimental to workers' wellbeing.

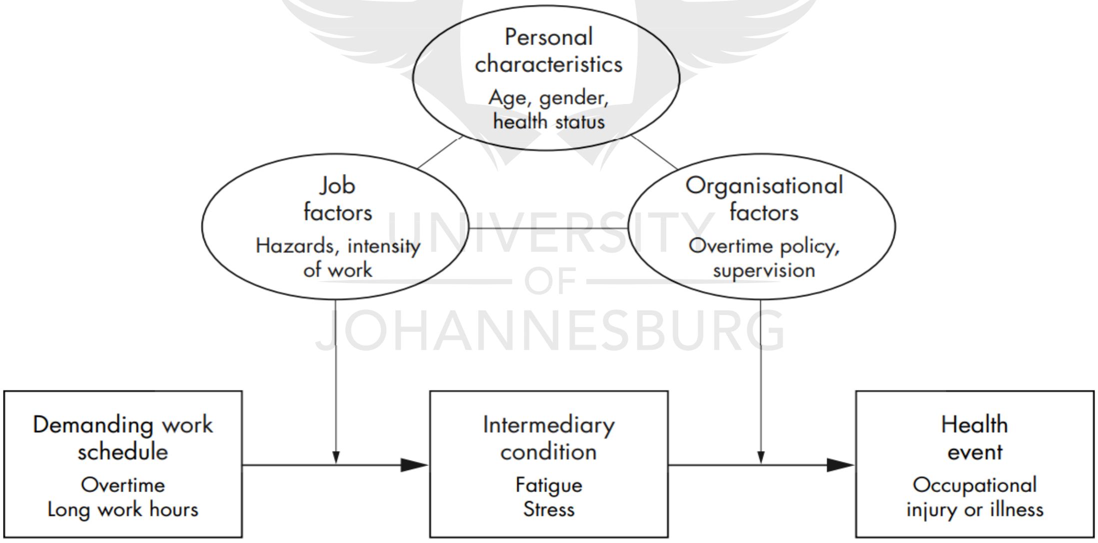

Figure 2.21: Relationship between work schedules and occupational health risks.

Table 2.6: Sandstone processing occupational health risks (ETI, 2015).

HAZARD TYPE	HAZARD FACTORS	DESCRIPTION	RISKS
Physical hazards	Silica dust	Repeated exposure to silica dust generated by production processes	Respiratory diseases, including silicosis

	Noise	Noise and vibration caused by machines used for calibrating, sawing, cutting, shaping, blasting and tumbling stone.	Hearing damage or loss, hand/arm vibration syndrome
Accident hazards	Dangerous tools	Risk of injury due to manual or mechanical cutting, sawing and shaping	Cuts or other injuries
	Chemicals and solvents	Exposure to chemicals during the polishing process	Skin inflammation, eye injury, chemical poisoning from inhalation or ingestion
	Heavy loads	Carrying heavy loads when handling, packing, loading and transporting blocks of stone	Long-term health issues related to over-exertion and muscle strain, as well as skeletal disorders
	Falling objects	Risk of stone slabs or blocks falling on workers during handling and transportation	Physical injury
	Stone debris	Exposure to stone debris and ricochets propelled by mechanical processes such as calibrating, cutting, sawing, shaping, blasting, polishing and tumbling	Eye injury
	Wet or uneven Surfaces	Exposure to stone debris and ricochets propelled by mechanical processes such as calibrating, cutting, sawing, shaping, blasting, polishing and tumbling	Fall-related injury

2.8.2.9 Environmental Sustainability and Impact of Mining Dimensioned Stone

QwaQwa community members have happily allowed dimensioned sandstone to be mined from their area, although their preference would have been to achieve this mining process sustainably. The mining of sandstone in QwaQwa has economic, environmental, labor, political, and social repercussions on the local community and globally. It is considered a threat to the natural surroundings by some community members. This sentiment is echoed by Vintro et al (2014) who highlight the seriousness effect that mining has on the environment. These researchers cited such examples as chronic soil erosion and dust filling up the water pours in the soil. A study by Moran (2014) on environmental sustainability also revealed the urgency to adhere to environmental requirements. Moran noted that the supply of minerals is closely related to social and ecological impacts and results in generational and intergenerational equity. The authors examined economic, ecological, ethical, and technological dimensions of an integrated framework for the management of sustainability in mining. Detsele (2010) noted that the mining industry is steadily embracing the sustainable development concept in managing the constant depletion of natural resources and the environmental degradation that has now become so crucial.

Recent studies have revealed that the mining sector is attempting very hard to minimise the adverse effects of mining on the ecology; nevertheless, its positive impact on durable development is yet to be established (Ribeiro-Duthie et al., 2017). Hentschel et al. (2003) contend that the mining sector is essentially unstainable due to reports of the worsening health and safety issues that are coupled with extremely high environmental costs. This may, in part, be because environment degradation is related to the level of welfare of a community (Ditsele, 2010). According to Dreschler (2017), artisanal miners stress economic development than ecological sustainability. For instance, he observed that artisanal and small-scale miners hardly partake in land restoration programmes. In addition, Buxton (2013) reported that most governments established mining companies and NGOs that often focus on the bad issues associated with artisanal mining and therefore choose not to interact with this sector, although they know that artisanal mining has the potential to add value to the community through sustainable development. This lack of assistance and cooperation has left the experienced challenges unaddressed, preventing artisanal miners from engaging in sustainable development. Thus, the artisanal mining sector has remained neglected and underfunded by governments globally.

2.8.2.10 Environmental Impact of Sandstone Mining

Artisanal sandstone mining contributes significantly to the financial and collective upliftment of society. The QwaQwa community is not exceptional in that dimensioned stone is also the main livelihood of some other impoverished communities (Burton, 2013). Generally, the impact of dimensioned stone mining on the environment is somewhat low, compared to the other minerals. This is because most of the sandstone mining activities are curried out manually – using human power.

The common impact of dimensioned stone mining is the transformation of a large section of the landscape. In other words, the landscape is modified, due to mining disturbances. Indeed, large stone blocks are extracted and left in the open, visible to the public (Langer, 2002). The extent of these land disturbances is usually noticeable for a long time. Spectators observe the change as it unfolds. In addition, land disturbance has an enormous impact on the vegetation and causes both ground and surface water pollution (Ditsele, 2010).

Dust and noise are inherent to mining. Previous sections discussed the impact of dust in detail. Noise, in dimensioned stone mining, is mainly produced by vehicles and trucks used for transportation. The noise level created by the movements of these vessels has negative effects on the surrounding community. The effect of high noise level on individuals can be both physical and psychological. Mining activities contribute to climate change as they usually involve the use of fossil energies associated with the emission of greenhouse gases that constitute the primary source of worldwide warming and climate alteration. In dimensioned-stone mining, fossil fuel is mainly used in the transportation of stone blocks. Ruttinger and Vigya (2016) noted that the intense use of fossil fuel in mining would result in mining becoming the major contributor to greenhouse-gas emissions. Dimensioned-stone mining also disturbs the vegetation, as mentioned earlier. In large forest areas, the removal of trees causes a critical in-balance in the absorption of the carbon dioxide emitted by human activities.

2.9 Artisanal Mining in Africa and Other Regions of the World

ASM is generally characterised as informal mining where miners use basic traditional tools to mine minerals. Nonetheless, the description of ASM changes from country to country (Phiri, 2012). This is mainly because of numerous variables that are distinct to specific countries or regions. These variables include, among others, mine minerals output, labour productivity, investment costs, amount of utilised resources, sales, and the levels of technological sophistication – as defined by the mining operation itself. In South Africa, ASM was first officially assessed by the government in 1994. The latter then opened doors to the historically-disadvantaged South Africans (HDSAs) by making participation in the mining sector an opportunity for economic empowerment. In addition, the South African government – through the Department of Mineral Resources (DMR) – elaborated a legal framework to promote ASM. The DMR also established the Directorate of Small-Scale Mining Programme (DSSMP). The latter offered aspiring small-scale miners all the necessary help (DMR, 2017), namely:

- Setting themselves up as a legal entities;
- Assistance with the process of identifying mineral deposits by conducting feasibility studies;
- Environmental impact assessment (EIA) and the management thereof;
- Legal advisory and preparation of professional contractual arrangements, mineral rights and so on;
- Analysis and estimation of reserve for the selected deposits;
- Market assessment; and
- The development or purchase of mining equipment(s).

Included in the DSSMP was the National Small-Scale Mining Development Framework (NSSMDF) established in 1999 (Solomons, 2016). This seems to be assisting artisanal miners very well, as reports received from most stakeholders tend to indicate that the NSSMDF has provided several small-scale miners with resources and funds to establish and sustain their operations. This establishment availed up to about R15.1 million (approximately $1.2 million) for the development of small-scale quarrying operations.

Research conducted by Dreschler (2017) estimates that over 30 different minerals are being mined by ASM operations throughout the Southern African Development Community (SADC) region. Most developing countries view artisanal mining activities as an economic opportunity for poverty alleviation; hence, most artisanal miners have concentrated on the exploitation of gold, diamond, and emerald, and not dimensioned stones. ASM, according to Seccatore (2017), is generally a mining operation conducted by individuals, groups, or communities – often informally – in developing nations. Seccatore further explained that this form of mining is conducted on the surface – using un-mechanised tools such as hammers, chisels, crowbars and so forth. ASM operations are becoming increasingly popular with many impoverished communities resorting to small-scale mining for survival, because of a lack of financial opportunities. A study by Ledwaba (2016) revealed that participation in ASM is likely to increase over the years, given the socioeconomic realities of many developing African countries. The latter suffer from severe poverty and high unemployment levels, along with growing inequalities. Many rural communities have identified ASM as an alternative means to provide for their families. Although ASM activities seem as a solution to rural poverty, this is not always true. Indeed, in some cases, serious problems arise and result in increased poverty and unwarranted diseases in the community. This is because ASM is characterised by a range of complex, mainly unlawful and unstructured undertakings in penurious, secluded, rural, unpoliced locations. This observation is strongly supported by Nhlengetwa et al (2015) who sounded a strong warning to ASM operatives about these dangers, before concluding that ASM generally provides livelihoods and income for many rural communities affected by poverty. A study conducted recently by the World Bank (2017) has estimated artisanal miners to about 100 million in over 70 developing countries. These are found in Africa, Latin America, and the Asia-Pacific regions that are actively involved in ASM operations.

2.9.1 The Challenges and Prospects of Artisanal Mining

The ASM sector is growing gradually in terms of the number of artisanal miners. However, some challenges are hindering its progress, notably the acquisition of mining rights and land tenancy. Most miners' lack of financial prospects means that they do not have access to mineral markets. Moreover, they do not comply with health, safety and environmental rules and are technological unskilled (Ledwaba, 2016). Artisanal mining in South Africa has experienced various government interventions, such as the establishment of the Small-Scale Mining Directorate in 2004 (Hinton, 2016). Figure 2.22 below shows the graphical road map of ASM in South Africa – with key indicators and the time span.

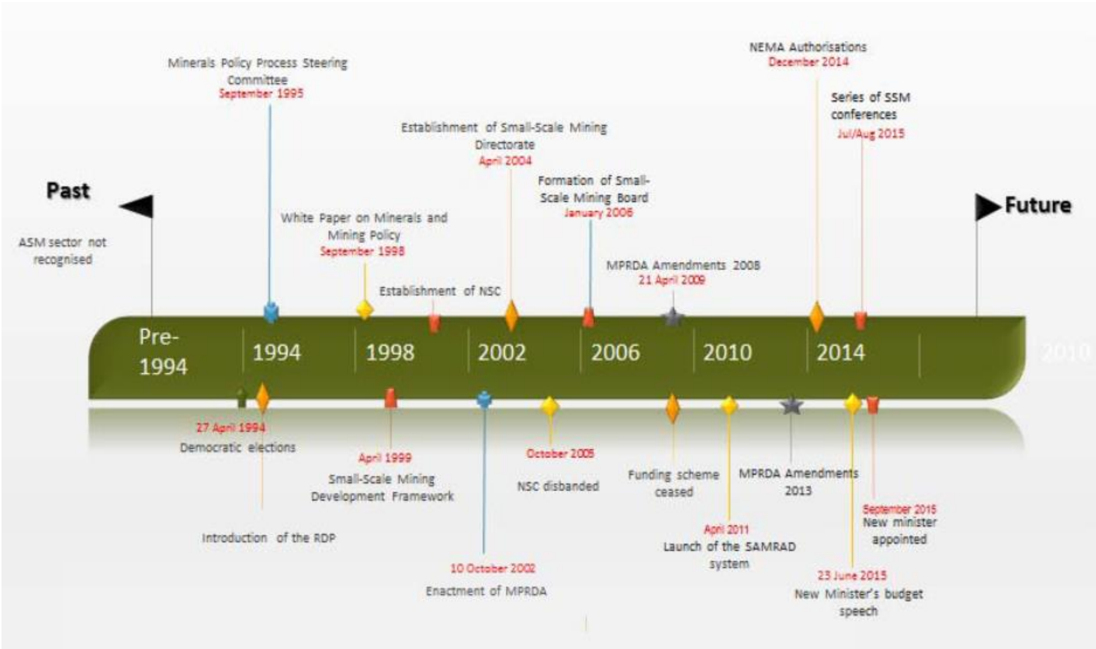

Figure 2.22: Roadmap of ASM in South Africa (Ledwaba, 2016).

As shown in Figure 2.22 above, prior to 1994, ASM activities were not given serious attention by the South African government. As such, potential miners were not supported technically or given any financial support. However, post-1994, the government introduced such programmes as the Black Economic Empowerment (BEE) and the Reconstruction and Development Programme (RDP) aimed at redressing historical imbalances. The change of government in 1994 enabled more previously disadvantaged ethic groups to enter and participate in the ASM sector. This is when most of the current sandstone miners started their operations. Nonetheless, this increased participation did not led to any significant development of the sector. Many operators are still struggling with such challenges as lack of access to markets as well as technical and financial support; thereby losing the value of their mining activity in the process (Mkubukeli, 2016). This argument was also echoed by Hauschka (2003) who states that, irrespective of the benefits and socio-economic prospects brought by ASM, most artisanal miners remain poor – with many more (especially in Africa) still living below the poverty line, due to operational deficiency and the lack of support to access the markets. Clearly, the success of ASM is highly dependent on such aspects as skills development, access to appropriate technology, fair markets, and structural support, which can be achieved through the establishment and implementation of sound policy interventions (Debrah, et al., 2014).

In recent years, significant research has examined the negative aspects of the ASM sector and analysed how these characteristics affect the life standard of the miners and surrounding communities. Some scholars have highlighted serious hazards that affect both the miners and the environment (Smith et al., 2017). The bulk of literature highlights challenges that include, *inter alia*, elevated levels of pollution, land degradation, chemical contamination, lack of safety processes and procedures in the mines, as well as diseases emanating from ASM activities. According to Dzobo (2015), the health, safety and environmental challenges facing the ASM sector are likely to continue, if governments and all key role-players fail to provide support in terms of finance and technological interventions for the development of this sector. The current position of limited contribution to sustainable rural development is deplorable but it does provide immediate poverty-relief and daily sustenance to many who directly or indirectly participate in rural development activities. In addition, literature has shown that the supporters of socio-economic benefits believe that ASM, if well established and maintained, can yield positive socio-economic benefits for local communities (Ledwaba, 2016). The plea to improve the negative characteristics of ASM is shared by many scholars who stress that it is essential for efforts to be made to maximise the profits associated with ASM and to prevent or minimise the potential adverse impacts. Figure 2.23 below presents a graphical description of the socio-economic benefits that are likely to derive from ASM activities.

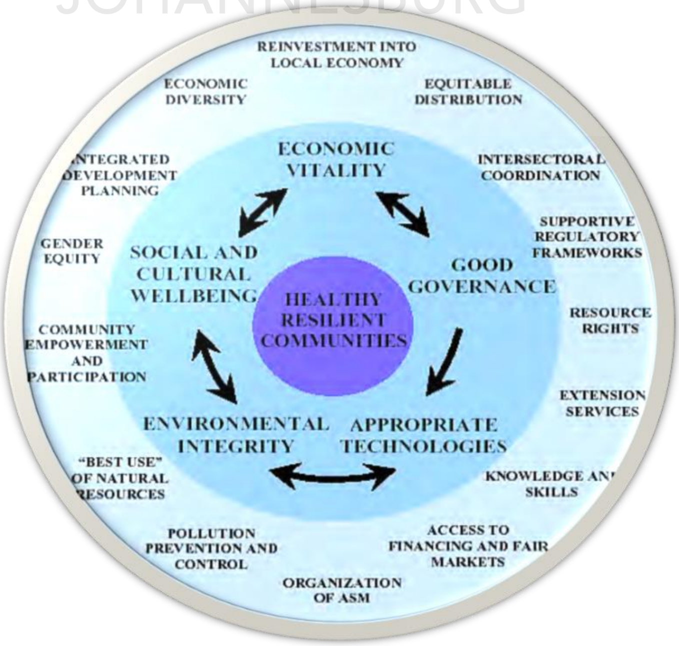

Figure 2.23: ASM as a catalyst for development (Hinton, 2016).

As highlighted in Figure 2.23 above, the development and sustainability of the ASM sector depends on specific interdisciplinary aspects that are expected to work collaboratively to make the sector viable. These aspects include, among others, economic strength, sound decision-making and good governance structures, the application or development of relevant technology interventions, acceptable environmental management system(s) to mitigate current environmental hazards, and good socio-economic welfare. Research on the socio-economic benefits of the ASM sector has not been exploited fully; because many governments are reluctant to acknowledge the value of this sector. The lack of government commitment, absence of regulation, inadequate support, and the use of basic equipment contribute to ecological pollution, occupational health and security issues and, in many instances, appalling socio-economic circumstances (Veiga et al., 2009).

2.9.2 The Different Types of Sandstone Located in QwaQwa

This section will not be complete without discussing the composition and the different types of sandstone mined in QwaQwa. The proposed decision model – if adopted – will ensure the efficient mining of the different types of sandstone located at the Drakensburg Mountains in QwaQwa, Free State Province.

Sandstones are sedimentary rocks comprised of lithified sand with a high presence of quartz and feldspar sand. These stone materials are held permanently by such cementing materials as calcite, clay iron oxides, and silica (Shrivastava et al., 2017). In other word, these stones consist of sand-size grains that are cemented or matrixed as a bonding constituent. The lithification process leads to a solid, condensed material. The final product is the colour of its constituents. The predominant colours are bronze, yellowish, or dark red. The major categories of sandstone are described based on their specific properties such as feldspar, quartz, and clastic materials (Farrokhrouz and Asef, 2017). Various sandstones exist; each with a varying amount of quartz. These stones have broad applications in geotechnical engineering and construction management.

In QwaQwa, a laboratory study conducted on six samples of its local sandstone by Mubiayi(2014) revealed that the sandstone in this area was predominantly composed of quartz materials with colours ranging from yellowish, reddish, greenish, blackish, whitish to greyish – mainly because of the presence of chemical and mineral elements. The latter include aluminium, calcium, iron, potassium, magnesium, manganese, sodium, phosphorus silicon, and titanium. The water absorption percentage was also tested and showed the following absorption percentages: 5.9, 6.0, 6.6, 5.8, 6.4, and 2.7, for the six samples. Mubiayi also studied the uniaxial compressive strength of the QwaQwa sandstone and determined a variation from 8.28 MPa for the whitish sandstone to 56.74 MP for the greyish sandstone – with a grain structure observed using an optimal microscope. The structure varied from course, course-fine, medium, to fine grains. The most important aspect in Mubiayi's study is the dielectric properties of the sandstone in QwaQwa. These properties related directly to how sandstone is likely to absorb microwave heat and retain the heat generated undissipated. This heat is precisely what causes the differential expansion in the sandstone, resulting in the cracking. The results revealed that the dielectric constant and the loss factors of sandstone found in QwaQwa ranged from 2.45 – 3.19 (greenish), 2.39 – 2.51 (reddish), 2.20 – 2.51 (yellowish), 1.80 – 2.51 (greyish), 2.39 – 2.98 (blackish), and 2.56 – 2.87 (whitish). Conversely, the dielectric loss factor revealed the following ranges: 0.14 – 0.52 (greenish), 0.01 – 1.01 (reddish), 0.01 – 0.19 (yellowish), 0.01 – 0.18 (greyish), 0.07 – 0.37 (blackish), and 0.001 – 0.137 (whitish).

2.10 Financial Viability of Solar-Energy-Activated Microwave Artisanal Mining

Artisanal mining is a subsistence activity that is purely manual and involves individuals or families. It is an income-generating activity for many poor rural people who have fewer employment alternatives. However, these miners are not guaranteed sustained income or social security, due to the informal and unpredictable nature of their job (Ahmad, 2015). Since artisanal mining depends on manual labour and hand tools, the recovery of valuable minerals is low; hence, the productivity is equally low. This results in low revenue and unsustainable mining (D'Souza, 2002). The use of rudimentary tools does not enable artisanal miners to meet the increasing demand of valuable minerals, which elucidates the need to introduce low-cost technologies in the artisanal mining. Such technologies will run on such readily available renewable energy sources as solar-activated microwave cutter.

The national electricity grid and diesel generators are the most commonly used sources of electricity in South African mining operations. Unstable electricity supply from the grid and escalating electricity price can tremendously affect negatively the production rate and income from mining operations (Votteler and Brent, 2016). To diversify electricity sources, renewable technologies like PV and wind energy are already being utilised as alternatives at mines located in distant areas with limited access to established electric grids (Choi and Song, 2017). These renewable technologies also nurture alternative industries that profit from exhausted excavations. With the significant drop of capital costs for renewables (GIZ, 2014), renewable technologies are considered as cost-efficient and sustainable, in addition to being eco-friendly.

Among various renewable technologies, Votteler and Brent (2016) identified solar PV as the best option for the majority of South African mining operations. This is due to: (i) its low initial investment costs; (ii) its current cost being half that paid for diesel generators and falling short of equalling that of the national utility supplier (Eskom); (iii) its vast availability; and (iv) the existence of a well-established service infrastructure. The electricity generated from renewables can replace costly fossil-fuel-powered generators used in processing plants. For instance, a PV/diesel hybrid system installed in one of the South African chromium mines has reduced 30% of its annual diesel demand (GIZ, 2014). While the price of coal-generated electricity in South Africa has increasing over the years, the price of solar PV has dropped by one third in the last decade and will continue to fall as per the reducing price trend. While the price of the solar PV equipment in South Africa is about R5/kWh against Eskom's R0.50/kWh in 2010, the current PV system costs less than R1/kWh whereas Eskom's electricity price has increased continually (Whiteman, 2015).

According to IRENA (2016), the prices of a solar PV module has reduced by 80% between 2009 and 2015. During the same period, the cost of the balance of system (e.g. inverter, battery, wiring and cables) also declined significantly. This has led to the reduction of the total installation and running cost of utility-scale solar PV by 62%, as shown in Figure 2.24. In 2015, the weighted average country-level PV module price ranged from \$0.52 to \$0.72/W, with the price for South Africa being around \$0.55/W. The global average total installation and running cost of utility-scale solar PV in 2015 was \$1.8/W. It is expected that the total installation and running cost in 2025 will be 43% to 65% lower than the cost in 2015, with about 70% reduction coming from the lower balance of system (BoS) costs.

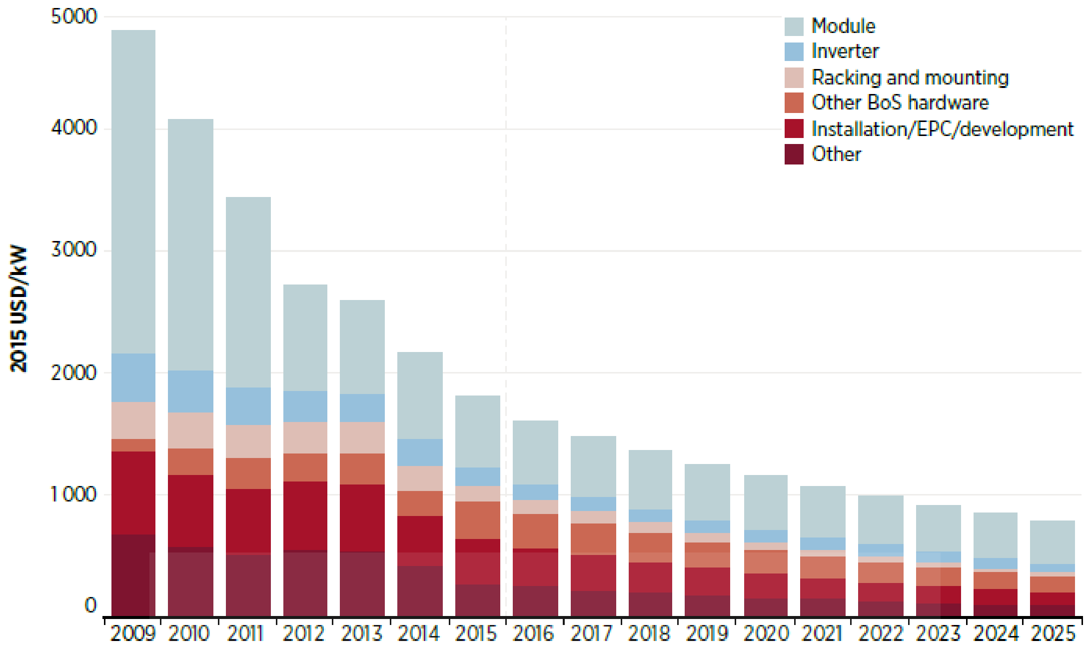

Figure 2.24: Decreasing trend of global weighted average installation costs of utility-scale solar PV (IRENA, 2016).

An economic comparison of various alternative energy sources is undertaken using the levelled cost of energy (LCOE). The latter is the total cost required for the installation and operation of a project to break even. It includes the initial investment cost, operations and maintenance (O & M), as well as the fuel cost (Makhijani et al., 2013). As per the US National Renewable Energy Laboratory (NREL), the LCOE is the overall life cycle charge divided by the aggregate energy production (1), expressed in \$/kWh or \$/MWh (Jaffe, 2013).

LCOE = Total life cycle cost (TLCC) / Total energy output (Q_{total}) (1)

Figure 2.25 below presents the average cost of the components (e.g. capital cost, O & M costs, and fuel cost) of the levelled rate of different power sources in the USA's metropolitan areas. The utility-scale solar PV (\$50/MWh) has the second lowest average LCOE, after wind (\$47/MWh). These LCOE prices of wind and utility-scale solar PV are lesser than the lowest LCOE among conventional energy sources (i.e. gas-combined cycle, \$63.5/MWh). Utility-scale solar PVs are cheaper than their community and residential counterparts. Out of 18, 11 alternative energy sources cost an average of \$104/MWh, which is \$33 less than conventional energy sources. While the capital cost of most renewable sources (e.g. wind, solar) may seem higher compared to that of conventional sources, most of the renewable technologies are already competitive solutions – as they have lower O & M and fuel costs.

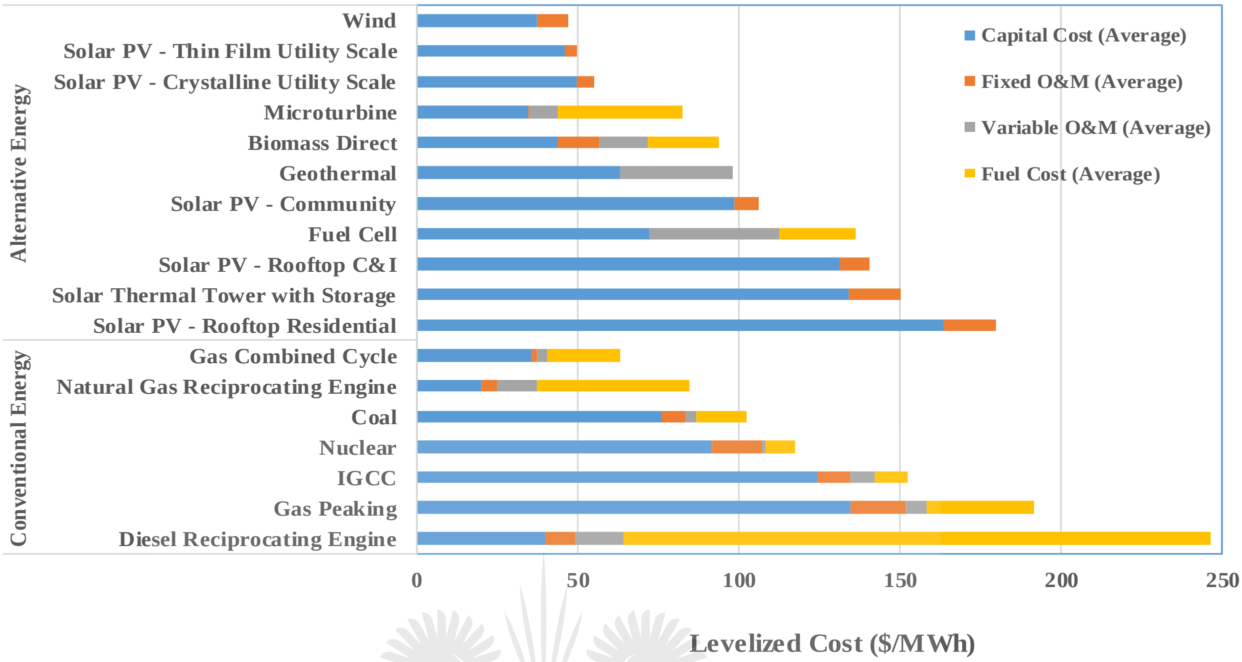

Figure 2.25: Components of levelled-cost in the United States (Lazard, 2016).

The projection of LCOE for selected electricity sources in South Africa is presented in Figure 2.26. The prices of both photovoltaic and concentrated solar technologies will continue to decline. The price of solar PV is projected to fall below that of wind making the former the most affordable renewable technology beyond 2020 (WWF, 2014). The price of solar PV is further predicted to fall well below the average cost of grid electricity by 2030.

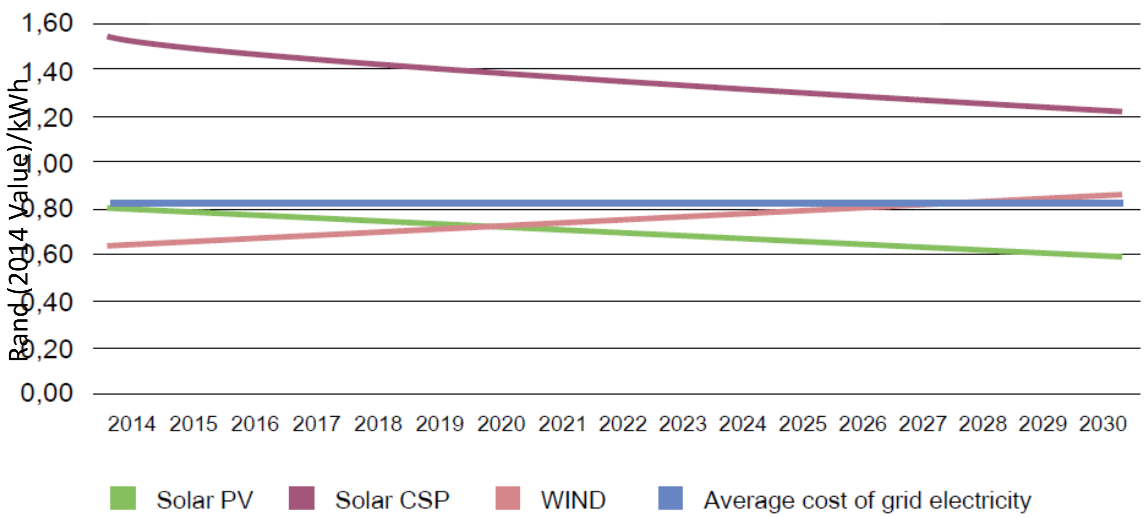

Figure 2.26: Projection of LCOE for electricity sources in South Africa (WWF, 2014).

2.11 Summary of Literature Review

The main objective of the literature analysis was to gain a deeper understanding of the current work done by researchers on mineral extraction technologies – especially in the mining of sandstone – and to identify any gaps that, if explored, would result in improving the comprehensive assessment of new emerging technology in the mining of sandstone. The ancillary objective of the literature appraisal was to identify and elaborate arrays of criteria and sub-criteria related to the five perspectives identified during the preliminary survey, to elaborate an assessable hierarchical modelling framework – using the MCDM technique.

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3.0 CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The preceding chapter explains the overall methodology used in this study in terms of the research design, besides the data gathering and analysis methods. The design adopted by the researcher enables him to connect to the conceptual research problem at hand. To this end, both descriptive and quantitative design approaches were used. The data required to address the research questions were acquired from case studies, interviews, questionnaires, and the expert pairwise decision questionnaire survey. The number of respondents who participated in both the surveys and the interviews and who provided meaningful information totaled 136. The breakdown is as follows: 36 respondents were interviewed (nine employees from each of the four sites visited), 40 general questionnaires were received back in an acceptable order, and 60 experts had consistent pairwise comparison questionnaires that were analysable using the excel software specifically developed for this purpose.

The four sites used for the case studies were visited more than five times and notes were taken during all the tours. Although more than 100 questionnaires were distributed to the miners and the community at large, only 40 were returned in a desirable state and were therefore analysed to answer the research questions concerning the soft issues investigated. These include the acceptability of the emerging technology and the environment aspects of ASM. Only twelve pairwise comparison questionnaires per criteria (STEEP) were analysed after intense scrutiny and selection of those that seemed consistent with the comparison process. The initial questionnaires distributed to each area of expertise were 35 copies per group – in each perspective. Data analysis was done using both excel and SPSS software. The results from these analyses were then used in answering the research questions – according to the responses from both the miners and the experts.

3.2 Research Questions

The questions guiding this investigation were divided into two categories: the soft issues and the hard issues requiring mathematical analysis using the SPSS software. The following five questions were used as the basis of the research investigations.

1. What are the viewpoints of practitioners and experts regarding the use of solar-energy-activated microwave technologies to mine sandstone based on the STEEP perspectives?
2. What best-known concepts and applications would enable the development of a scientific judgement on the best emerging technology with respect to the mining of sandstone in QwaQwa?
3. How can the small-scale processing of sandstone be improved using scientifically safe and sustainable techniques?
4. What are the major environmental issues emanating from the mining of sandstone in QwaQwa?
5. How acceptable are the proposed new emerging technologies to the QwaQwa mining community, local authorities, traditional leaders, and artisanal miners themselves?

3.3 Research Methodology

A mixed-research involving two approaches, namely, case study and survey was conducted. The survey approach included a general probing of miners, the QwaQwa community, mining experts and practitioners, policymakers, and researchers. Their expert opinions or judgements on the mining technology being evaluated were captured using the pairwise comparison questionnaires. The overall methodology was divided into three stages, to answer the research question (see Figure 3.1). The data for the soft aspect of the research were acquired from the case studies, interviews and general questionnaires. This investigation addressed issues regarding the acceptability of the new emerging technology by the mining community, environmental issues emanating from the mining of sandstone in QwaQwa, general health and safety problems experienced by the miners, and the sensitive issues regarding land use for either the mining of sandstone or tourism. Although the latter was initially not part of the evaluation process, it became a prominent point in all the discussions – as it advocated strongly for landscape preservation.

The total number of subjects interviewed was thirty-six (36): nine employees per visited mining site. Although a hundred (100) general questionnaires were distributed, only 40 were fully completed in an acceptable manner. The general questionnaire had the following sections: general background, health and safety aspects, government policy and regulation implementation, environmental aspects, as well as water and land usage.

The hardcore portion of the study used the pairwise comparison questionnaires designed to suit each of the five perspectives used to evaluate the emerging technology. Overall, sixty (60) questionnaires were used in the analysis, twelve per perspective, using the excel software model developed specifically for this analysis. This is because the cost of the commercial MCDM software has become very expensive.

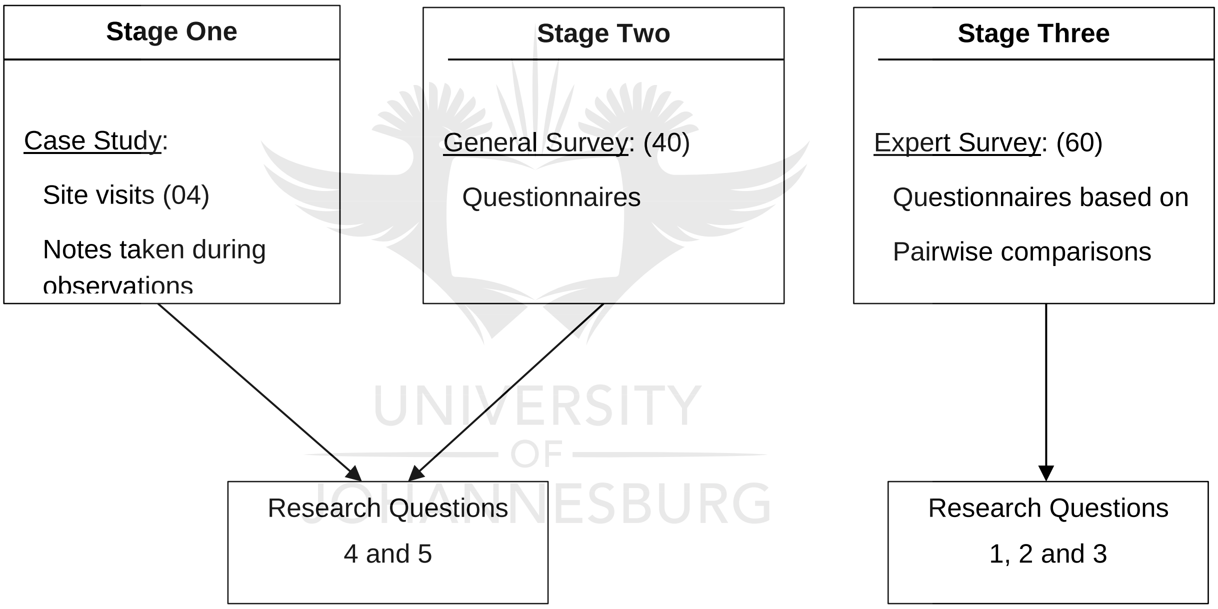

Figure 3.1: Research methodology used in the investigations.

The first stage of this study included multi-case studies where four artisanal sandstone mine-sites based in QwaQwa were visited multiple times and questionnaires were administered to both the miners and the surrounding community. The results of this preliminary study were triangulated by means of observation during the site visits. This research stage aimed primarily to establish the state of artisanal sandstone mining in QwaQwa. The result of these case studies enabled the identification of the five STEEP perspectives and the two important alternatives to use in the development of the MCDM for the investigation and evaluation of the technological mining of sandstone in QwaQwa (see Figure 3.2).

The second and third stages of the investigation were conducted simultaneously. This involved a more detailed collection of data from a larger sample of miners and the mining community. The survey approach is a buildup or expansion of the case study approach used to formulate a hierarchical decision model (HDM) for the evaluation of the alternative emerging equipment for mining sandstone.

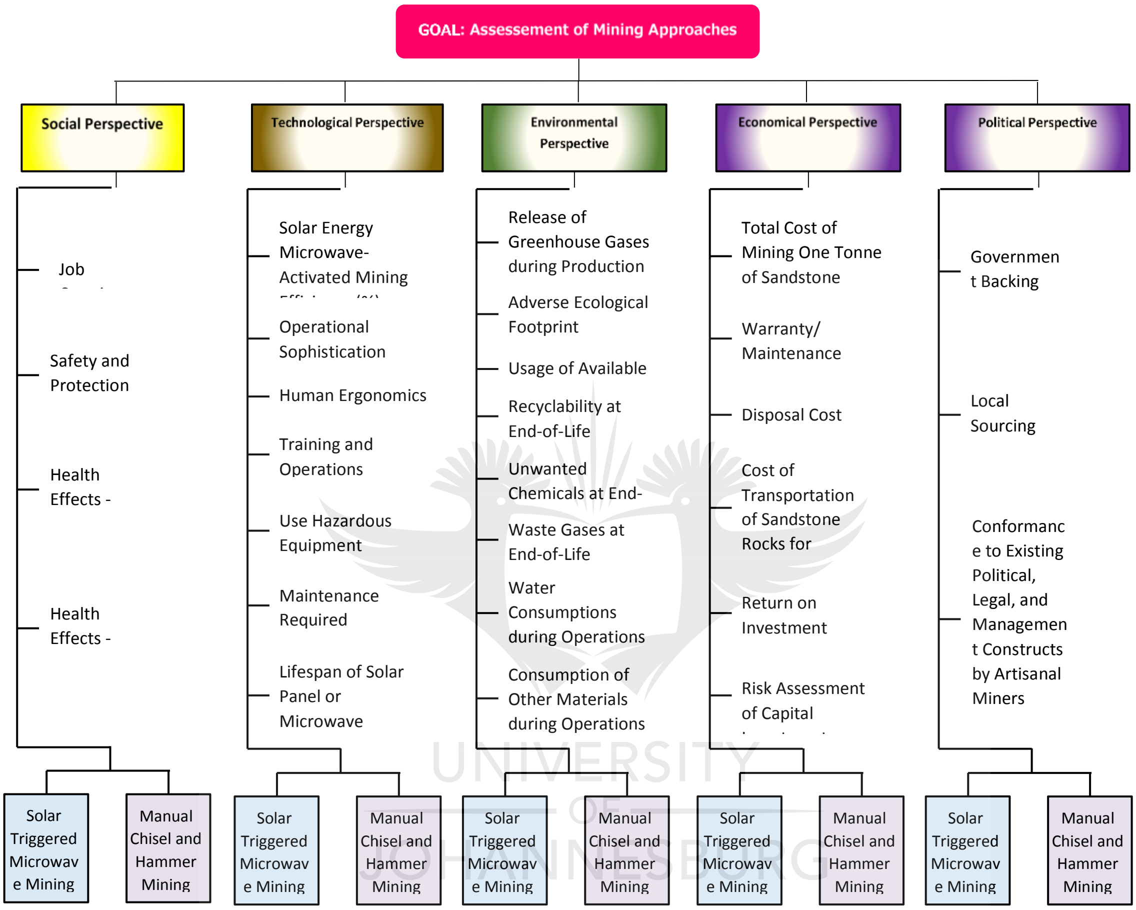

Figure 3.2: Formulated model for the evaluation of sandstone mining technology.

The researcher's easiest way to formulate a HDM was to select various levels of criterion that would be evaluated by the experts and practitioners. These evaluators consisted of experienced artisanal miners; mine executives, including operational managers; government officials; traditional leaders; experienced academicians; and external industry analysts. These experts were requested to give their collective judgements. The emerging technology evaluation process required competing and contrasting perspectives that had both qualitative and quantitative inputs from these experts. The pairwise ratio values recorded by means of the survey tool were analysed using an excel software model and the SPSS software. The results were then ranked based of the pairwise expert judgement ratios. The resulting model is expected to provide guidance regarding the selection and improvement of the mining technology. This prototype will also benefit government officials, the QwaQwa community, and the small-scale mining industry worldwide.

3.4 Decision Model as a Tool for Analysis

In formulating the decision model for the evaluation of the emerging technology for mining sandstone, an all-inclusive methodology based on the five STEEP standpoints was applied using the following major steps.

- The building of the hierarchical decision model.
- The selection of the expert panel.
- The collection of data and the establishment of their validation.
- The analysis of the results using the excel software specifically designed for the pairwise judgement analysis.
- The evaluation of inconsistencies.

The next section explains the above steps in detail.

3.4.1Building of the Hierarchical Decision Model

The network flow diagram used to build the hierarchical decision model was developed in such a way that it commences with the identification of the paramount mission or objective that is then followed by the perspectives (see Figure 3.2). The criteria were subsequently formulated in relation to the most important attributes of the perspectives on the artisanal mining of sandstone.

Table 3.1: Building of the hierarchical decision model

1. Mission: Comprehensive evaluation of the emerging technology for the artisanal mining of sandstone.
2. Perspectives and criteria considered - social, technological, environmental, economic, and political.
3. Select criteria and corresponding sub-criteria. E.g. Social, Job creation; Health
4. Select sub-criteria (factors) for each criterion
5. Structure problems as hierarchical decision model (HDM) framework.
6. Select expert panel (for each case) e.g. economists.
7. Build/ refine the decision model.
8. Build Judgement quantification instruments.
9. Collect and validate data using research instruments and tools for decision modelling and consistency analysis.
10. Analyse the initial results and convene expert judgemental ratio values, and resolve inconsistencies in the pairwise values.
11. Analyse results – relative to the specific technology's ranking.
12. Built/compare consistency functions for each factor.
13. Obtain technology value for each perspective.
14. Identify performance gaps for each factor and determine where major improvements are required.
15. Perform a consistency analysis for criteria/factors, variations and effect rankings, as well as decisions.

Figure 3.2 above presents the different levels of the hierarchical decision model. As for Figure 3.3, it provides the diagrammatic representation of the HDM. The top mission is the evaluation of the emerging technology for the extraction of sandstone in QwaQwa. The perspectives used in the process of evaluating the two alternatives follow this.

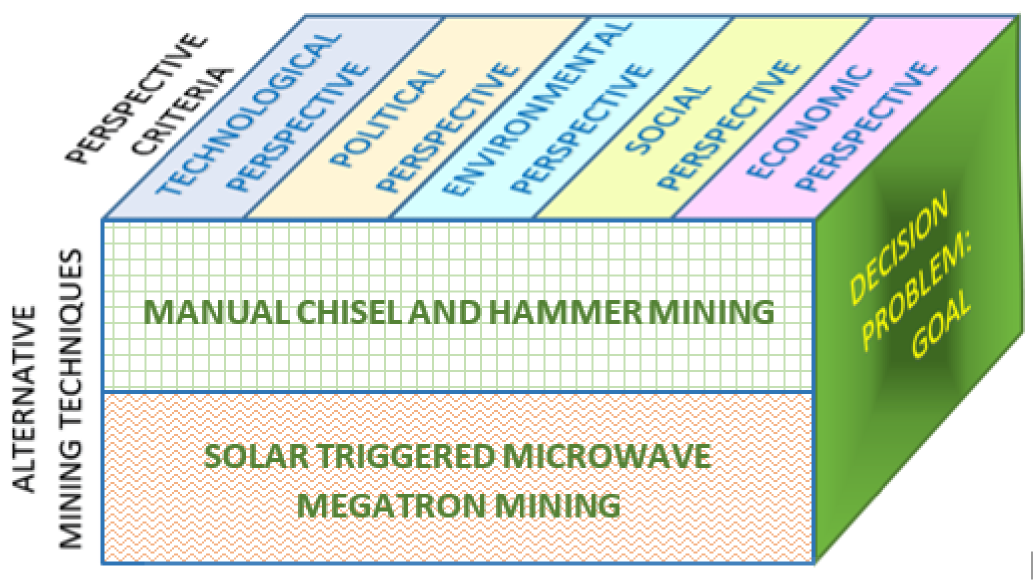

Figure 3.3: Diagrammatic representation of the hierarchical structure of the evaluation of the solar-energy-triggered microwave artisanal mining.

The HDM development is done through four distinct stages, starting with the objective – which is the highest element in the hierarchy, as reflected in figure 3.2 above.

- The mission or ultimate goal of this investigation is to undertake a complete appraisal of the emerging technology for sandstone mining in QwaQwa.
- The STEEP perspectives, which follow the mission, are the important enablers of the mission to be achieved. Therefore, the mission is weighed against each of the perspectives (social, technological, economical, environmental, and political).
- The criteria and factors for each perspective are a sub-division of each perspective to a lower level to be use by the expert decision-makers in their pairwise comparisons. For example, the social perspective can be divided into job creation or health and safety that may be further split into public safety and work safety.
- The HDM represents the overall relationship in the framework. The judgement quantification instrument based on the pairwise comparison is then used to gather information from the experts – for the synthesis and ranking of the two alternatives.

3.4.2 Selection of the Experts in Each Group

Stratified sampling was used in the selection of the experts. It was complemented by snowball sampling. The latter used exponential non-discriminative sampling based on the study by Pattison (2013). In this type of sampling, every participant recruits a colleague; nevertheless, every participant is not expected to recruit a colleague. The chain is discretionary and the choice to recruit depends on the participant who may or may not recruit an additional participant (Emersion, 2015).

The researcher's choice of snowball sampling over several other methods is because of its convenience and ease-of-reach of the population, in addition to its affordability and efficient costing. A comparison table showing eleven (11) other methods that could have been used by the researcher in the selection of experts (Table 3.2) is provided below.

Table 3.2: Expert selection methods

Identification	Description	Advantages	Disadvantages
Snowball sampling	In snowball sampling, the selection of the participants is typically dependent on acquaintance. The process requires experts to name other colleagues. A researcher normally identifies a few known experts who would then be expected to name other colleagues to join in the research process. The cycle continues until an adequate number of participants is achieved. Snowball sampling is also known as chain referral sampling (Etikan et al, 2016). This kind of sampling is normally used where there is no easy access to knowledge or data from extended associates (Waters, 2015). The major challenge with snowball sampling is that the outcomes can, sometimes, be lopsided, if the initial specialists are from the same organisation. This is the case with academia, industry, government or regional affiliations (Emersion, 2015). The only solution to this problem is to recruit experts from a variety of organisations. This helps to maintain a stable group of specialists across various organisational classes.	Snowball sampling requires no planning and resources. This method allows the researcher to access designated populations easily, at an affordable cost.	The most common disadvantage is that the researcher has little or no control over the participants. In addition, the experts tend to choose colleagues who have similar ideas and traits. There is a high level of sampling bias and creep, since the experts may invite only their close associations.
Citation analysis	The sampling method relies on Mapping Science through bibliometric comparison – using citation databases. This method identifies experts through the articles they have published or referenced. The identification may even be extended further by grouping authors into specialty areas (Wen et al., 2017). The initial identification process uses documents such as: • Science Citation Index Expanded (SCI-EXPANDED), • Social Sciences Citation Index (SSCI), and • Arts & Humanities Citation Index (A&HCI).	This is an organised method for the identification of experts who have produced scholarly works and are up-to-date with the state of the art	These citation documents are limited to formal (scientific) literature and bibliometric. Since they are scholarly, no industrial expertise or experiential knowledge is covered at all.

		knowledge in their area of expertise.	
Social network analysis	The social network analysis (SNA) is the act of analysing information flows from social networks. The latter consist of experts who associate through interdependencies (e.g. common specialist knowledge) (Guy et al., 2013; Manju, 2016). Social nets are classified into two areas: personnel profiling and document profiling. Personnel profiling searches keywords linked to an individual, while document profiling searches keywords related to documents. The frequency of occurrence of these keywords would then be used to identify these experts (Bozzon et al., 2013; Leonardi, 2015).	Social networks are well-organised and have a constant flow of knowledge and interactions that can easily be used to identify experts.	Large data released, very time consuming, and learning SNA tools is essential.
Wikipedia	Wikipedia is a vast, constantly evolving knowledge repository. Authors who publish on Wikipedia do so with the intension of sharing knowledge (Spasojevic et al., 2013).	This is a free publication platform which is very easy to access and use.	The identified experts needs further identification.
Academic sources	Some websites may be used to identify professors globally. An example is: http://news.uns.purdue.edu/newsweb.experts.html. Additional information about professors may be obtained from the institutional website. Professors usually state, in their résumé, papers published and courses taught.	The simplest method to identify experts. This is relevant to this study, since the researcher is an academician.	The expertise is limited to academics only – except in cases where an individual professor worked extensively in the industry first, before joining academia.
Google Advanced (or other website discussion LinkedIn or groups).	These are voluntary discussion group messages, including blogs and discussions by groups of experts such as those occurring on http://groups.google.com (Liu et al., 2015).	Free, and easy to access and use.	Selected experts need further verification.
Google Advanced Searches	If you have some background knowledge of an expert, typing in the name may give you the information about this expert and may lead to finding other experts	Free Internet search and easy to access and use.	Necessitates significant "manual searching".
Specialist witness National database	Law.com has a professional database, http://experts.law.com/, which is free of charge. To register as an expert, an annual fee is required.	Specialists are ready to advise.	Specialist witnesses charge high fees.
Trade associations such as the National Union of Mine Workers of South Africa	These are experienced members of the trade union movement. They publish papers in trade periodicals and attend workman-related symposia that constitute a very good source of experienced experts.	Experienced experts may be identified for specific trades.	Mainly work for their employees in government or the industry.

Respondent-driven sampling.	This type of expert elicitation is a very new method of sampling, as it combines both snowball sampling and mathematical modelling. It targets specific experts (Gile, 2015). It can be accessed from http//www.respondentdrivensampling.org.	The method is simple and cost-effective. Normally used in hard-to-reach populations.	Bias due to network communities.
Voluntary expert sampling	This is a non-probability form of sampling. In this case, the possible participation is advertised and experts get recruited voluntarily to participate in the study.	Easy method to identify an expert. Genuine willingness to participate in the study.	The quality of the expertise may not be very good. The volunteer may also withdraw, at times, before the study completion.

The researcher, being a faculty member at the University of Johannesburg, started with professors form this institution who had a deep understanding of mining operations and government dealings. These professors then nominated more colleagues who were willing to participate in the exercise. The targeted professors were from the UJ departments listed below:

- Urban Development;
- Town and Regional Planning (Social);
- Mining (Technical);
- Economics (Economic);
- Geography and Environmental Science (Environmental); and
- Political Science (Political).

Included in the above list were some members of the three major mining unions in South African who work very closely with one of the professors. The main reason for including the unions was their expert knowledge of the mining industry and their exposure to government policy.

Generally, the number of experts per decision perspective is expected to be between six and twelve; giving and total of below sixty experts, in most cases. Any number of experts above twelve does not add any significant benefits to the aggregated results (Sheikh, 2013).

3.4.3 Data Collection and Validation

The observations, during the site visits, together with the survey from miners and structured questionnaires administered for the experts' quantified judgement were used as data acquisition and gathering tools. The ability to interact with the miners and the community as a whole gave the researcher the opportunity for triangulation and validation of the knowledge acquired. The data were analysed using an excel software model specially developed for this task. The consistency values form each matrix were scrutinised after the consistency ratio values had been calculated and re-analysed using the same excel software, after the building blocks had been finalised by the experts.

3.4.4 Analysis of Results Using the Developed Excel Model

The judgement quantification data from the experts provided the relative rankings of the values of the perspectives, the criteria, and alternatives. The choices marked by the experts were used to develop a matrix structure. The latter was normalised and used to calculate the priority Eigen vectors for the perspectives, criteria, and alternatives. The Eigen principal values were calculated to enable the establishment of the consistency ratio for each element. Inconsistencies and disagreements were resolved by going back to the experts. Attempts to explain the process followed – when calculating the Eigen priority vectors and the Eigen principal values as well as the consistency index and ratios for each element, as discussed in detail below.

3.4.4.1 The Pairwise Comparison

The pairwise comparison is a preference choice made by the experts mandated by the researcher to show preference for one of two items. The magnitude of their liking of one item better than the other is indicated on a relative scale, as shown in Figure 3.4 below. In the latter, the pencil is liked more than the rubber; hence, a mark is made as shown in the figure. The relative scale to measure how much one likes one item in comparison to the other has descriptive wordings attached to the number scale – ranging from 1 to 9 on either side. (see appendix III). The example of a pencil and a rubber shows a preference of seven (7) on the left side – towards the pencil. Because the selection is on the left, the number seven is entered in the matrix structure. The opposite preference of the rubber over the pencil is given by the reciprocal of the first choice, 1/7. The preference of the same item is always of an equal value; hence, the comparison of one rubber to another is given the value of one.

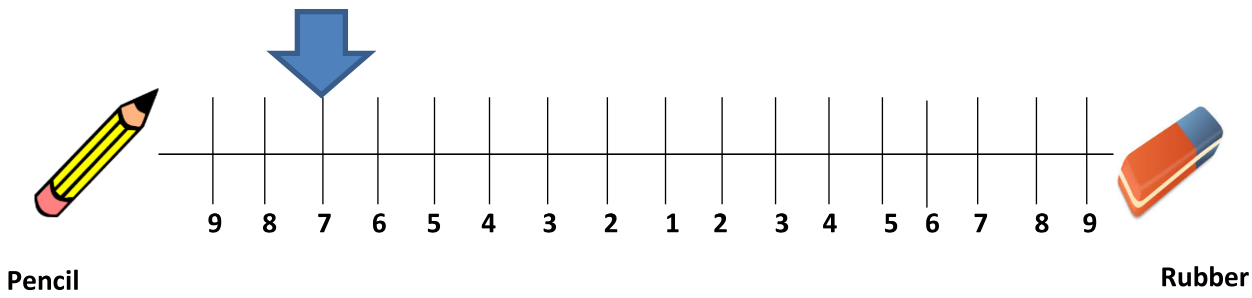

Figure 3.4: Pairwise comparison of two items relative to a scale of 1 to 9.

In the example below, three items are compared, namely, a pencil, a rubber, and a ruler. These items would have to be compared three times, to evaluate their ranking. A matrix structure, as shown below, is then developed to enable the derivation of the priority Eigen vectors.

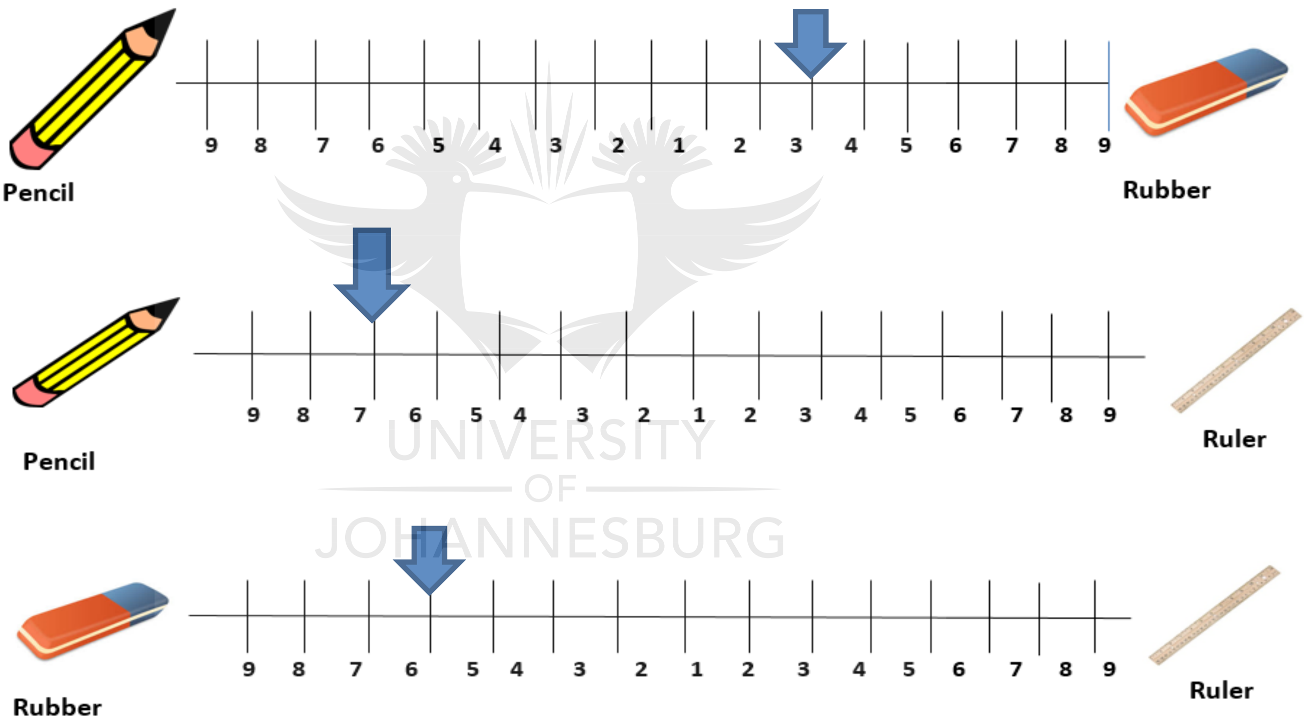

Figure 3.5: Pairwise comparison of three items.

Table 3.3: Matrix (A) of the three items in the example.

	Pencil	Rubber	Ruler
Pencil	1	1/3	5
Rubber	3	1	7
Ruler	1/5	1/7	1
SUM	21/5	31/21	13

Table 3.4: Normalised Matrix (A) of the three items.

	Pencil	Rubber	Ruler
Pencil	5/21	7/31	5/13
Rubber	15/21	21/31	7/13
Ruler	1/21	3/31	1/13
SUM	1	1	1

The matrix structure is then normalised by dividing each component in a column by the totality of all the components in that specific column. The sum in each column should now amount to one. The normalised principal Eigen vectors can be obtained by averaging across each row.

Table 3.5: Normalised principal Eigen vector (W) for the three items.

	Pencil	Rubber	Ruler		
Pencil	5/21	7/31	5/13		0.2828
Rubber	15/21	21/31	7/13	=	0.6434
Ruler	1/21	3/31	1/13		0.0738

The analysis has shown that rubber is most preferred than pencil and ruler, as shown by the above percentages that must total 100%. To verify the consistency of each participant, the principal Eigen value has to be determined and used to evaluate the consistency ratio. The principal Eigen value is gained by multiplying the totality of each column by the matching elements in the Eigen vector and summing them. In the above example, this value is given by:

$$\lambda_{max} = (21/5*0.2828) + (31/21*0.6434) + (13*0.0738) = 3.0967 \quad (1)$$

To measure if the experts' opinions are consistent, we check if the comparison is transitive. This can only be achieved if the experts maintain a logical flow in their judgement.

A comparison matrix is consistent if $a_i*a_j = a_k$ (Catala-Lopez, 2014). This conclusion was also reached by Saaty (1980) who later developed the consistency measure called the degree of consistency – based on the formula given below:

$$CI = (\lambda_{max} - n) / (n-1) \qquad (2)$$

In the example above, λ_{max} was 3.0967 for the three comparisons where the value of n = 3. CI would therefore be given by: (3.0967 – 3) /2 = 0.0484. Saaty (1980) also developed a universal consistency index called the random index. The samples used in the derivation of this index comprised of up to 500 matrices. The standard index for a maximum of ten comparisons is shown in Table 3.6 below.

Table 3.6: Standard random consistence index (RI).

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The (RI is then compared to the CI by way of a ratio. If the latter is smaller than 10%, the comparison and expert opinion are accepted. However, if the ratio were greater than 10%, the experts would have to be consulted to adjust the judgement values.

$$CR = CI/RI \qquad (3)$$

In the above example involving the three items, the CR value is given as 0.0484/0.58 = 0.083, which is 8.3%. This is acceptable, since 8.3% ≤ 10%.

3.4.5 Consistency Analysis Using the SPSS Software

A consistency analysis was performed using the SPSS software, to establish the experts' degree of consistency, especially regarding the distribution of their choices along the measuring scale – from +9 to –9. A further study was undertaken to measure the degree of correlation among the various groups, for each perspective.

3.5 Research Methodology Conclusion

The methodology chapter has explained how both the soft and hard stages of the study were conducted in an attempt to address the research questions. The mixed-methodology approach employed four case studies, thirty-six interviews, and one hundred surveys. The survey itself was divided into two sections, namely, the structured general questionnaires (40 members of the community) and the expert pairwise decision-comparison questionnaires (60 experts). The outcomes of the inquiry exposed issues concerning the acceptability of the new technology by the QwaQwa mining community. Although contrasting views emerged regarding land usage for the mining of sandstone, the local government officials requested the researcher to accommodate the views regarding land preservation. In addition, the survey reported environmental issues emanating from the continuous mining of sandstone in QwaQwa. Hence, several guidelines that could be followed to improve the wellbeing and security conditions of the QwaQwa public were elaborated. The ranking of the emerging technology during the evaluation was attained using the pairwise comparison tool considered in this study under the hard issues analysis – using both excel and the SPSS software.

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4.0 CHAPTER FOUR
RESEARCH RESULTS

4.1 Introduction

This chapter discusses the outcomes of the three different techniques applied in the research investigations. The first part reports on the research findings based on the soft issues generally dealt with by qualitative and descriptive reporting. This section also explains the observed activities recorded during the visits of the four sandstone extraction sites as well as the interviews that the researcher had with the mine employees. The second section reports on the hard issues pertaining to the statistical and mathematical modelling used in the analytical hierarchy decision-making process to appraise the potential of an emerging technology in sandstone mining.

Discussions on the soft issues mentioned above focussed on sandstone miners and the QwaQwa community as a whole. The initial investigation related to the acceptability of the new emerging technology by the QwaQwa community. The issue of land use explored the tense competition between the landscape preservation required to promote tourism and the expansion of sandstone mining that would directly interfere with tourism activities. Issues concerning the occupational health and safety of both the miners and the community were also discussed. The most common health-related problems highlighted during the interviews were silicosis and musculoskeletal issues. In addition, environmental issues emanating from the mining of sandstone were mentioned to educate the QwaQwa miners about the environmental impact of sandstone mining.

The data used in the analysis – to explain these issues – were collected from a multi-case study, interviews, and the general survey questionnaire. Overall, one hundred general questionnaires were administered to both the miners and the QwaQwa community. Nevertheless, only forty (40) could be used in the analysis. The data pertaining to the hard issues involving statistical and mathematical analysis were acquired through the pairwise-comparison expert questionnaires. In total, thirty-five (35) questionnaires – per perspective – were distributed to each group of experts in their specific field. However, due to extensive inconsistencies, only twelve questionnaires per perspective were analysed. Generally, the number of experts per decision perspective is capped at six to twelve – giving an overall total of just under sixty experts.

Any additional experts beyond twelve does not give significant benefits to the aggregated results (Sheikh, 2013).

4.2 Findings of the Soft Issues Investigation

This research study started as a preliminary investigation aimed at enabling the researcher to understand the current mining conditions and processes in QwaQwa. The resultant findings assisted in identifying the five main perspectives and measures used in the formulation of the methodical hierarchy decision framework. Over five visits were made to each of the investigated mining sites, after a pre-arranged meeting with the mine owners. In some cases, the researcher needed help to overcome the language barrier.

4.2.1 Community Acceptability of Emerging Technology for Sandstone Mining

QwaQwa is a small town located in the municipality of Thabo Mofutsanyane in the Free State Province of South Africa. It is approximately 325 kilometres south of Johannesburg, the commercial hub of South Africa. The name QwaQwa comes from the San language and means "whiter than white". Figure 4.1 below shows the sandstone-rich Drakensburg Hills in the Free State.

Figure 4.1: The Drakensberg Mountain chain landscape in QwaQwa (Agwa-Ejon et al., 2015).

The initial study in QwaQwa began with a tour of the area and an interaction with both miners and government authorities in the area. The community was then explained the purpose of the researcher's visit and requested by the local chief to cooperate with him during the period of the study. The interaction with miners revealed that most of these respondents had served their mines for over five years. As such, they had vast knowledge and skill regarding indigenous mining operations. Figure 4.2 below shows the respondents' number of years spent working for their respective mines. In addition to having several years of experience, the researcher also found that the majority of these miners were old. Yet, their young relatives were uninterested to learn their skills to take over. This is a very big threat to the future of sandstone mining in QwaQwa and it could only be averted through the adoption of new emerging technologies such as the ones under investigation. Figure 4.2 reveals the respondents' years of experience in their current position in their respective mines.

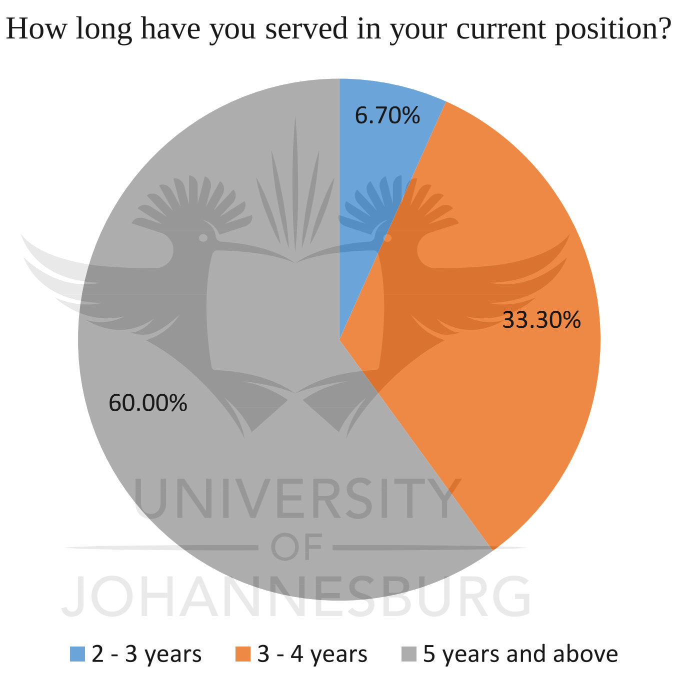

Figure 4.2: Respondents' years of service in their current position in their artisanal mining establishment.

In addition to the above result, it was also discovered that the mines in QwaQwa are heavily dominated by male owners (64%). Figure 4.3 below shows the male-female distribution of sandstone mine ownership for the visited sites in QwaQwa.

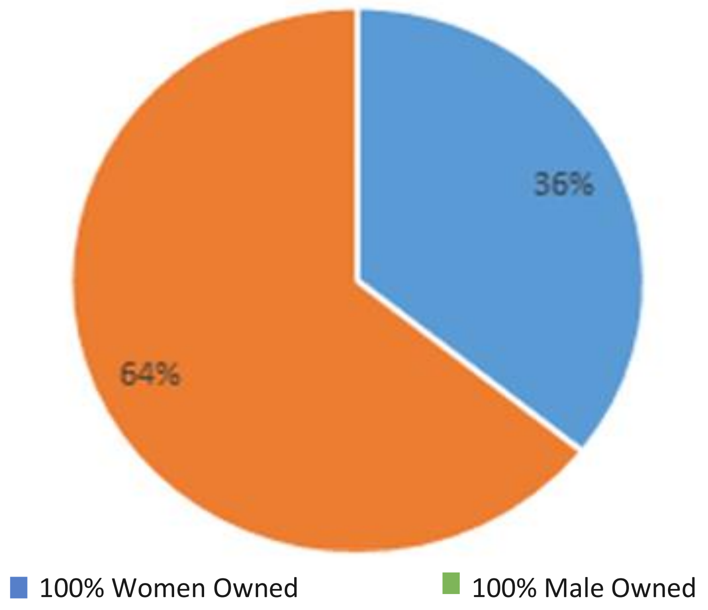

Figure 4.3: Ownership of sandstone mines by male and female miners.

The probable reason for this disproportionality could be the fact that artisanal mining processes are extremely laborious and normally accompanied by several accidents and casualties. This makes females somewhat reluctant to operate sandstone mines. This was the view expressed by one of the female mine owners who has since retired from active sandstone mining.

During the field visits and subsequent interviews, the views obtained from the QwaQwa mining community revealed that up to 65% of the members were in support of and ready to adopt the new emerging mining technology. The challenge, though, would be in equipping these miners with the necessary skills and knowledge to enable them to adapt to the forth-coming change. Of the 35% respondents who did not support the adoption of an emerging technology, a few were still undecided and needed more time to think about their choices. Others wanted to continue with the current status quo, citing their ability to survive and having educated all their children with the income derived from the current mining techniques. The majority of the 35% unsupportive respondents chose not to support the adoption of the new emerging technology, to promote tourism. Figure 4.4 below shows the acceptability of the emerging technology by the QwaQwa mining community. The results of the interviews and the general survey revealed that the QwaQwa community members were ready to try the new emerging technology.

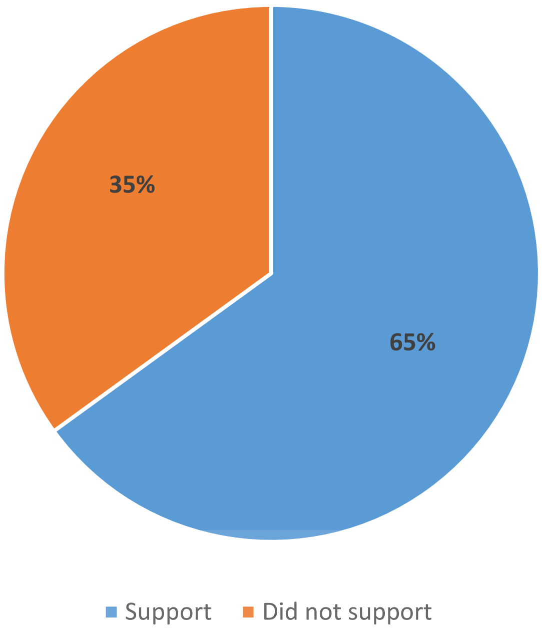

Figure 4.4: Acceptability of emerging technology by the mining community in QwaQwa.

4.2.2 The Impact of Sandstone Mining on Land and Water Usage

In the processing of sandstone, which involves cutting and polishing, water is utilised constantly to dispel the heat engendered by the cutting of stones and slabs as well as to control excessive dusts during operations. This contributes minimally to the contamination of the water supply system, since most of the mining sites are located far away from the townships and are in areas with light undergrowth and limited water sources. The impact of sandstone mining on water usage is therefore negligible, compared to most dimensioned precious stones (Hentschel et al., 2002). However, land usage for the mining of sandstone has become a controversial issue. During the interviews with the QwaQwa community, two strong views emerged. Some expressed the need to preserve the Drakensburg landscape for tourism, whereas others wanted to continue mining sandstone and, occasionally, use the same land for limited grazing. Figure 4.5 below provides more details on the 35% of respondents who could not support the adoption of a new emerging technology. It should be noted that, out of the two categories mentioned above, 71% of the 35% unsupportive members support landscape preservation.

Grab (2015) echoed the view that South Africa has some of the world's best and most remarkable sandstone backdrops and landforms. This view was also held by the majority of the respondents who did not support the introduction of an emerging technology in sandstone mining.

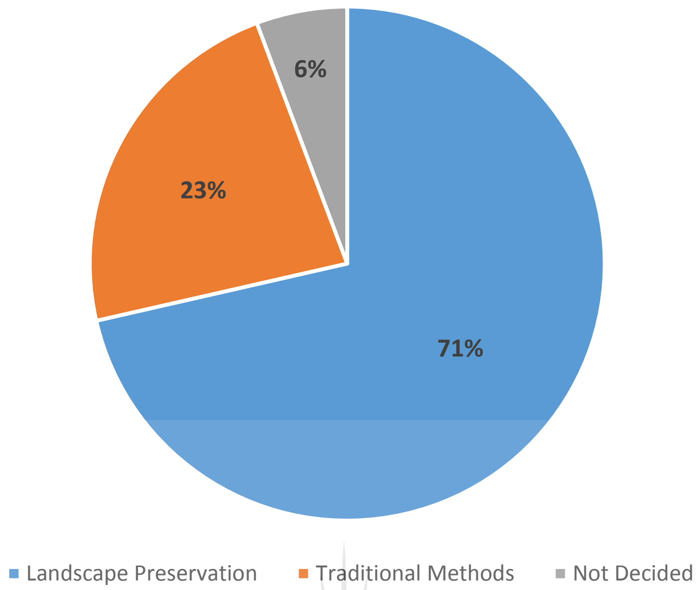

Figure 4.5: Details of the QwaQwa mining community members who do not support emerging technology.

4.2.3 The Health Impact of Mining Sandstone on the Community

Interviews conducted with miners in the four mine sites assessed the effect of the artisanal mining of sandstone on human wellbeing. The interviewees reported a persistent deterioration of their health. All the miners interviewed were employed at the time. The general questionnaire administered to the miners had three sections:1) Employees' health conditions before joining the mine; 2) The current mining practices; and 3) Employees' health conditions after working in the mines for five or more years. The result revealed a significant deterioration of the miners' health, as shown in Figure 4.6 below. The latter is a reflection of the miners' concerns, although none of them indicated being in poor health. The most health-related problems reported by the miners were silicosis and musculoskeletal issues. The relative measure of health in this case was the number of treatments received or medical consultations had by a miner in a month. The only way the researcher could attempt to triangulate this observation was by examining employees' absenteeism records. The scrutiny of these records revealed that they are not longitudinally representative, as most of the data were only kept for under a year.

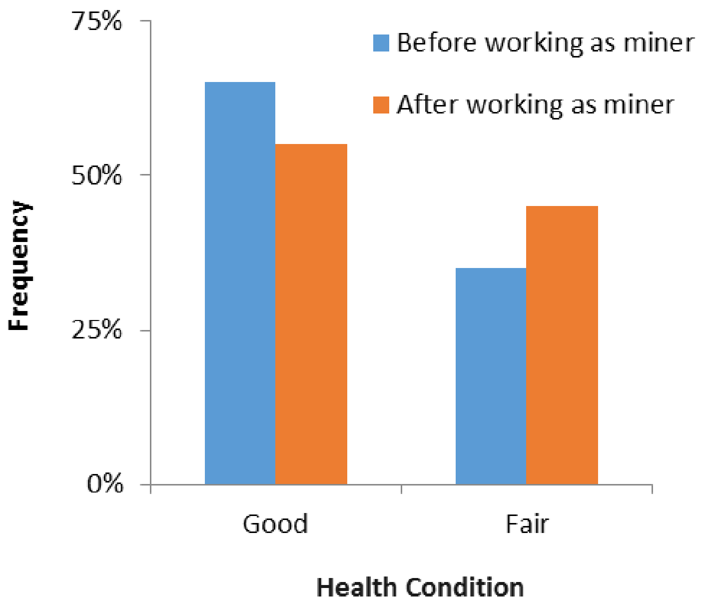

Figure 4.6: General health of miners before and after working in the mines.

4.2.4 The Environmental Issues Emanating from the Mining of Sandstone

The environmental issues are discussed in three stages. The first phase is the removal of the top soil. The second step involves the extraction of massive blocks of sandstone that are taken to the warehouse for handling. The third and last stage is linked to the cutting and polishing of the stones to make them ready for commercialisation. An examination of the processes revealed that sandstone mining uses two types of energy source:

1. Diesel fuel used in the carrying of large stones from the quarry to the handling workshop; and

2. Coal used by Eskom to generate the electricity used to operate machines during the cutting and polishing of the sandstone.

Most of the activities affecting the environment occur during the second and third stages of sandstone processing. This is because both the elimination of the uppermost soil and the careful extraction of large rocks use chisels, hammers, and wheelbarrows control by human power. Therefore, it is assumed that no gas emissions occur. Furthermore, these traditional, basic tools only require human power – which has no direct impact on the environment. The only substantial impact from this initial stage is the negative aesthetic image due to land surface removal. Figure 4.7 below shows the perceived negative visual effect of manual sandstone mining on the natural landscape.

Figure 4.7: Visual image of the top soil removed before the extraction of sandstone.

The researcher noted that the highest contribution to environmental degradation occurred during the second stage. Fossil fuels used in the transportation of large stones to the warehouse, for further processing, emit both carbon dioxide (CO_2) and sulphur dioxide (SO_2) – especially diesel fuel. The effects of these emissions are global warming, ozone layer depletion, and acidification. These emissions cause immense problems in the lives of members of the QwaQwa community.

The gas emissions in the third and final stage of sandstone processing are similar to those of the preceding stages. Nonetheless, they are minimal, compared to the transportation emissions that remain the highest. A study by Burchart-Korol et al. (2016) emphasised the need to reduce the quantity of fossil-fuel inputs in mining processes, if the environmental performance of mining is to be improved. This view is strongly supported by the researcher who has therefore suggested various ways of minimising the use of fossil fuel, in his recommendations.

In conclusion, the artisanal mining of sandstone remains an illegal mining activity in South Africa. The involvement of unregistered companies means that recordkeeping has been very limited. This makes it very difficult to monitor and assess the environmental effects of artisanal sandstone mining comprehensively.

4.3 Findings from Hard Mathematical and Statistical Investigations

This section of the research on hard issues aims to provide information on the statistical and mathematical analysis used by the researcher to gather expert opinion from various fields of specialisation. The reporting is divided into two sections, namely, the pairwise comparison matrix results and the SPSS statistical software analysis discussion.

4.3.1 The Pairwise Comparison Matrix Results

The experts made judgements based on pairwise choices relating to the adoption of the emerging technology in mining sandstone. A matrix of results based on these choices was elaborated and utilised to build a prototype for the selection of the technology that could subsequently be adopted for the mining of sandstone. Figure 4.8 below shows the four levels of the model.

The first level in the hierarchy structure is level 0 which is related to the goal the researcher is expected to attain. The goal of the present investigation is to assess the use of an emerging equipment for the artisanal mining of sandstone. This constitutes the focal point of the investigation of the hard issues. The second level is level 1 that is where the designated experts are given the questionnaires to enable them to express their opinions and judgemental values. This is the level where the five (5) perspectives are compared and judged against the goal. A (5 x 5) matrix is then developed – based on the judgment values chosen by these experts – to compare the perspectives with respect to the goal. An example of one matrix, taken from one of the twelve participants, associated with the social perspective is shown in Table 4.1 below.

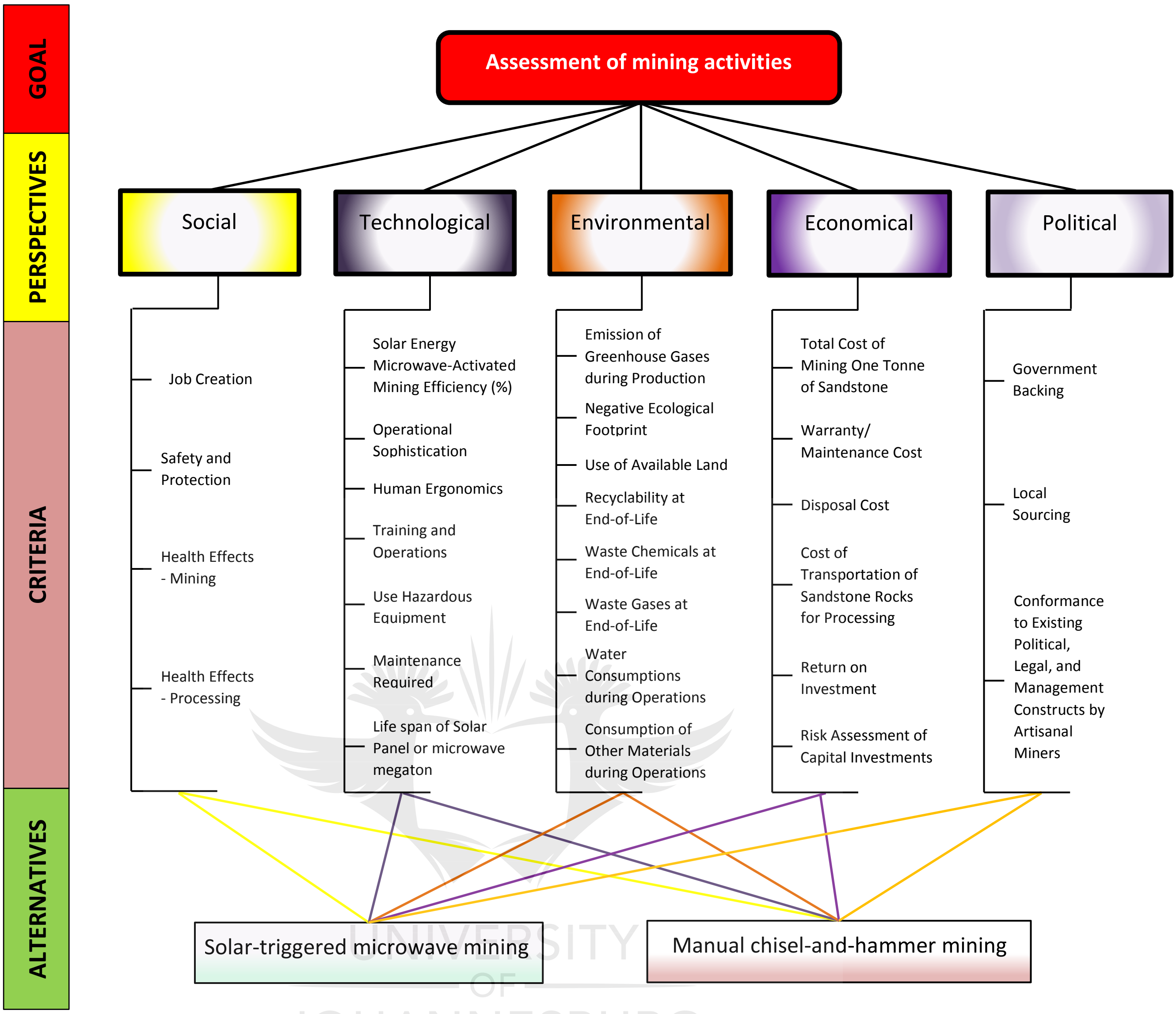

Figure 4.8: Framework for the multi-criteria decision-making model for sandstone mining..

Table 4.1: Pairwise comparison of the perspective matrices associated with the social scientists' expert judgements with respect to the goal.

Pairwise comparison matrix by a social scientist regarding the goal					
Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	4.00	2.00	6.00	7.00
Technological	0.25	1.00	2.00	2.00	6.00
Economical	0.50	0.50	1.00	3.00	6.00
Environmental	0.17	0.50	0.33	1.00	3.00
Political	0.14	0.17	0.17	0.33	1.00
Sum	2.06	6.17	5.50	12.33	23.00

Normalising the comparison matrix						
Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.49	0.65	0.36	0.49	0.30	**0.4577**
Technological	0.12	0.16	0.36	0.16	0.26	**0.2140**
Economical	0.24	0.08	0.18	0.24	0.26	**0.2020**
Environmental	0.08	0.08	0.06	0.08	0.13	**0.0868**
Political	0.07	0.03	0.03	0.03	0.04	**0.0394**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.35138
Consistency Index (CI)	0.087845
Consistency Ratio (CR)	0.0784

Thirty-five (35) pairwise comparison questionnaires per perspective were sent to designated experts in various mining fields. Some of these questionnaires were physically distributed by the researcher, especially those intended for professors in various universities in Gauteng. Overall, one hundred and seventy five (175) questionnaires were distributed as a survey tool for the MCDM analysis. The values of the consistency index (CI) and the consistency ratio (CR) varied considerably from the results given by these experts. After the initial screening – and where economically viable – the inconsistent questionnaires were sent back to the experts, requesting their second judgement – with the hope of reducing the inconsistency to an acceptable level. Eventually, only twelve (12) questionnaires per perspective were analysed. A list of all the matrices pertaining to level one – categorised by perspective – is provided as Appendix II. The final weighted average of all sixty (60) (5 x 5) matrices was calculated using the arithmetic mean. All priority vectors' arithmetic means, consistency indexes, and consistency ratios were also calculated using the arithmetic mean.

In level two, each of the criteria is compared to its associated perspective. An example relating to the environmental criteria matrix is shown in Table 4.2 below. It must be noted that the matrix structure varied according to the number of criteria associated with a particular perspective, as shown by the environmental example in Figure 4.8 above. All twelve matrices for each criteria are included as Appendix III. The arithmetic mean of these criteria matrixes is also calculated to find the average judgement value for the twelve expert participants.

Table 4.2: Pairwise comparison matrix developed by an environmental expert with respect to the environmental perspective.

Pairwise comparison matrix for environmental criteria								
Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00
NEF	1.00	1.00	1.00	1.00	0.25	2.00	2.00	0.33
UAL	0.50	1.00	1.00	1.00	1.00	0.50	2.00	1.00
RE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WC	0.50	4.00	1.00	1.00	1.00	0.33	1.00	1.00
WG	1.00	0.50	2.00	1.00	3.00	1.00	1.00	2.00
WCO	1.00	0.50	0.50	1.00	1.00	1.00	1.00	1.00
CMP	1.00	3.00	1.00	1.00	1.00	0.50	1.00	1.00
Sum	7.00	12.00	9.50	8.00	10.25	7.33	10.00	8.33

Normalising the comparison matrix for environmentalists.									
Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.14	0.08	0.21	0.13	0.20	0.14	0.10	0.12	**0.1392**
NEF	0.14	0.08	0.11	0.13	0.02	0.27	0.20	0.04	**0.1242**
UAL	0.07	0.08	0.11	0.13	0.10	0.07	0.20	0.12	**0.1088**
RE	0.14	0.08	0.11	0.13	0.10	0.14	0.10	0.12	**0.1138**
WC	0.07	0.33	0.11	0.13	0.10	0.05	0.10	0.12	**0.1248**
WG	0.14	0.04	0.21	0.13	0.29	0.14	0.10	0.24	**0.1611**
WCO	0.14	0.04	0.05	0.13	0.10	0.14	0.10	0.12	**0.1020**
CMP	0.14	0.25	0.11	0.13	0.10	0.07	0.10	0.12	**0.1261**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.940234
Consistency Index (CI)	0.134319
Consistency Ratio (CR)	0.0953

The alternatives are housed in level 3 where each of them is compared against each of the criteria. Because of the large outcry for land preservation, the researcher incorporated land preservation in the two mining methods to assess the impact of the emerging technology. In total, twenty-eight (28) (3 x 3) matrices were developed for each of the twelve participants. An example of the (3 x 3) matrix for the alternatives compared to the Job Creation criteria within the social perspective is shown in Table 4.3. Again, the average of all twelve nominated participants is calculated using the arithmetic mean. The impact of the criteria on the two alternatives and the incorporation of the predominant view of landscape preservation was weighted by combing the two matrices. The final (3 x 5) matrix is then derived from these two matrices.

Table 4.3: Pairwise comparison matrix of the two alternatives – including the landscape preservation option – compared to the Job Creation criteria in the social perspective.

Pairwise comparison matrix for alternatives			
Options	**Solar**	**Manual**	**None**
Solar	1.00	3	3
Manual	0.33	1.00	2.00
Land Preservation	0.33	0.50	1.00
Sum	**1.67**	**4.5**	**6**

Normalisation of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6000	0.6667	0.5000	**0.5889**
Manual	0.2000	0.2222	0.3333	**0.2519**
Land Preservation	0.2000	0.1111	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

The alternatives are ranked by preference, according to the expert choices indicated by the sixty participants, by combining the criteria's weighted average and the final middling priority vector of the five perspectives.

Table 4.4: Aggregate overall matrix including all levels of the framework.

	Social	Technological	Economical	Environmental	Political	Overall Priority	Idealized Priority	Rank
Solar	0,0733	0,1062	0,0892	0,0949	0,0556	0,4193	1,0000	1
Manual	0,0678	0,0393	0,0686	0,0591	0,0480	0,2829	0,6747	3
Land Preservation	0,0603	0,0295	0,0511	0,1019	0,0591	0,3020	0,7203	2

Overall CI	Overall RI	Overall CR
0,1159	2,2400	0,0517

The overall consistency ratio is also calculated using the formula below that represents the weighted average of all the matrices involving all the criteria and the five perspectives.

$CR_T \quad = \quad \sum w_i \, CI_i \, / \sum w_i \, RI_i = 0{,}0517$ (<10%, is therefore acceptable).

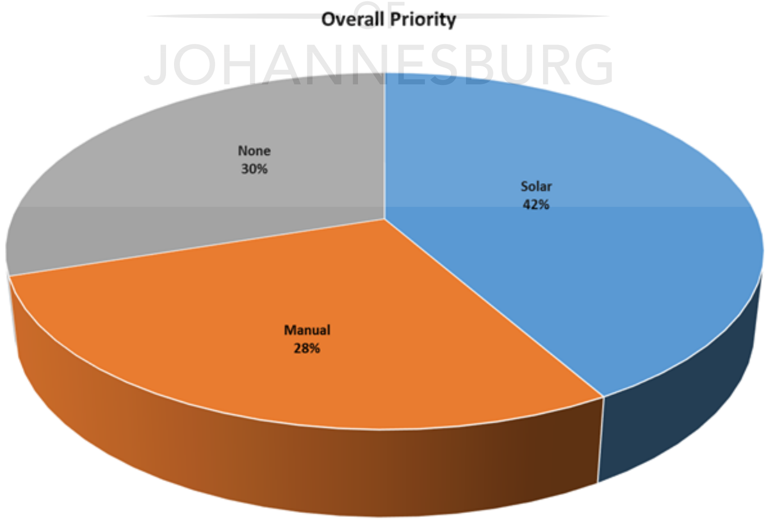

Figure 4.9: The overall final weights with respect to the goal, after accommodating the views of land preservation supporters.

The overall ranking of the two alternatives and the land conservation views added on specific requests from local government authorities is revealed in Figure 4.9 above. The experts highly rated the solar-energy-microwave-activated emerging technology. The average weighted value stood at 0.42, which is very close to the value obtained previously from the QwaQwa community during the interviews. The possible explanation for this close match is that most of the experts felt the imperative to improve South Africa's sandstone mining industry which is currently dominated by imports from the neighbouring Lesotho. A weight of 0.28 was derived from the experts supporting the traditional mining methods. Another way of interpreting these weights is that solar-energy-activated microwave mining is (0.42/ 0.28) fifteen times more preferred than the traditional tools. The difference in the choices exercised by the experts is not significant. This is probably because of the high initial investment cost of implementing such an emerging technology. For instance, all the miners would need to be technically trained and assisted, to be able to adapt to the new technology.

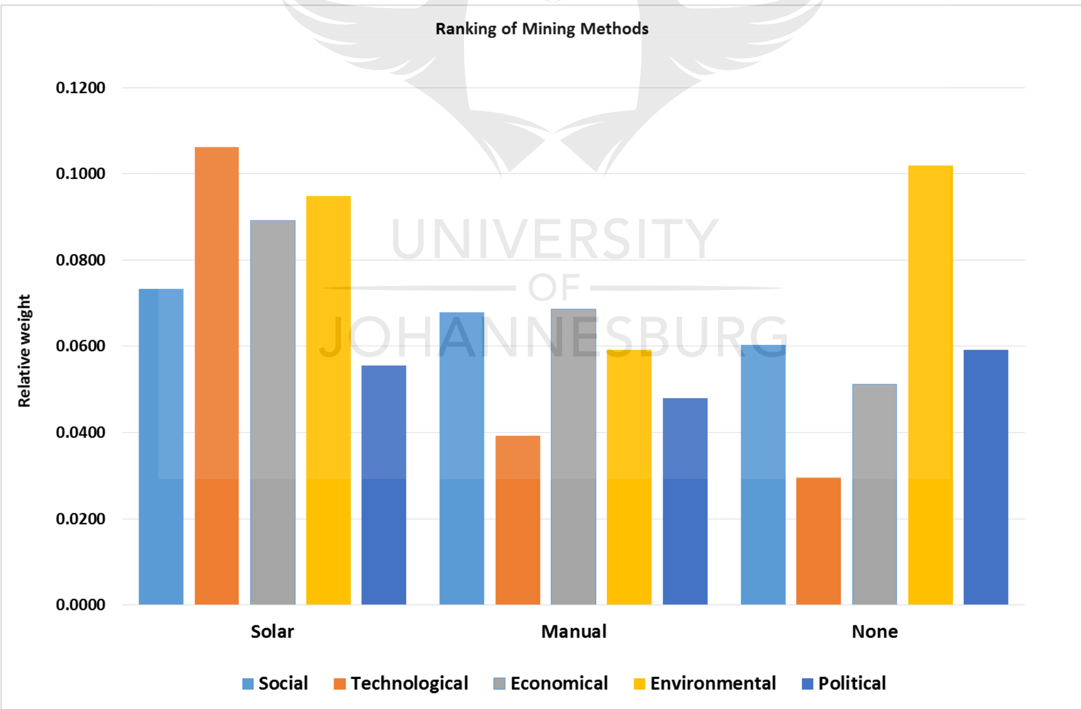

Figure 4.10: Relative weighted average of perspectives with respect to the goal.

The choices made by the experts and their judgement rankings are shown in Figure 4.10 above. A more significant value representation is evident in the technological perspective than in the rest – when judging the solar-energy-activated microwave proposed as mining equipment. Environmental issues also dominated the weighted averages of both the use of solar technology and land preservation. This generally supports the views expressed by the miners who seem unaware of the negative environmental impacts of artisanal sandstone extraction.

4.3.2 The SPSS Statistical Software Analysis Discussion

The statistical analysis in Table 4.5 below summarises the judgement quantification of all sixty experts who participated in the pairwise comparison of the five perspectives. The values are derived from the pairwise scale that ranged from +9 to –9. The most recorded median value was -2 which occurred while the experts were comparing the following perspectives: social against technological; social against political; technical against economic; technical against political; economic against environmental; and economic against political. Figure 5.11 indicates the range in the choices made by these experts. It varied between 14 and 17 points for all the perspectives.

Table 4.5: Analysis of the results obtained from the sixty experts using SPSS statistical software.

		SP & TP	SP & EP	SP & EnP	SP & PP	TP & EP	TP & EnP	TP & PP	EP & EnP	EP & PP	EnP & PP
N	Valid	60	60	60	60	60	60	60	60	60	60
	Missing	0	0	0	0	0	0	0	0	0	0
Mean		-0.42	0.65	1.23	-0.43	0.40	1.03	-0.48	0.40	-1.62	-1.95
Std. Error of Mean		0.47	0.51	0.57	0.53	0.43	0.45	0.58	0.38	0.54	0.59
Median		-2.00	1.00	1.00	-2.00	1.00	1.50	-2.00	1.00	-2.00	-3.00
Mode		-2	-3	-2	-3	-2	4	-2	-2	-2	-2
Std. Deviation		3.65	3.92	4.43	4.14	3.33	3.50	4.51	2.96	4.14	4.55
Skewness		0.13	0.27	0.13	0.29	0.29	-0.23	0.35	0.03	0.16	0.18
Kurtosis		-1.17	-1.21	-1.26	-0.84	-0.72	-1.12	-1.14	-1.14	-1.14	-1.15
Range		14	15	15	16	14	14	17	11	15	15
Minimum		-7	-6	-6	-7	-6	-7	-8	-5	-9	-9
Maximum		7	9	9	9	8	7	9	6	6	6
Percentiles	25	-3.00	-3.00	-2.75	-3.75	-2.00	-2.00	-4.00	-2.00	-5.00	-6.00
	50	-2.00	1.00	1.00	-2.00	1.00	1.50	-2.00	1.00	-2.00	-3.00
	75	3.00	4.00	5.00	2.75	3.00	4.00	3.75	2.75	2.00	3.00

SP = Social perspective; TP = Technological perspective; EP = Economic perspective; EnP = Environmental perspective; and PP = Political perspective.

4.4 Research Results Conclusion

The next chapter addresses most of the issues raised in the problem statement. The analysis was broken into two categories, namely, the soft issues and the hard issues. The soft issues reported on the qualitative and descriptive findings of the research. The hard issues mainly reported on the mathematical and statistical challenges. The problems encountered during the research were mainly fieldwork-related and include difficult communication due to language barrier, challenges in organising visits to mine site with minimal disruption to production, and uneasy access to vital records from mine owners. Some experts could not make consistent choices. This rendered their preference and judgement values invalid, since the acceptable value derived from the consistency ratio has to be maintained at less than 10%. This resulted in more than 50% of the pairwise-comparison questionnaires not being used in the final analysis.

Although attempts were made to explore the electronic pairwise comparison analysis by using commercial software, the idea was abandoned after it became clear that the software was unaffordable. The analysis was then done using a tailor-made excel spreadsheet software. The results derived from the SPPS software revealed a trend in the choices of the sixty experts, especially in the technology experts' comparison.

Research Findings and Discussion References

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5.0 CHAPTER FIVE
RESEARCH FINDINGS DISCUSSION

5.1 Introduction

In this chapter, the researcher deliberates on the implications of the research findings regarding sandstone mining in QwaQwa and their significance for both the soft and hard mathematical statistical research issues investigated. The chapter also presents the finding from the analysis of the physics of the multi-criteria tool used. The five research questions posed in Chapter One are discussed. Additionally, the present chapter examines the soundness and trustworthiness of the information acquired from both the QwaQwa community and various experts who participated in the pairwise comparison judgment questionnaires. The researcher then attempts to justify the worthiness and truthfulness of the conclusions drawn in this study.

5.2 Implications and Significances of the Soft Issues findings

The discussion on the soft issues focuses on the four important problems identified during the study. Sandstone miners and the QwaQwa community being at the centre of the conversation, the initial investigation was on the acceptability of the emerging technology by the QwaQwa community at large. The results showed that most of the community support the adoption of the emerging technology, which enables government officials to change the status quo. Community support is very vital for any project to succeed. Support from the community means that its members are ready to learn and contribute to the successful implementation of the emerging technology. The major implication of this study is the complexity and significant logistics problem resulting from the implementation of the emerging technology. Government officials would need to regroup miners into co-operatives, to share the available resources equally among all beneficiaries. Male miners' dominance as sole breadwinners would need to be redressed. If the emerging technology is implemented effectively, there will be improved productivity, and an increase in jobs that would result in a better standard of living for all. In addition, the introduction of the emerging technology would increase the production capacity of local miners thus enabling them to satisfy the sandstone demand in South Africa. As a result, the importation of sandstone from neighbouring Lesotho would eventually be phased out progressively.

The findings presented in Chapter Four highlighted the intense competition between the landscape preservation required to promote tourism and the continued use of land for sandstone mining. Up to 35% of the community supported land preservation with no mining of sandstone at all. The QwaQwa community and local government officials requested that the researcher included land preservation as a viable alternative in the pairwise comparison, to accommodate all the stakeholders in QwaQwa. The significance of this land saga is that, if it is not managed properly, the mining of sandstone in QwaQwa would become excessively expensive as most miners would want to reserve land exclusively for themselves. Although the chief allocates most of the land, government regulations still require all prospectors to apply for mining rights and licences. Nevertheless, the study identified land acquisition as a potential source of conflicts that should be managed, if possible, by consensus. This should be done through a committee including the Chief, local government officials, and the mining community. The situation is also aggravated by the recent government bill that seeks to achieve the repossession of land without compensation and then its redistribution to the needy in the community (South African Government Gazette No. 38418, 2015 pp 1-30).

The results also revealed that the mining of sandstone in QwaQwa causes ill health to the miners and the community. This increases medical costs for the local municipality to very significant levels. To reduce these costs, awareness programmes need to be started in most community centres. This is to encourage miners to use such safety gears as dust masks, earplugs, and hard hats. These miners should also undergo routine medical check-ups, to avoid excessive costs due to untreated illnesses. Indeed, the most costly impact on the mining of sandstone is the absenteeism of mineworkers that is directly linked to their ill health and compromised wellbeing.

The study also revealed the lack of awareness by the mining community of the environmental effects emanating from the mining of sandstone. Indeed, although most of these miners have been working in mines for years, they remain uninformed about the damage that the artisanal mining of sandstone causes to the environment. To manage this damage to the environment, local government officials need to embark urgently on an intense campaign to educate QwaQwa-based miners about the environmental impact of sandstone mining. The significant effect of using fossil fuels in transporting heavy rocks should be reduced to a minimum, since fossil fuels are the highest polluters of the environment in the context of sandstone mining.

5.3 Implications and Significance of the Hard Issues Findings

The hard issues outcomes are discussed in two sections. The first section deals with the results from the pairwise comparison by experts – using the judgement quantification questionnaire and analysed by means of the MCDM tool developed using the tailored excel spreadsheet. The second section discusses the results from a further analysis using the SPSS statistical software.

5.3.1.1 The Mathematical Modelling of MCDM for the Emerging Technology

The MCDM mathematical modelling used in the selection of an emerging technology is based on the work undertaken by Chinoda (2013). The model represented STEEP perspectives as parameters. These perspectives have discrete and finite numbers describing a finite set 'w' which varies for each criterion of n number of alternative feasible actions w_i (i = 1, 2, numbers). In this case, several evaluation criteria f_j (j =1, 2, numbers) are deemed applicable in the decision-making process; where w_1 is evaluated to be better than and different from w_2, in keeping with the i^{th} evaluation criteria, if $f_j(w_1) > f_j(w_2)$. In this scenario, the final decision issue can be presented as an n-x-m-dimensions matrix called evaluation or impact matrix. Its components p_{ij} (i=1,2,…m; j=1, 2,…, n) symbolise the assessment of the j^{th} alternative using the i^{th} criterion.

5.3.1.2 The Physics Principle of the MCDM Theory and the Symmetry of Values

Scientific law and principles enunciate universal truths about nature and the knowledge corpus they comprise. Natural laws are rules that all natural procedures seem to follow. Physics uses equation prototypes to explain what nature and the body of knowledge mean physically. The physics of this study emanates either from fundamental or elementary principles – from observation or from experimentation. In striving to understand the MCDM, the physical emanation aspect discusses the extensive experience of experts in their respective areas of qualification and skills. The choice of expert judgment is therefore formulated in more complete and universal expressions of an experienced expert in a specific field of study. It can be concluded that the formula emanates from an original form that is either observation or experience, which can be identified as their physical original expression or their physics.

Physicists derive most of their tools from the principles of symmetry. The physics of the MCDM can be argued on principles of symmetry. The main principle of symmetry in physics states that, if a set of causes is invariant with respect to any transformation, their overall effect is invariant with regard to the same transformation (Rosen, 2005). By using multiple-standard evaluation techniques, the issue of aggregating the weights of the criteria acquired using various evaluation techniques or expert groups arises. In such instances, the notion of the geometric mean is generally used, although the arithmetic mean or other concepts that help to conglomerate the weight can also be used.

The below equation rests on the notion of the geometric mean for weights integration. It suffices to note that equation (5) below is symmetric, meaning that its outcome does not depend on the determination of original estimates and recalculated values (Vinogradova et al., 2018).

$$\alpha_j = \frac{\omega_j W_j}{\sum_{j=1}^{m} \omega_j W_{j'}} \qquad 5$$

Where α_j represents the recalculated weights of the criteria, $\omega(R_j) = \omega_j$ is the original weight of the j-th standard R_j and $\omega(X/R_j) = W_j$ represents novel masses of the standards. The latter are calculated by a dissimilar technique or by an alternative experts group, with X symbolising the event when new criteria masses are obtained.

5.3.2 The Expert Quantification Values Analysed Using SPSS

The central tendency measurement obtained from SPSS descriptive statistics for the sixty (60) experts gave the median, the mean and the range as being -2, -1.9 up to 1.23, and 14 to 17 points, respectively. This result shows the dominance of the social perspective and the lack of extreme scores away from the distribution centre. This is further demonstrated by the skewness and kurtosis shown in Figure 5.1 below.

The skewness and kurtosis gave an insight into the shape of the distribution resulting from the choices made by the experts. The skewness that is the measure of the dataset's symmetry or lack thereof shows that the sixty (60) experts favoured the perspectives on the right hand of the comparison balance. In other words, the right hand tail of the distribution was longer than the left one and therefore had more choices from the experts, as shown in Figure 5.1 below. Kurtosis, however, measures the collective mass of the tails – comparative to the remainder of the distribution. The kurtoses from the expertise judgement quantification results were all-negative. This implies that most of the choices were made centrally and not in the tails as in the ideal normal distribution.

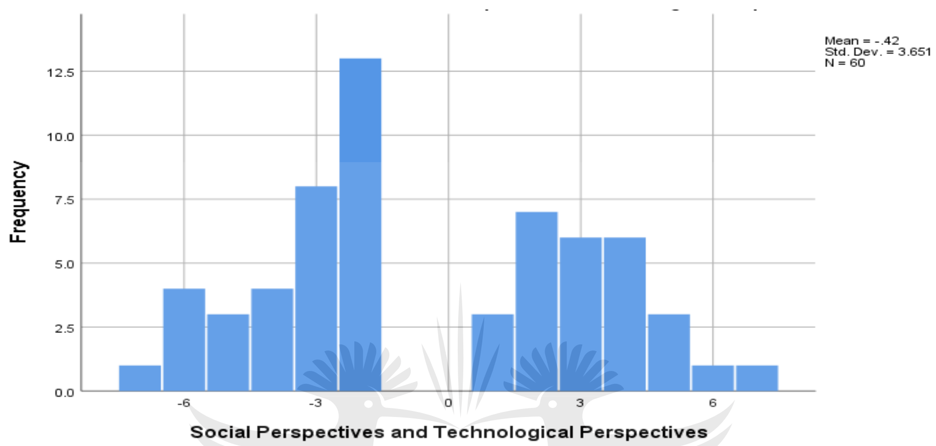

Figure 5.1: Distribution of pairwise quantification value in the social perspectives.

5.4 Responses to the Research Questions Posed in Chapter One

The first research question sought to establish the viewpoints of sandstone mining practitioners and experts regarding the introduction of solar-energy-activated microwave technology as an emerging technology in the mining of sandstone in QwaQwa. Twelve experts were identified for each of the five perspectives and were requested to make judgment quantification values. The pairwise comparison judgement was based on these five perspectives (STEEP), with respect to the goal mentioned above. The result supported the adoption of the solar-energy-activated microwave in sandstone mining – by 42 percent. The appendices I, II, and III show the detailed calculations made during the evaluation process.

The second question guiding this research investigation probed the best-known concepts and applications used in the development of a scientific judgment tool. The researcher used the MCDM method to evaluate the solar-energy-activated microwave sandstone-mining gun. The method relied on expert opinion to make judgements that were both qualitative and quantitative, to evaluate the two alternatives. As mentioned before, the issue of land was also added and discussed – at the request of the community. The land issue is central presently. This is due to the National Government's intention to reallocate land to qualifying citizens without compensation to the current owners. Thus, the researcher considered the MCDM methodology as the most scientific technique to use in the evaluation of an emerging technology such as the one contemplated.

The third question aimed to identify how the small-scale processing of sandstone could be improved through the adoption of a scientific, safe and sustainable technique. This is probably the most important question in this study, because it carries the main purpose of this research. As mentioned earlier by the researcher, the adoption of the solar-energy-activated microwave mining equipment or gun technology would revolutionise the efficiency and productivity of sandstone mining in QwaQwa. Because of the increased productivity and drop in the cost of production, more resources would be available for re-investment in better sandstone mining techniques.

The fourth research question considered the environmental issues emanating from sandstone mining. The research revealed that emissions from fossil fuels, during the transportation of large rocks, were the major polluters of the environment. Indeed, both CO_2 and SO_2 are emitted extensively during sandstone transportation and processing. The effects of these emissions are the depletion of the ozone layer, acidification, and global warming. The researcher has recommended the relocation of the sandstone processing plant to the vicinity of the mining area. The movement of sandstone blocks within the plants would be achieved by using conveyor belts powered by solar energy based on a cleaner production and JIT principles.

The last research question posed probed the acceptability of the emerging technology in QwaQwa. This study was initially undertaken to investigate this and establish the status quo in the mining of sandstone in QwaQwa. The result of this initial study revealed a very strong support for the introduction of a new technology. Issues then arose regarding the ongoing debate on land ownership and the availability of land for sandstone mining. This convinced the researcher to include land preservation in the mining of sandstone or for tourism as one of the discussion options. A survey carried out by the researcher then revealed a 65% support for the introduction of emerging technology into the mining of sandstone in QwaQwa.

5.5 Discussions on the Validity and Reliability of the Data obtained

The role of validity and reliability in this study is to ensure that the results are rigorous and unquestionable. In an attempt to achieve this outcome, the researcher used stringent controls and duplicated data acquisition methods. In this research, the reliability of human judgement was identified as one of the challenges. This is because the same expert may rate the same criteria differently, depending up on the time of the day or his/her mood at that particular moment. This implies that the judgement quantification values obtained could be difficult to repeat and inherently less reliable. To manage this challenge, the researcher adhered to the values obtained from the calculation of the Eigen priority vectors, the Eigen principal values, as well as the consistency index and ratios. These values calculated through pre-determined formulas gave a clear indication on whether or not the participating experts were consistent in their choices during the pairwise quantification process. Where the ratios were found to be above the acceptable value of 10%, the results were omitted from the ultimate analysis.

The sixty participants in the study were all global experts in their specific areas of interest and specialisation. As such, they represented the worldview in the mining paternity. This means that the decisions made by these experts on the artisanal mining of sandstone could be applied anywhere in the world where sandstone deposits exist. The selection of the sixty expert participants rested on stratified snowball selection. This was simply because the researcher recognised them as genuine experts in their specific areas of expertise after stringent checks based on the guidelines listed in Table 3.2 above. An additional reason for their choice was economical, since some of the questionnaires were personally administered to these experts by the researcher, in their offices. In selecting the criteria to be measured, the researcher realised that it was difficulty to cover every single area of interest in mining with only one measure. It was therefore decided to choose only the important parameters. Appendix I shown in the book of appendices was used by the researcher to consult over one hundred experts in their fields of specialisation, to validate the parameters which were most representative in the five perspectives used in the assessment of the emerging technology. A tailored-made excel spreadsheet was then used in the analysis of the data acquired. It was selfvalidating in that any questionable quantification data were excluded at the beginning of the analysis process.

In conclusion, the data obtained is considered valid and reliable because of the accurate, meaningful, and credible decisions derived from the data acquired from both the QwaQwa community and the sixty experts. The researcher had sufficient controls to enable him to draw meaningful conclusions that are generalisable because of the worldwide views expressed by the individual experts.

Discussion Chapter References

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6.0 CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This final chapter of the study comprises of five subtopics linked to the findings, namely, the research assumptions, the conclusions, the contribution to knowledge which will explain the intellectual merit of this study, the limitations, and the recommendations.

6.2 Research Assumptions

This investigation was guided by four assumptions. The first assumption made was that these experts were knowledgeable in their respective areas of expertise and that their judgement selection was properly thought – since the model depended heavily on the choice of their worldviews. The second assumption, which was based on the experts' selection criteria, was mainly driven by the snowball methodology. The researcher assumed that the experts introduced to him were genuine and knowledgeable in their relevant fields of expertise. The third assumption was that the experts did not include their personal and experiential biases in the judgment and choice applied to the pairwise decision making. The fourth assumption related to the results of the modelling process. These are likely to change in future, since the experts' inclinations and the conclusions were instantaneous. In making decisions, the user would normally assume that these choices are likely to stand over time.

6.3 Conclusions

This section summarises the findings of the study which were found to be in line with the researcher's expectations. An integrated-analytical-hierarchy decision model was developed in this study to evaluate the solar-energy-activated microwave sandstone equipment – using the STEEP. Experts from specific fields of expertise gave their judgment quantification values. The latter were used to rank the available alternatives, namely, mining with traditional tools such as chisel and hammer, as well as mining using the solar-energy-activated microwave. The ranking of these alternatives revealed good support for the solar-energy-activated microwave mining equipment – with a score of up to 42% – followed by land preservation at 38%. The land debate became a prominent area of deep engagement that had to be considered in the evaluation.

Traditional mining tools had a score of 20%. The resultant model is expected to provide guidance in the selection and improvement of emerging mining technology. The model will also benefit decision-makers in government, the QwaQwa community, and the small-scale mining industry worldwide. It is hoped that, if this new technology were adopted, it would change the way miners in QwaQwa operate. The increased productivity of sandstone would result in the better pricing of sandstone and its by-products in Southern Africa. In addition, more efficient and cost-effective operations in the artisanal mining of sandstone would be developed. If unsuccessful, the model will nevertheless be useful in showing what does not work effectively and will open the possibility for others to make viable improvements.

6.4 Contribution to the body of knowledge

The intellectual merit of this investigation is that it has developed a policymaking model to ensure a complete evaluation of solar-energy-activated microwave sandstone mining. This is to assist government officials, mine owners, academicians, policy-makers, and energy suppliers in making better decisions regarding an emerging technology evaluation and commercialisation. The evaluation is based on the STEEP perspective – with two alternatives – which later incorporated land preservation, as suggested by the mining community in QwaQwa. In addition, this research has applied the expert judgment pairwise tool to the five perspectives considered, although the examples of analytical hierarchy decision-making model reported in the literature were confined to only three perspectives, in most cases. Clearly, this research has not developed any new theories but has rather presented a practical application of the analytical hierarchy decision modelling – using a STEEP approach – to two related options for the mining of sandstone by the QwaQwa mining community.

6.5 Limitations

This section presents the limitations encountered in the study. The analytical hierarchy decision-making model methodology – although it is a good tool grounded in a subjective classification of perspectives, standards, and available alternatives – has the following critical limitations – when applied to the artisanal mining of sandstone.

- The methodological approach used in the evaluation of the emerging technology for the mining sandstone relied on the experts' worldviews to rank the perspectives, criteria, and alternatives – to arrive at an outcome that cannot be applied to different decision-makers considering the same priorities.

- The analytical hierarchy decision-making model had a specific set of elements such as the five perspectives used in the assessment, the criteria, and the two alternatives. Any changes in these elements require the re-evaluation of the entire expert-judgment quantification process.

- In undertaking a decision, the whole judgment and preference process informing the decision making considers one stage in time and the opinions, urgencies, penchants and conclusions reflected at that specific moment. In reality, decision-making is dynamic; therefore, these decision-making elements may change – giving a varied outcome which can only be re-established through a complete re-evaluation.

- The sampling technique used in the selection of experts was a stratified method assisted by snowball sampling. This method, although it allows the researcher to assess the expert population easily, assumes that the nominating expert does not give names of close associates only. This results in the nomination of friends who share similar traits and characteristics of the same mining environment.

- The major limitation in the pairwise comparison judgement choices is the inability to avoid inconsistencies. Most experts are lost and entangled in their preferences. This results in illogical and therefore unacceptable choices. In this study, although thirty-five questionnaires were administered to the experts, only twelve were found to be consistent – forcing the researcher to limit the analysis to twelve expert responses for each perspective.

6.6 Recommendations

In this section the researcher outlines some of the problems identified and suggests ways in which they could be addressed to improve artisanal sandstone mining in QwaQwa. The researcher strongly advocates for a one-stop shop in QwaQwa, where all miners would be encouraged to acquire both knowledge and materials about artisanal mining. This opportunity would also enable all stakeholders to learn more about artisan mining techniques and to develop interest in sandstone mining. Sharing ideas is a very noble way of growing business. If all mine owners were to share their business ideas, this might lead to the formation of co-operatives. Exposure to new ideas and lifelong learning are very vital tools for businesses. It is therefore recommended that – where possible – miners who are able to read and reap benefits from a QwaQwa artisanal mining bi-monthly newsletter. This would engage the community – especially the youth – and ignite their interest in sandstone mining.

The issue of water and land utilisation needs to be resolved by consensus – through meetings and discussion with traditional leaders. The researcher recommends that both mining and land preservation initiatives be carried out simultaneously. This entails the elaboration of a clear plan on how to restore landscapes to their original status – for tourism to continue un-interrupted – where mining activities have been completed.

Artisanal miners in QwaQwa suffer from inadequate financial support. Government officials have clearly indicated that they are unable to support miners individually. Therefore, the recommendation is that mine owners establish co-operatives to enable the government to fund them as groups. The creation of co-operatives would make it much easier to implement the adoption of an emerging technology such as the solar-energy-activated microwave-mining tool for the exploitation of sandstone, as the cost of the initial investment would be shared among many mine owners. The researcher also suggested that the processing of sandstone be close to the extraction site, to limit the transportation of large rocks. This would, in turn, reduce the emission of GHGs. Moreover, where possible, solar-powered conveyor belts should be used to convey dimensioned stones within the plant. Furthermore, the researcher strongly recommends the application and use of more than three perspectives or criteria in decision-making, as opposed to the current three noted in most examples from the literature. The major challenge in introducing several perspectives is the danger of being entangled in several inconsistencies. Nonetheless, the researcher believes in the saying that practice makes perfect. As such, the continuous use of several perspectives would create an opportunity to resolve the current inconsistencies in judgment experienced by most users of MCDM tools.

APPENDIX I: DECISION MODEL CRITERIA VALIDATION

DECISION MODEL CRITERIA VALIDATION

INSTRUMENT

STEEP Decision Model Criteria Validation

Q1 Social; Technical; Economic; Environmental and Political (STEEP)

Decision Model Criteria Validation

The objective of this instrument is to finalize the list of criteria that should be used for each of the five social, technical, economic, and political (STEEP) perspectives to be used in the evaluation of Solar energy microwave artisanal mining of Sandstone from the viewpoint of selected experts. Please indicate below by marking with "X" on each criterion, whether or not it should be included. Also, please add additional criteria you consider important and your comments.

Q2 Please select your area of expertise. Multiple perspectives may be selected.

- Social Perspective (1)
- Technical Perspective (2)
- Economic Perspective (3)
- Environmental Perspective (4)
- Political Perspective (5)

Answer If social perspective is selected

Q3 Social Perspective Criteria	Yes (1)	No (2)
Job Creation - Job Creation is a top priority for many communities. Artisanal sandstone mining is a source of income for many communities in rural areas in South Africa. (1)	◯	◯
Safety and Protection - Normally miners have to wear safety shoes and protection gloves to protect themselves against cuts and injuries.(2)	◯	◯

Health Effects - During Artisanal mining of Sandstone, dusts are produced, and heavy stones are lifted resulting in long-term negative health effects.(3) ◯ ◯

Health Effects - During Operations and Processing Phase, Long-term negative health effects occurs due to dusts inhalation, water contamination and sun burn due to extensive exposure. (4) ◯ ◯

Additional Criteria or Comments (5)

	Yes (1)	No (2)
Answer If Technical Perspective Is Selected		

Q4 Technical Perspective: Criteria

Solar Energy Microwave activated Mining Efficiency (%) – The percentage increase in production due to increased efficiency. (1) ◯ ◯

Operational Sophistication - The level of skill required to mine using the Solar Energy Microwave activated mining equipment. The reduction in the percentage of manual labour expected from the miners. (2) ◯ ◯

Human Ergonomics - The level of interaction between the miners and the Solar energy Microwave activated mining equipment. (3) ◯ ◯

Training and Operations - The level of additional training required for the miners and the challenges during adaptation. (4) ◯ ◯

Usage of Hazardous Equipment (e.g. X-rays) – Usage of hazardous equipment may be an issue if there is accidental leakage or contact with the miners. (5) ◯ ◯

Maintenance Requirement - The level of maintenance required to ensure that Solar energy activated microwave mining equipment is in proper working condition. (6) ◯ ◯

Life of Solar energy Panel or microwave megaton This represents the duration of useful life of the Mining equipment. (7) ◯ ◯

Additional Criteria or Comments (8)

Answer If Economic Perspective Is Selected

Q5 Economic Perspective: Criteria

Total Cost of mining one tonne of Sandstone.- The operational cost of mining one metric tonne of Sandstone. (1)

Warranty/Maintenance Cost - Warranty may vary from 10 to 25 years with varying performance levels. To maintain the equipment at peak performance during the mining of sand stone. (2)

Disposal Cost - This is the disposal cost at end of life of the Solar energy Microwave activated mining equipment. (3)

Cost of Transportation of Sandstone rocks for processing - The cost of diesel and trucks used in the transportation of sandstone pre-dimensioned rocks. (4)

Return on Investment - Lifetime return on investment based on internal rate of return (IRR). (5)

Risk Assessment - This is the cost of risk in using Solar energy Microwave activated mining equipment. Risk may include cost of downtime/maintenance and the cleanup of negative environmental impact during operations such as leakage of microwave rays. (6)

Additional Criteria or Comments (7)

Answer If Environmental Perspective Is Selected

Q6 Environmental Perspective: Criteria

Emission of Greenhouse Gases During Production - Governments are encouraging sustainability and are restricting greenhouse gas (GHG) emission such CO2, NOx, and Sox. In the future utilities may consider this as a factor for evaluation of Solar Energy Microwave activated mining equipment. (1)

Negative Ecological Footprint - How much of a negative development will the Artisanal mining of Sandstone have on the underlying and surrounding crops, woods, water etc.? (2)

Use of Available Land In many parts of the world land is a scarce resource and better utilization by Artisanal miners is a consideration. (3)

Recyclability at End – of -Life - Disposal of Solar panels and microwaves parts at the end -of-life are more attractive if the component materials can be easily recycled. (4)

Waste Chemicals at End -of -Life - Waste chemicals may be released by the disposal of solar panels and Microwave parts hence these must be disposed of according to governing regulations. This would incur higher costs. (5)

Waste Gases at End -of -Life - Waste gases may be released by the disposal of Solar energy microwave activated mining equipment and hence these must be disposed of according to governing regulations. This would incur higher costs. (6)

Water Consumption During Operations - Water consumption may be required for cooling or cleaning during Sandstone processing operations.(7)

Consumption of Other Materials During Operations - Other materials may be consumed during operations. (8)

Additional Criteria or Comments (9)

Answer If Political Perspective Is Selected

Q7 Political Perspective: Criteria

Government Backing - Government support through financing, incentives, preferences, and general backing can affect the production and processing of Sandstone (1)

Local Sourcing - Certain countries (e.g. Lesotho) require partial local sourcing of dimensioned processed Sandstone. (2)

Conformance to Existing Political, Legal, and Management Constructs by Artisanal Miners are accustomed to established business or regulatory practices and change is difficult. (3)

Additional Criteria or Comments (4)

APPENDIX II: THE GENERAL QUESTIONNAIRE USED IN DATA COLLECTION OF STAGE ONE STUDY

<u>The General Questionnaire used in data collection of stage one study</u>

The researcher is pursuing a PhD study at the University of Johannesburg in Multiple perspective and hierarchical decision modelling as applied to new technologies used in artisanal mining and processing of sandstones in QwaQwa, Free State.

You are invited to participate in the above-mentioned study by providing the required information in order for this study to be successfully conducted.

All the information you provide will be used strictly for academic purposes only. Participation in this research is voluntary and your confidentiality will be safeguarded as the analysis will only focus on the patterns in the data over a number of informants. No names or information about any individual will be published or given to any other party.

1. Mine description and location:
   Specify the location and characteristics of the mining site --
   ----

2. Mine contact person:---
   ----

3. Occupation/position in the organisation:--
   ----

4. Do you think that artisanal sandstone mining has positive impacts on the surrounding community:
   Yes ☐ No ☐

   Please explain your response in detail ---
   ----

5. Are you aware of any environmental damages or health and Safety issues resulting from artisanal sandstone mining?
   Yes ☐ No ☐

   If yes, please name them:--
   ----

6. What are the possible way in which you could minimise the damages and issues named in (4) above? (please explain answer in detail)--
   ----

7. Do you think that artisanal sandstone mining has disturbed the local ecosystem?
   Yes ☐ No ☐

   If yes, please specify to what extent:

   1. Don't know ☐ 2. Insignificant ☐ 3.Small extent ☐ 4.great extent ☐

8. Do you think that artisanal sandstone mining has had a negative impact on the local visual landscape?

   Yes ☐ No ☐

   If yes, please indicate to what extent:

   1. Small impact ☐ 2.Medium impact ☐ 3.Great impact ☐

9. Are there any governmental policies and regulations that regulate artisanal sandstone miners' activities?

   1. Yes ☐ 2. No ☐ 3. Do not know ☐

   If yes, please specify --
   ----

10. Are artisanal sandstone miners involved in the drafting of these policies and regulation?

    Yes ☐ No ☐

11. Are Artisanal sandstone miners engage in any land rehabilitation activities?

    Yes ☐ No ☐

    If yes, please explain in detail ---
    ----

12. Who implements these rehabilitation activities? ---
    ----

13. Do you support the introduction of new technologies in the artisanal mining of Sandstone in QwaQwa

    Yes ☐ No ☐

    If yes: Please explain in detail the reasons for your support.---
    ----

14. What challenges do miners experience in implementing the rehabilitation strategies?-----------
    ----

15. Sandstone production:

    Indicate annual sandstone production for the last five years: (tonnes).

    2012---------------------------------------
    2013---------------------------------------
    2014---------------------------------------
    2015---------------------------------------
    2916---------------------------------------

15. Land use:

Please specify the size of land covered in each of the areas stated below: -------------------------
----

Name	Unit	Quality of Data (calculated/ estimated/measured)	Value
Extraction area			
Facilities area			
Overburden disposal area			
Total land use			

16. **Transportation distance:**

Transport	Unit	Quality of Data (calculated/ estimated/measured)	Average distance
On site transport			
External transport			
Total			

DATA COLLECTION QUESTIONAIRE FOR STAGE ONE OF THE STUDY

EMPLOYEE QUESTIONNAIRES

The researcher is pursuing a PhD study at the University of Johannesburg in Multiple perspective and hierarchical decision modelling as applied to new technologies used in artisanal mining and processing of sandstones in QwaQwa, Free State.

You are invited to participate in the above-mentioned study by providing the required information in order for this study to be successfully conducted.

All the information you provide will be used strictly for academic purposes only. Participation in this research is voluntary and your confidentiality will be safeguarded as the analysis will only focus on the patterns in the data over a number of informants. No names or information about any individual will be published or given to any other party.

1. How long have you been working in this organisation? -- --

2. Age: --

3. Gender: Male ☐ Female ☐

4. Indicate the approximate quantity of sandstone that you extract on a daily basis: (Kgs)-------- --

5. Life Style: (mark the appropriate answer with a cross).

   Leaving alone ☐ Leaving with family ☐

6. Household location (mark the appropriate answer with a cross).

   Leave in the nearby village ☐ Leave in miners camps ☐

7. How many hours do you work on a daily basis? ---

8. Do you smoke? (mark the appropriate answer with a cross).
   Yes ☐ No ☐

9. Alcohol consumption: (mark the appropriate answer with a cross).
   1. Great consumption ☐ 2. Low consumption ☐ 3. No alcohol ☐

10. How would you describe your general health before stating to work as a sandstone artisanal miner?
1. Good ☐ 2. Fair ☐ 3. Poor ☐

11. Please tick the adequate box if you have experienced the following heath issues since you started working at the mine:

Respirator problems	
Shortness of breath	
Cough	
Chest pain	
Musculoskeletal problems	
Back pain	
Muscle pain	
General tiredness	
Hearing problems	
Vision problems	
Skin infection	

12. How would you describe your general heath since you started working at the mine?
1. Good☐ 2. Fair☐ 3.Poor ☐

13. Do you support the introduction of new technologies in the artisanal mining of Sandstone in QwaQwa?
Yes ☐ No☐

If yes: Please explain in detail the reasons for your support?---
----

APPENDIX III: SAMPLE OF THE PAIRWISE COMPARISON QUESTIONNAIRE

<u>Sample of the pairwise comparison questionnaire for the five perspectives in the MCDM Model. [Option 01] (Social Perspective)</u>

The researcher is pursuing a PhD study at the University of Johannesburg in Multiple perspective and hierarchical decision modelling as applied to new technologies used in artisanal mining and processing of sandstones in QwaQwa, Free State.

You are invited to participate in the above mentioned study by providing the required information in order for this study to be successfully conducted.

All the information you provide will be used strictly for academic purposes only. Participation in this research is voluntary and your confidentiality will be safeguarded as the analysis will only focus on the patterns in the data over a number of informants. No names or information about any individual will be published or given to any other party.

Using the verbal scale description below compare the importance of the five perspectives with respect to the study goal which is the Comprehensive assessment of technologies used in the artisanal mining of sandstone. Please mark your preferred score on the subsequent tables shown below and also State the organisation you are working for: ____.

Extremely preferred	Very very strongly preferred	Very strongly preferred	Strongly plus preferred	Strongly preferred	Moderately plus preferred	Moderately preferred	Weakly or slightly preferred	Equal	Weakly or slightly preferred	Moderately preferred	Moderately plus preferred	Strongly preferred	Strongly plus preferred	Very strongly preferred	Very very strongly preferred	Extremely preferred
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Social Perspectives

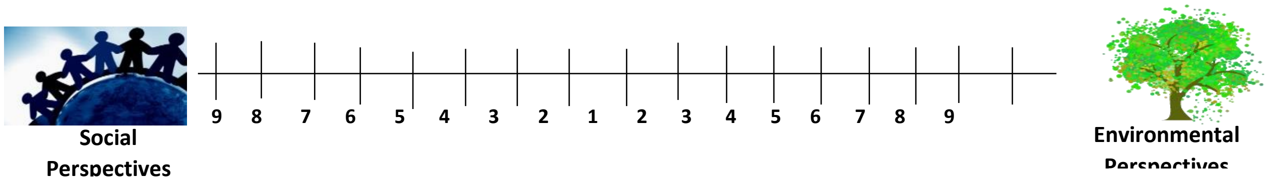
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

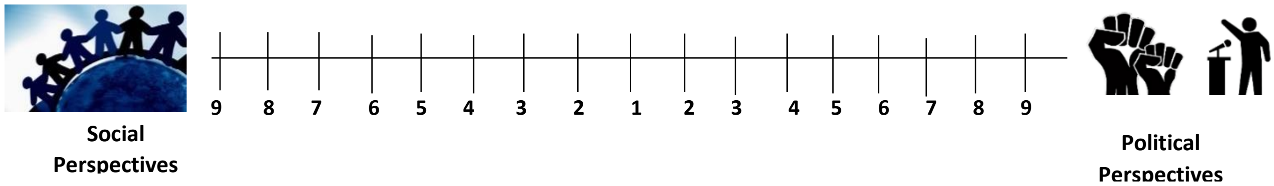
Technological Perspectives

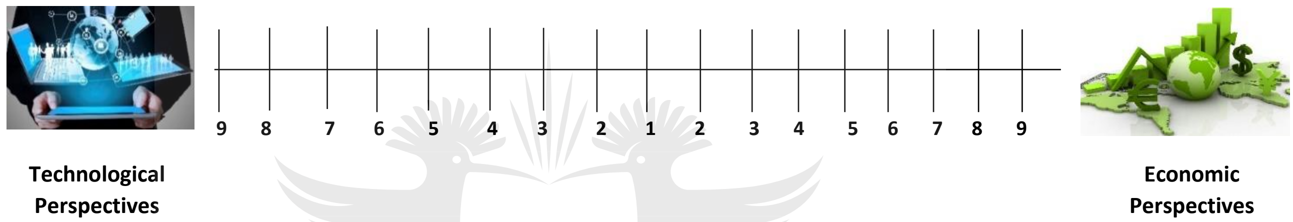
Social Perspectives

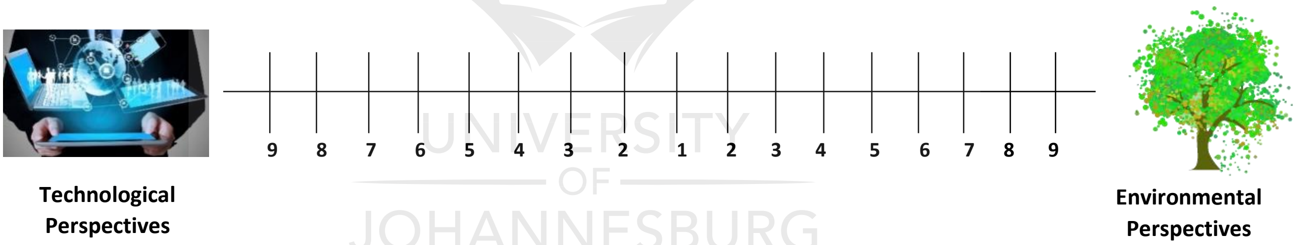
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

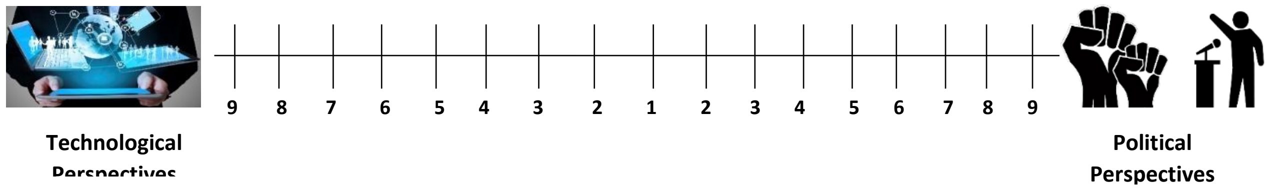
Economic Perspectives

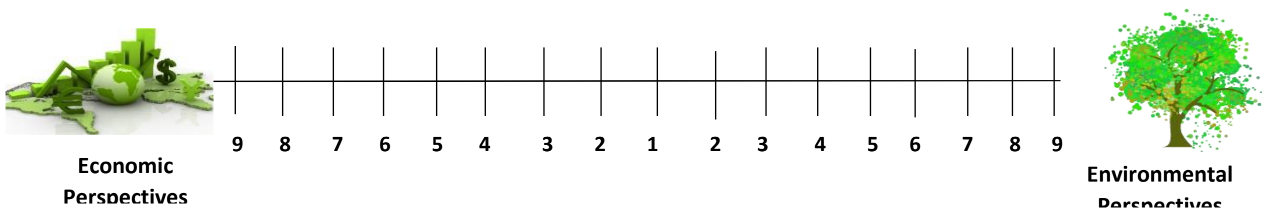

Social Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Environmental Perspectives

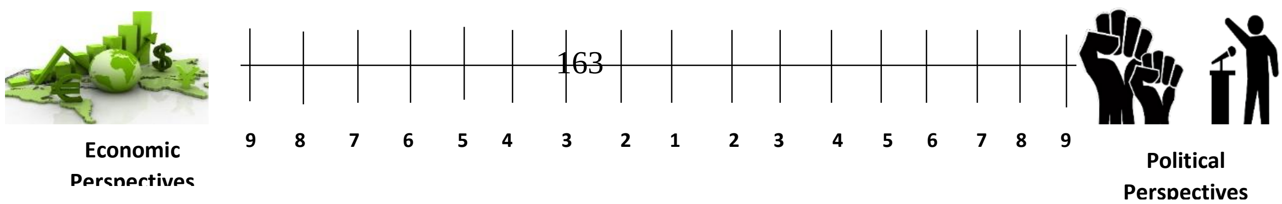

Social Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Political Perspectives

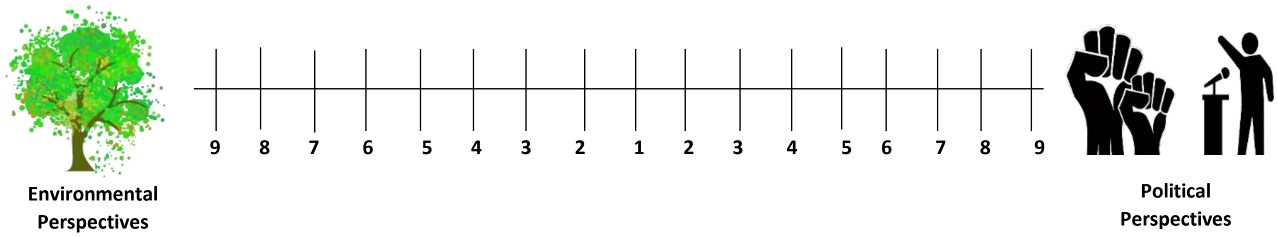

Technological Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Economic Perspectives


Technological Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Environmental Perspectives


Technological Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Political Perspectives


Economic Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Environmental Perspectives


Economic Perspectives
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9
Political Perspectives



[01] pairwise comparison of attributes in the social perspectives

The researcher is pursuing a PhD study at the University of Johannesburg in Multiple perspective and hierarchical decision modelling as applied to new technologies used in artisanal mining and processing of sandstones in QwaQwa, Free State.

You are invited to participate in the above-mentioned study by providing the required information in order for this study to be successfully conducted.

All the information you provide will be used strictly for academic purposes only. Participation in this research is voluntary and your confidentiality will be safeguarded as the analysis will only focus on the patterns in the data over a number of informants. No names or information about any individual will be published or given to any other party.

Using the verbal scale description below compare the importance of the ATTRIBUTES linked to the SOCIAL PERSPECTIVE used in the Comprehensive assessment of technologies used in the artisanal mining of sandstone. Please mark your preferred score on the tables below by comparing the two attributes shown at the extreme end of each table.

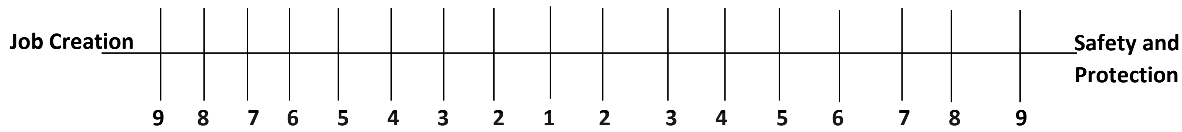
Please indicate your area of expertise by a cross if multiple:

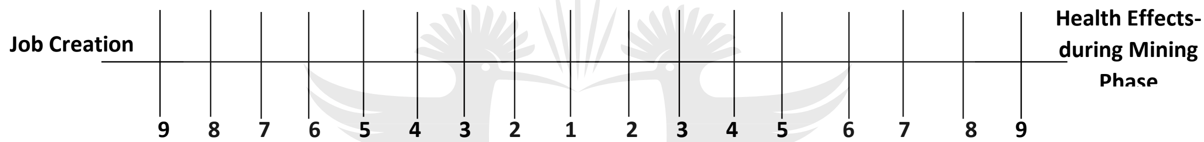
Social Perspective: ◯ Technological Perspective: ◯

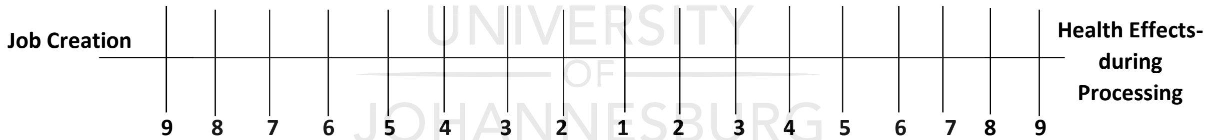
Economic Perspective: ◯ Environmental Perspective: ◯

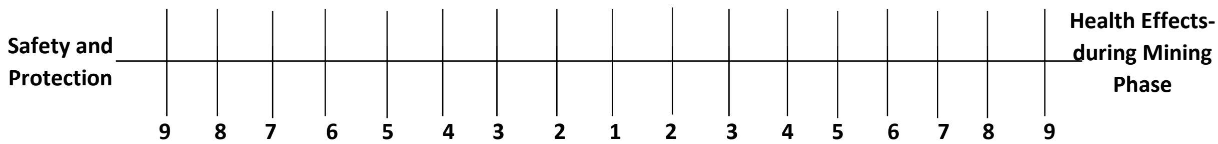
Political Perspective: ◯

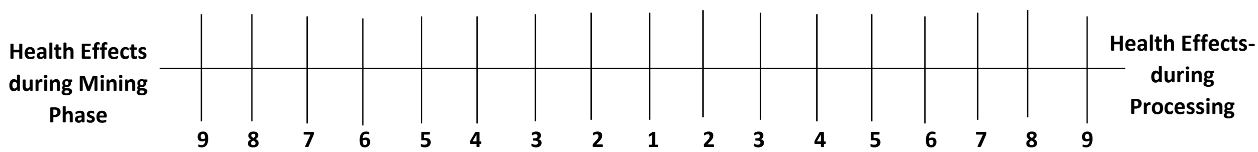
Extremely preferred	Very very strongly preferred	Very strongly preferred	Strongly plus preferred	Strongly preferred	Moderately plus preferred	Moderately preferred	Weakly or slightly preferred	Equal	Weakly or slightly preferred	Moderately preferred	Moderately plus preferred	Strongly preferred	Strongly plus preferred	Very strongly preferred	Very very strongly preferred	Extremely preferred


Job Creation
Safety and Protection
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9


Job Creation
Health Effects- during Mining Phase
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9


Job Creation
Health Effects- during Processing
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9


Safety and Protection
Health Effects- during Mining Phase
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9


Health Effects during Mining Phase
Health Effects- during Processing
9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

Pairwise comparison for social sub-perspectives (attributes) used in the MCDM

The researcher is pursuing a PhD study at the University of Johannesburg in Multiple perspective and hierarchical decision modelling as applied to new technologies used in artisanal mining and processing of sandstones in QwaQwa, Free State.

You are invited to participate in the above mentioned study by providing the required information in order for this study to be successfully conducted.

All the information you provide will be used strictly for academic purposes only. Participation in this research is voluntary and your confidentiality will be safeguarded as the analysis will only focus on the patterns in the data over a number of informants. No names or information about any individual will be published or given to any other party.

Using the verbal scale description below compare the importance of the MINING ALTERNATIVES with respect to SOCIAL SUB- PERSPECTIVE (attributes) used in the Comprehensive assessment of technologies as applied to the artisanal mining of sandstone. Please mark your preferred score on the tables below by comparing the two alternatives shown at the extreme end of each table.

Extremely preferred	**Very very strongly preferred**	**Very strongly preferred**	**Strongly plus preferred**	**Strongly preferred**	**Moderately plus preferred**	**Moderately preferred**	**Weakly or slightly preferred**	**Equal**	**Weakly or slightly preferred**	**Moderately preferred**	**Moderately plus preferred**	**Strongly preferred**	**Strongly plus preferred**	**Very strongly preferred**	**Very very strongly preferred**	**Extremely preferred**
9	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

Compare the importance of the alternatives with respect to <u>job creation</u>

Solar Energy Triggered Microwave Mining	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Manual Chisel and Hammer Mining**
Solar Energy Triggered Microwave Mining	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Preservation and no mining activities**

Manual Chisel and Hammer Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservation and no mining

Compare the importance on the alternatives with respect to <u>safety and protection</u>

Solar Energy Triggered Microwave Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Manual Chisel and Hammer Mining
Solar Energy Triggered Microwave Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservation and no mining activities
Manual Chisel and Hammer Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservati on and no mining activities

Compare the alternatives importance with respect to <u>health effects during operational mining phase</u>

Solar Energy Triggered Microwave Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Manual Chisel and Hammer Mining
Solar Energy Triggered Microwave Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservation and no mining activities
Manual Chisel and Hammer Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservation and no mining activities

Compare the alternatives importance with respect to <u>health effects during the sandstone-processing phase</u>

Solar Energy Triggered Microwave Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Manual Chisel and Hammer Mining

Solar Energy Triggered Microwave Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservation and no mining activities

Manual Chisel and Hammer Mining	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Preservation and no mining activities

APPENDIX IV: THE MATRICES OF PERSPECTIVES COMPAIRED WITH RESPECT TO THE GOAL

THE MATRICES OF PERSPECTIVES COMPAIRED WITH RESPECT TO THE GOAL

Pairwise comparison by Technology experts Compared with respect to Goal.

Pairwise comparison matrix for perspective to goal (1)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.14	0.17	0.14	1.00
Technological	7.00	1.00	2.00	0.25	6.00
Economical	6.00	0.50	1.00	0.50	3.00
Environmental	7.00	4.00	2.00	1.00	8.00
Political	1.00	0.17	0.33	0.13	1.00
Sum	22.00	5.81	5.50	2.02	19.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.05	0.02	0.03	0.07	0.05	**0.0448**
Technological	0.32	0.17	0.36	0.12	0.32	**0.2587**
Economical	0.27	0.09	0.18	0.25	0.16	**0.1893**
Environmental	0.32	0.69	0.36	0.50	0.42	**0.4574**
Political	0.05	0.03	0.06	0.06	0.05	**0.0499**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.399015
Consistency Index (CI)	0.099754
Consistency Ratio (CR)	0.0891

Pairwise comparison matrix for perspective to goal (2)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	2.00	2.00	3.00
Technological	0.50	1.00	2.00	3.00	5.00
Economical	0.50	0.50	1.00	2.00	1.00
Environmental	0.50	0.33	0.50	1.00	3.00
Political	0.33	0.20	1.00	0.33	1.00
Sum	2.83	4.03	6.50	8.33	13.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**

Social	0.35	0.50	0.31	0.24	0.23	**0.3255**
Technological	0.18	0.25	0.31	0.36	0.38	**0.2953**
Economical	0.18	0.12	0.15	0.24	0.08	**0.1542**
Environmental	0.18	0.08	0.08	0.12	0.23	**0.1374**
Political	0.12	0.05	0.15	0.04	0.08	**0.0876**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.39939
Consistency Index (CI)	0.099848
Consistency Ratio (CR)	0.0891

Pairwise comparison matrix for perspective to goal (3)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	1.00	0.20	1.00	2.00
Technological	1.00	1.00	0.50	1.00	2.00
Economical	5.00	2.00	1.00	3.00	3.00
Environmental	1.00	1.00	0.33	1.00	5.00
Political	0.50	0.50	0.33	0.20	1.00
Sum	8.50	5.50	2.37	6.20	13.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.12	0.18	0.08	0.16	0.15	**0.1398**
Technological	0.12	0.18	0.21	0.16	0.15	**0.1652**
Economical	0.59	0.36	0.42	0.48	0.23	**0.4178**
Environmental	0.12	0.18	0.14	0.16	0.38	**0.1972**
Political	0.06	0.09	0.14	0.03	0.08	**0.0800**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.348038
Consistency Index (CI)	0.087009
Consistency Ratio (CR)	0.0777

Pairwise comparison matrix for perspective to goal (4)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	0.33	0.20	3.00
Technological	3.00	1.00	1.00	0.17	3.00
Economical	3.00	1.00	1.00	0.20	3.00
Environmental	5.00	6.00	5.00	1.00	8.00
Political	0.33	0.33	0.33	0.13	1.00
Sum	12.33	8.67	7.67	1.69	18.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.08	0.04	0.04	0.12	0.17	**0.0896**
Technological	0.24	0.12	0.13	0.10	0.17	**0.1509**
Economical	0.24	0.12	0.13	0.12	0.17	**0.1548**
Environmental	0.41	0.69	0.65	0.59	0.44	**0.5571**
Political	0.03	0.04	0.04	0.07	0.06	**0.0477**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.399662
Consistency Index (CI)	0.099916
Consistency Ratio (CR)	0.0892

Pairwise comparison matrix for perspective to goal (5)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	1.00	1.00	1.00
Technological	0.50	1.00	0.50	1.00	1.00
Economical	1.00	2.00	1.00	1.00	0.33
Environmental	1.00	1.00	1.00	1.00	0.33
Political	1.00	1.00	3.00	3.00	1.00
Sum	4.50	7.00	6.50	7.00	3.67

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.22	0.29	0.15	0.14	0.27	**0.2155**
Technological	0.11	0.14	0.08	0.14	0.27	**0.1493**
Economical	0.22	0.29	0.15	0.14	0.09	**0.1791**
Environmental	0.22	0.14	0.15	0.14	0.09	**0.1505**
Political	0.22	0.14	0.46	0.43	0.27	**0.3056**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.353151
Consistency Index (CI)	0.088288
Consistency Ratio (CR)	0.0788

Pairwise comparison matrix for perspective to goal (6)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	2.00	6.00	6.00
Technological	0.33	1.00	2.00	3.00	7.00
Economical	0.50	0.50	1.00	4.00	7.00

Environmental	0.17	0.33	0.25	1.00	4.00
Political	0.17	0.14	0.14	0.25	1.00
Sum	2.17	4.98	5.39	14.25	25.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.46	0.60	0.37	0.42	0.24	**0.4193**
Technological	0.15	0.20	0.37	0.21	0.28	**0.2432**
Economical	0.23	0.10	0.19	0.28	0.28	**0.2155**
Environmental	0.08	0.07	0.05	0.07	0.16	**0.0841**
Political	0.08	0.03	0.03	0.02	0.04	**0.0379**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.427421
Consistency Index (CI)	0.106855
Consistency Ratio (CR)	0.0954

Pairwise comparison matrix for perspective to goal (7)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.25	0.20	0.17	1.00
Technological	4.00	1.00	0.25	0.25	2.00
Economical	5.00	4.00	1.00	1.00	5.00
Environmental	6.00	4.00	1.00	1.00	6.00
Political	1.00	0.50	0.20	0.17	1.00
Sum	17.00	9.75	2.65	2.58	15.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.06	0.03	0.08	0.06	0.07	**0.0582**
Technological	0.24	0.10	0.09	0.10	0.13	**0.1325**
Economical	0.29	0.41	0.38	0.39	0.33	**0.3604**
Environmental	0.35	0.41	0.38	0.39	0.40	**0.3855**
Political	0.06	0.05	0.08	0.06	0.07	**0.0634**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.182681
Consistency Index (CI)	0.04567

Consistency Ratio (CR)	0.0408

Pairwise comparison matrix for perspective to goal (8)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.17	0.17	0.20	3.00
Technological	6.00	1.00	3.00	2.00	7.00
Economical	6.00	0.33	1.00	0.50	6.00
Environmental	5.00	0.50	2.00	1.00	7.00
Political	0.33	0.14	0.17	0.14	1.00
Sum	18.33	2.14	6.33	3.84	24.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.05	0.08	0.03	0.05	0.13	**0.0671**
Technological	0.33	0.47	0.47	0.52	0.29	**0.4159**
Economical	0.33	0.16	0.16	0.13	0.25	**0.2042**
Environmental	0.27	0.23	0.32	0.26	0.29	**0.2747**
Political	0.02	0.07	0.03	0.04	0.04	**0.0380**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.383057
Consistency Index (CI)	0.095764
Consistency Ratio (CR)	0.0855

Pairwise comparison matrix for perspective to goal (9)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	2.00	2.00	2.00
Technological	0.33	1.00	1.00	0.33	2.00
Economical	0.50	1.00	1.00	0.50	3.00
Environmental	0.50	3.00	2.00	1.00	5.00
Political	0.50	0.50	0.33	0.20	1.00
Sum	2.83	8.50	6.33	4.03	13.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.35	0.35	0.32	0.50	0.15	**0.3343**
Technological	0.12	0.12	0.16	0.08	0.15	**0.1259**
Economical	0.18	0.12	0.16	0.12	0.23	**0.1613**
Environmental	0.18	0.35	0.32	0.25	0.38	**0.2956**

Political	0.18	0.06	0.05	0.05	0.08	**0.0829**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.30904
Consistency Index (CI)	0.07726
Consistency Ratio (CR)	0.0690

Pairwise comparison matrix for perspective to goal (10)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.20	0.13	0.17	0.13
Technological	5.00	1.00	0.33	2.00	0.25
Economical	8.00	3.00	1.00	3.00	0.50
Environmental	6.00	0.50	0.33	1.00	0.17
Political	8.00	4.00	2.00	6.00	1.00
Sum	28.00	8.70	3.79	12.17	2.04

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.04	0.02	0.03	0.01	0.06	**0.0333**
Technological	0.18	0.11	0.09	0.16	0.12	**0.1337**
Economical	0.29	0.34	0.26	0.25	0.24	**0.2772**
Environmental	0.21	0.06	0.09	0.08	0.08	**0.1047**
Political	0.29	0.46	0.53	0.49	0.49	**0.4512**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.341547
Consistency Index (CI)	0.085387
Consistency Ratio (CR)	0.0762

Pairwise comparison matrix for perspective to goal (11)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.20	0.20	0.50	5.00
Technological	5.00	1.00	1.00	1.00	5.00
Economical	5.00	1.00	1.00	1.00	5.00
Environmental	2.00	1.00	1.00	1.00	5.00
Political	0.20	0.20	0.20	0.20	1.00
Sum	13.20	3.40	3.40	3.70	21.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**

Social	0.08	0.06	0.06	0.14	0.24	**0.1133**
Technological	0.38	0.29	0.29	0.27	0.24	**0.2951**
Economical	0.38	0.29	0.29	0.27	0.24	**0.2951**
Environmental	0.15	0.29	0.29	0.27	0.24	**0.2496**
Political	0.02	0.06	0.06	0.05	0.05	**0.0469**
Sum	1.00	1.00	1.00	0.30	1.00	

Principal Eigen Value	5.410832
Consistency Index (CI)	0.102708
Consistency Ratio (CR)	0.0917

Pairwise comparison matrix for perspective to goal (12)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	1.00	1.00	1.00	5.00
Technological	1.00	1.00	1.00	1.00	5.00
Economical	1.00	1.00	1.00	1.00	8.00
Environmental	1.00	1.00	1.00	1.00	9.00
Political	0.20	0.20	0.13	0.11	1.00
Sum	4.20	4.20	4.13	4.11	28.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.24	0.24	0.24	0.24	0.18	**0.2281**
Technological	0.24	0.24	0.24	0.24	0.18	**0.2281**
Economical	0.24	0.24	0.24	0.24	0.29	**0.2495**
Environmental	0.24	0.24	0.24	0.24	0.32	**0.2567**
Political	0.05	0.05	0.03	0.03	0.04	**0.0377**
Sum	1.00	1.00	1.00	0.34	1.00	

Principal Eigen Value	5.054697
Consistency Index (CI)	0.013674
Consistency Ratio (CR)	0.0122

Pairwise comparison by Social Scientist experts Compared with respect to Goal.

Pairwise comparison matrix for perspective to goal (1)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	3.00	3.00	0.20
Technological	0.50	1.00	2.00	3.00	0.20

Economical	0.33	0.50	1.00	3.00	0.25
Environmental	0.33	0.33	0.33	1.00	0.17
Political	5.00	5.00	4.00	6.00	1.00
Sum	7.17	8.83	10.33	16.00	1.82

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.14	0.23	0.29	0.19	0.11	**0.1908**
Technological	0.07	0.11	0.19	0.19	0.11	**0.1348**
Economical	0.05	0.06	0.10	0.19	0.14	**0.1050**
Environmental	0.05	0.04	0.03	0.06	0.09	**0.0541**
Political	0.70	0.57	0.39	0.38	0.55	**0.5153**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.445591
Consistency Index (CI)	0.111398
Consistency Ratio (CR)	0.0995

Pairwise comparison matrix for perspective to goal (2)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	0.33	2.00	0.25
Technological	0.33	1.00	0.33	2.00	0.33
Economical	3.00	3.00	1.00	3.00	0.50
Environmental	0.50	0.50	0.33	1.00	0.25
Political	4.00	3.00	2.00	4.00	1.00
Sum	8.83	10.50	4.00	12.00	2.33

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.11	0.29	0.08	0.17	0.11	**0.1512**
Technological	0.04	0.10	0.08	0.17	0.14	**0.1052**
Economical	0.34	0.29	0.25	0.25	0.21	**0.2679**
Environmental	0.06	0.05	0.08	0.08	0.11	**0.0756**
Political	0.45	0.29	0.50	0.33	0.43	**0.4001**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.352478
Consistency Index (CI)	0.08812
Consistency Ratio (CR)	0.0787

Pairwise comparison matrix for perspective to goal (3)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.50	4.00	2.00	0.50
Technological	2.00	1.00	5.00	2.00	3.00
Economical	0.25	0.20	1.00	0.33	0.33
Environmental	0.50	0.50	3.00	1.00	2.00
Political	2.00	0.33	3.00	0.50	1.00
Sum	5.75	2.53	16.00	5.83	6.83

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.17	0.20	0.25	0.34	0.07	**0.2075**
Technological	0.35	0.39	0.31	0.34	0.44	**0.3674**
Economical	0.04	0.08	0.06	0.06	0.05	**0.0582**
Environmental	0.09	0.20	0.19	0.17	0.29	**0.1872**
Political	0.35	0.13	0.19	0.09	0.15	**0.1798**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.374847
Consistency Index (CI)	0.093712
Consistency Ratio (CR)	0.0837

Pairwise comparison matrix for perspective to goal (4)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	4.00	2.00	0.50
Technological	0.33	1.00	3.00	0.25	0.25
Economical	0.25	0.33	1.00	0.50	0.33
Environmental	0.50	4.00	2.00	1.00	0.50
Political	2.00	4.00	3.00	2.00	1.00
Sum	4.08	12.33	13.00	5.75	2.58

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.24	0.24	0.31	0.35	0.19	**0.2674**
Technological	0.08	0.08	0.23	0.04	0.10	**0.1067**
Economical	0.06	0.03	0.08	0.09	0.13	**0.0762**
Environmental	0.12	0.32	0.15	0.17	0.19	**0.1936**
Political	0.49	0.32	0.23	0.35	0.39	**0.3560**

Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.432488
Consistency Index (CI)	0.108122
Consistency Ratio (CR)	0.0965

Pairwise comparison matrix for perspective to goal (5)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	6.00	3.00	3.00	3.00
Technological	0.17	1.00	1.00	0.25	2.00
Economical	0.33	1.00	1.00	0.50	2.00
Environmental	0.33	4.00	2.00	1.00	3.00
Political	0.33	0.50	0.50	0.33	1.00
Sum	2.17	12.50	7.50	5.08	11.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.46	0.48	0.40	0.59	0.27	**0.4409**
Technological	0.08	0.08	0.13	0.05	0.18	**0.1043**
Economical	0.15	0.08	0.13	0.10	0.18	**0.1295**
Environmental	0.15	0.32	0.27	0.20	0.27	**0.2420**
Political	0.15	0.04	0.07	0.07	0.09	**0.0834**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.376946
Consistency Index (CI)	0.094236
Consistency Ratio (CR)	0.0841

Pairwise comparison matrix for perspective to goal (6)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	5.00	0.33	6.00	0.50
Technological	0.20	1.00	0.20	1.00	0.25
Economical	3.00	5.00	1.00	5.00	3.00
Environmental	0.17	1.00	0.20	1.00	0.20
Political	2.00	4.00	0.33	5.00	1.00
Sum	6.37	16.00	2.07	18.00	4.95

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**

Social	0.16	0.31	0.16	0.33	0.10	**0.2130**
Technological	0.03	0.06	0.10	0.06	0.05	**0.0593**
Economical	0.47	0.31	0.48	0.28	0.61	**0.4303**
Environmental	0.03	0.06	0.10	0.06	0.04	**0.0563**
Political	0.31	0.25	0.16	0.28	0.20	**0.2410**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.401457
Consistency Index (CI)	0.100364
Consistency Ratio (CR)	0.0896

Pairwise comparison matrix for perspective to goal (7)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	4.00	3.00	3.00	4.00
Technological	0.25	1.00	2.00	2.00	2.00
Economical	0.33	0.50	1.00	2.00	4.00
Environmental	0.33	0.50	0.50	1.00	3.00
Political	0.25	0.50	0.25	0.33	1.00
Sum	2.17	6.50	6.75	8.33	14.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.46	0.62	0.44	0.36	0.29	**0.4334**
Technological	0.12	0.15	0.30	0.24	0.14	**0.1897**
Economical	0.15	0.08	0.15	0.24	0.29	**0.1809**
Environmental	0.15	0.08	0.07	0.12	0.21	**0.1278**
Political	0.12	0.08	0.04	0.04	0.07	**0.0682**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.412601
Consistency Index (CI)	0.10315
Consistency Ratio (CR)	0.0921

Pairwise comparison matrix for perspective to goal (8)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	0.50	1.00	2.00
Technological	0.50	1.00	0.50	1.00	2.00
Economical	2.00	2.00	1.00	1.00	2.00
Environmental	1.00	1.00	1.00	1.00	2.00

Political	0.50	0.50	0.50	0.50	1.00
Sum	5.00	6.50	3.50	4.50	9.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.20	0.31	0.14	0.22	0.22	**0.2190**
Technological	0.10	0.15	0.14	0.22	0.22	**0.1682**
Economical	0.40	0.31	0.29	0.22	0.22	**0.2876**
Environmental	0.20	0.15	0.29	0.22	0.22	**0.2168**
Political	0.10	0.08	0.14	0.11	0.11	**0.1084**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.14619
Consistency Index (CI)	0.036548
Consistency Ratio (CR)	0.0326

Pairwise comparison matrix for perspective to goal (9)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.25	0.25	0.20	1.00
Technological	4.00	1.00	1.00	1.00	4.00
Economical	4.00	1.00	1.00	1.00	4.00
Environmental	5.00	1.00	1.00	1.00	4.00
Political	1.00	0.25	0.25	0.25	1.00
Sum	15.00	3.50	3.50	3.45	14.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.07	0.07	0.07	0.06	0.07	**0.0678**
Technological	0.27	0.29	0.29	0.29	0.29	**0.2827**
Economical	0.27	0.29	0.29	0.29	0.29	**0.2827**
Environmental	0.33	0.29	0.29	0.29	0.29	**0.2961**
Political	0.07	0.07	0.07	0.07	0.07	**0.0707**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.006894
Consistency Index (CI)	0.001724
Consistency Ratio (CR)	0.0015

Pairwise comparison matrix for perspective to goal (10)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.25	0.25	0.20	2.00

Technological	4.00	1.00	1.00	0.25	4.00
Economical	4.00	1.00	1.00	0.33	4.00
Environmental	5.00	4.00	3.00	1.00	4.00
Political	0.50	0.25	0.25	0.25	1.00
Sum	14.50	6.50	5.50	2.03	15.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.07	0.04	0.05	0.10	0.13	**0.0769**
Technological	0.28	0.15	0.18	0.12	0.27	**0.2002**
Economical	0.28	0.15	0.18	0.16	0.27	**0.2084**
Environmental	0.34	0.62	0.55	0.49	0.27	**0.4528**
Political	0.03	0.04	0.05	0.12	0.07	**0.0616**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.407894
Consistency Index (CI)	0.101974
Consistency Ratio (CR)	0.0910

Pairwise comparison matrix for perspective to goal (11)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	3.00	2.00	3.00
Technological	0.33	1.00	2.00	2.00	1.00
Economical	0.33	0.50	1.00	2.00	2.00
Environmental	0.50	0.50	0.50	1.00	2.00
Political	0.33	1.00	0.50	0.50	1.00
Sum	2.50	6.00	7.00	7.50	9.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.40	0.50	0.43	0.27	0.33	**0.3857**
Technological	0.13	0.17	0.29	0.27	0.11	**0.1927**
Economical	0.13	0.08	0.14	0.27	0.22	**0.1697**
Environmental	0.20	0.08	0.07	0.13	0.22	**0.1421**
Political	0.13	0.17	0.07	0.07	0.11	**0.1098**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.362302
Consistency Index (CI)	0.090575

Consistency Ratio (CR)	0.0809

Pairwise comparison matrix for perspective to goal (12)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	4.00	2.00	6.00	7.00
Technological	0.25	1.00	2.00	2.00	6.00
Economical	0.50	0.50	1.00	3.00	6.00
Environmental	0.17	0.50	0.33	1.00	3.00
Political	0.14	0.17	0.17	0.33	1.00
Sum	2.06	6.17	5.50	12.33	23.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.49	0.65	0.36	0.49	0.30	**0.4577**
Technological	0.12	0.16	0.36	0.16	0.26	**0.2140**
Economical	0.24	0.08	0.18	0.24	0.26	**0.2020**
Environmental	0.08	0.08	0.06	0.08	0.13	**0.0868**
Political	0.07	0.03	0.03	0.03	0.04	**0.0394**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.35138
Consistency Index (CI)	0.087845
Consistency Ratio (CR)	0.0784

Pairwise comparison by Economic experts Compared with respect to Goal.

Pairwise comparison matrix for perspective to goal (1)

Criteria	Social	Technological	Economical	Environme6ntal	Political
Social	1.00	0.25	0.50	2.00	0.14
Technological	4.00	1.00	4.00	7.00	0.50
Economical	2.00	0.25	1.00	2.00	0.25
Environmental	0.50	0.14	0.50	1.00	0.33
Political	7.00	2.00	4.00	3.00	1.00
Sum	14.50	3.64	10.00	15.00	2.23

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.07	0.07	0.05	0.13	0.06	**0.0770**
Technological	0.28	0.27	0.40	0.47	0.22	**0.3283**
Economical	0.14	0.07	0.10	0.13	0.11	**0.1104**
Environmental	0.03	0.04	0.05	0.07	0.15	**0.0680**

Political	0.48	0.55	0.40	0.20	0.45	**0.4162**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.364038
Consistency Index (CI)	0.09101
Consistency Ratio (CR)	0.0813

Pairwise comparison matrix for perspective to goal (2)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	1.00	0.13	1.00	1.00
Technological	1.00	1.00	0.13	1.00	1.00
Economical	8.00	8.00	1.00	5.00	9.00
Environmental	1.00	1.00	0.20	1.00	1.00
Political	1.00	1.00	0.11	1.00	1.00
Sum	12.00	12.00	1.56	9.00	13.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.08	0.08	0.08	0.11	0.08	**0.0870**
Technological	0.08	0.08	0.08	0.11	0.08	**0.0870**
Economical	0.67	0.67	0.64	0.56	0.69	**0.6444**
Environmental	0.08	0.08	0.13	0.11	0.08	**0.0966**
Political	0.08	0.08	0.07	0.11	0.08	**0.0852**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.069155
Consistency Index (CI)	0.017289
Consistency Ratio (CR)	0.0154

Pairwise comparison matrix for perspective to goal (3)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	5.00	0.20	0.17	0.17
Technological	0.20	1.00	0.13	0.17	0.20
Economical	5.00	8.00	1.00	1.00	1.00
Environmental	6.00	6.00	1.00	1.00	1.00
Political	6.00	5.00	1.00	1.00	1.00
Sum	18.20	25.00	3.33	3.33	3.37

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.05	0.20	0.06	0.05	0.05	**0.0829**

Technological	0.01	0.04	0.04	0.05	0.06	**0.0396**
Economical	0.27	0.32	0.30	0.30	0.30	**0.2985**
Environmental	0.33	0.24	0.30	0.30	0.30	**0.2935**
Political	0.33	0.20	0.30	0.30	0.30	**0.2855**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.431059
Consistency Index (CI)	0.107765
Consistency Ratio (CR)	0.0962

Pairwise comparison matrix for perspective to goal (4)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.50	0.20	0.50	0.50
Technological	2.00	1.00	0.20	0.50	0.50
Economical	5.00	5.00	1.00	0.50	2.00
Environmental	2.00	2.00	2.00	1.00	2.00
Political	2.00	2.00	0.50	0.50	1.00
Sum	12.00	10.50	3.90	3.00	6.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.08	0.05	0.05	0.17	0.08	**0.0864**
Technological	0.17	0.10	0.05	0.17	0.08	**0.1126**
Economical	0.42	0.48	0.26	0.17	0.33	**0.3299**
Environmental	0.17	0.19	0.51	0.33	0.33	**0.3073**
Political	0.17	0.19	0.13	0.17	0.17	**0.1637**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.410879
Consistency Index (CI)	0.10272
Consistency Ratio (CR)	0.0917

Pairwise comparison matrix for perspective to goal (5)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	7.00	4.00	2.00	1.00
Technological	0.14	1.00	0.20	0.25	0.14
Economical	0.25	5.00	1.00	0.25	0.17
Environmental	0.50	4.00	4.00	1.00	0.33
Political	1.00	7.00	6.00	3.00	1.00

Sum	2.89	24.00	15.20	6.50	2.64

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.35	0.29	0.26	0.31	0.38	**0.3173**
Technological	0.05	0.04	0.01	0.04	0.05	**0.0393**
Economical	0.09	0.21	0.07	0.04	0.06	**0.0924**
Environmental	0.17	0.17	0.26	0.15	0.13	**0.1765**
Political	0.35	0.29	0.39	0.46	0.38	**0.3744**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.403813
Consistency Index (CI)	0.100953
Consistency Ratio (CR)	0.0901

Pairwise comparison matrix for perspective to goal (6)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	0.33	0.11	0.17
Technological	0.50	1.00	0.33	0.17	0.13
Economical	3.00	3.00	1.00	0.25	0.17
Environmental	9.00	6.00	4.00	1.00	2.00
Political	6.00	8.00	6.00	0.50	1.00
Sum	19.50	20.00	11.67	2.03	3.46

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.05	0.10	0.03	0.05	0.05	**0.0566**
Technological	0.03	0.05	0.03	0.08	0.04	**0.0445**
Economical	0.15	0.15	0.09	0.12	0.05	**0.1122**
Environmental	0.46	0.30	0.34	0.49	0.58	**0.4352**
Political	0.31	0.40	0.51	0.25	0.29	**0.3515**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.400551
Consistency Index (CI)	0.100138
Consistency Ratio (CR)	0.0894

Pairwise comparison matrix for perspective to goal (7)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	0.50	0.25	6.00

Technological	3.00	1.00	1.00	1.00	6.00
Economical	2.00	1.00	1.00	1.00	5.00
Environmental	4.00	1.00	1.00	1.00	7.00
Political	0.17	0.17	0.20	0.14	1.00
Sum	10.17	3.50	3.70	3.39	25.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.10	0.10	0.14	0.07	0.24	**0.1285**
Technological	0.30	0.29	0.27	0.29	0.24	**0.2772**
Economical	0.20	0.29	0.27	0.29	0.20	**0.2495**
Environmental	0.39	0.29	0.27	0.29	0.28	**0.3048**
Political	0.02	0.05	0.05	0.04	0.04	**0.0400**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.234533
Consistency Index (CI)	0.058633
Consistency Ratio (CR)	0.0524

Pairwise comparison matrix for perspective to goal (8)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	5.00	1.00	1.00	6.00
Technological	0.20	1.00	0.17	0.20	5.00
Economical	1.00	6.00	1.00	1.00	7.00
Environmental	1.00	5.00	1.00	1.00	5.00
Political	0.17	0.20	0.14	0.20	1.00
Sum	3.37	17.20	3.31	3.40	24.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.30	0.29	0.30	0.29	0.25	**0.2868**
Technological	0.06	0.06	0.05	0.06	0.21	**0.0870**
Economical	0.30	0.35	0.30	0.29	0.29	**0.3068**
Environmental	0.30	0.29	0.30	0.29	0.21	**0.2785**
Political	0.05	0.01	0.04	0.06	0.04	**0.0410**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.407185
Consistency Index (CI)	0.101796
Consistency Ratio (CR)	0.0909

Pairwise comparison matrix for perspective to goal (9)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	3.00	1.00	7.00
Technological	0.50	1.00	3.00	0.25	4.00
Economical	0.33	0.33	1.00	0.33	7.00
Environmental	1.00	4.00	3.00	1.00	7.00
Political	0.14	0.25	0.14	0.14	1.00
Sum	2.98	7.58	10.14	2.73	26.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.34	0.26	0.30	0.37	0.27	**0.3063**
Technological	0.17	0.13	0.30	0.09	0.15	**0.1682**
Economical	0.11	0.04	0.10	0.12	0.27	**0.1292**
Environmental	0.34	0.53	0.30	0.37	0.27	**0.3591**
Political	0.05	0.03	0.01	0.05	0.04	**0.0372**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.443622
Consistency Index (CI)	0.110905
Consistency Ratio (CR)	0.0990

Pairwise comparison matrix for perspective to goal (10)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	3.00	0.25	4.00
Technological	3.00	1.00	2.00	0.25	3.00
Economical	0.33	0.50	1.00	0.25	2.00
Environmental	4.00	4.00	4.00	1.00	9.00
Political	0.25	0.33	0.50	0.11	1.00
Sum	8.58	6.17	10.50	1.86	19.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.12	0.05	0.29	0.13	0.21	**0.1602**
Technological	0.35	0.16	0.19	0.13	0.16	**0.1989**
Economical	0.04	0.08	0.10	0.13	0.11	**0.0909**
Environmental	0.47	0.65	0.38	0.54	0.47	**0.5013**
Political	0.03	0.05	0.05	0.06	0.05	**0.0486**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.413554
Consistency Index (CI)	0.103389
Consistency Ratio (CR)	0.0923

Pairwise comparison matrix for perspective to goal (11)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	1.00	2.00	0.20	5.00
Technological	1.00	1.00	1.00	0.20	2.00
Economical	0.50	1.00	1.00	0.20	5.00
Environmental	5.00	5.00	5.00	1.00	7.00
Political	0.20	0.50	0.20	0.14	1.00
Sum	7.70	8.50	9.20	1.74	20.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.13	0.12	0.22	0.11	0.25	**0.1659**
Technological	0.13	0.12	0.11	0.11	0.10	**0.1142**
Economical	0.06	0.12	0.11	0.11	0.25	**0.1312**
Environmental	0.65	0.59	0.54	0.57	0.35	**0.5410**
Political	0.03	0.06	0.02	0.08	0.05	**0.0477**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.352267
Consistency Index (CI)	0.088067
Consistency Ratio (CR)	0.0786

Pairwise comparison matrix for perspective to goal (12)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	2.00	0.20	3.00
Technological	0.50	1.00	2.00	0.33	5.00
Economical	0.50	0.50	1.00	0.17	4.00
Environmental	5.00	3.00	6.00	1.00	7.00
Political	0.33	0.20	0.25	0.14	1.00
Sum	7.33	6.70	11.25	1.84	20.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**

Social	0.14	0.30	0.18	0.11	0.15	**0.1742**
Technological	0.07	0.15	0.18	0.18	0.25	**0.1652**
Economical	0.07	0.07	0.09	0.09	0.20	**0.1044**
Environmental	0.68	0.45	0.53	0.54	0.35	**0.5111**
Political	0.05	0.03	0.02	0.08	0.05	**0.0450**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.401586
Consistency Index (CI)	0.100396
Consistency Ratio (CR)	0.0896

Pairwise comparison by Environmental experts Compared with respect to Goal.

Pairwise comparison matrix for perspective to goal (1)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	2.00	0.50	7.00
Technological	0.50	1.00	0.33	0.20	5.00
Economical	0.50	3.00	1.00	0.25	5.00
Environmental	2.00	5.00	4.00	1.00	7.00
Political	0.14	0.20	0.20	0.14	1.00
Sum	4.14	11.20	7.53	2.09	25.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.24	0.18	0.27	0.24	0.28	**0.2409**
Technological	0.12	0.09	0.04	0.10	0.20	**0.1100**
Economical	0.12	0.27	0.13	0.12	0.20	**0.1681**
Environmental	0.48	0.45	0.53	0.48	0.28	**0.4436**
Political	0.03	0.02	0.03	0.07	0.04	**0.0374**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.36025
Consistency Index (CI)	0.090062
Consistency Ratio (CR)	0.0804

Pairwise comparison matrix for perspective to goal (2)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	0.33	0.20	0.50
Technological	0.33	1.00	1.00	0.17	0.33
Economical	3.00	1.00	1.00	0.50	0.50
Environmental	5.00	6.00	2.00	1.00	2.00

Political	2.00	3.00	2.00	0.50	1.00
Sum	11.33	14.00	6.33	2.37	4.33

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.09	0.21	0.05	0.08	0.12	**0.1110**
Technological	0.03	0.07	0.16	0.07	0.08	**0.0812**
Economical	0.26	0.07	0.16	0.21	0.12	**0.1641**
Environmental	0.44	0.43	0.32	0.42	0.46	**0.4139**
Political	0.18	0.21	0.32	0.21	0.23	**0.2297**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.40971
Consistency Index (CI)	0.102428
Consistency Ratio (CR)	0.0915

Pairwise comparison matrix for perspective to goal (3)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.25	0.14	0.11	0.25
Technological	4.00	1.00	0.50	0.50	4.00
Economical	7.00	2.00	1.00	2.00	8.00
Environmental	9.00	2.00	0.50	1.00	6.00
Political	4.00	0.25	0.13	0.17	1.00
Sum	25.00	5.50	2.27	3.78	19.25

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.04	0.05	0.06	0.03	0.01	**0.0382**
Technological	0.16	0.18	0.22	0.13	0.21	**0.1805**
Economical	0.28	0.36	0.44	0.53	0.42	**0.4059**
Environmental	0.36	0.36	0.22	0.26	0.31	**0.3041**
Political	0.16	0.05	0.06	0.04	0.05	**0.0713**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.389347
Consistency Index (CI)	0.097337
Consistency Ratio (CR)	0.0869

Pairwise comparison matrix for perspective to goal (4)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	6.00	1.00	0.17	1.00
Technological	0.17	1.00	0.20	0.14	0.25
Economical	1.00	5.00	1.00	0.25	1.00
Environmental	6.00	7.00	4.00	1.00	4.00
Political	1.00	4.00	1.00	0.25	1.00
Sum	9.17	23.00	7.20	1.81	7.25

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.11	0.26	0.14	0.09	0.14	**0.1478**
Technological	0.02	0.04	0.03	0.08	0.03	**0.0406**
Economical	0.11	0.22	0.14	0.14	0.14	**0.1483**
Environmental	0.65	0.30	0.56	0.55	0.55	**0.5238**
Political	0.11	0.17	0.14	0.14	0.14	**0.1396**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.31535
Consistency Index (CI)	0.078838
Consistency Ratio (CR)	0.0704

Pairwise comparison matrix for perspective to goal (5)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	0.25	0.13	0.25
Technological	0.50	1.00	0.25	0.17	0.50
Economical	4.00	4.00	1.00	0.50	5.00
Environmental	8.00	6.00	2.00	1.00	4.00
Political	4.00	2.00	0.20	0.25	1.00
Sum	17.50	15.00	3.70	2.04	10.75

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.06	0.13	0.07	0.06	0.02	**0.0685**
Technological	0.03	0.07	0.07	0.08	0.05	**0.0582**
Economical	0.23	0.27	0.27	0.24	0.47	**0.2951**
Environmental	0.46	0.40	0.54	0.49	0.37	**0.4519**
Political	0.23	0.13	0.05	0.12	0.09	**0.1263**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.443806
Consistency Index (CI)	0.110952

Consistency Ratio (CR)	0.0991

Pairwise comparison matrix for perspective to goal (6)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.25	0.11	0.11	1.00
Technological	4.00	1.00	0.20	0.25	5.00
Economical	9.00	5.00	1.00	3.00	9.00
Environmental	9.00	4.00	0.33	1.00	9.00
Political	1.00	0.20	0.11	0.11	1.00
Sum	24.00	10.45	1.76	4.47	25.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.04	0.02	0.06	0.02	0.04	**0.0387**
Technological	0.17	0.10	0.11	0.06	0.20	**0.1264**
Economical	0.38	0.48	0.57	0.67	0.36	**0.4908**
Environmental	0.38	0.38	0.19	0.22	0.36	**0.3063**
Political	0.04	0.02	0.06	0.02	0.04	**0.0378**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.427067
Consistency Index (CI)	0.106767
Consistency Ratio (CR)	0.0953

Pairwise comparison matrix for perspective to goal (7)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	0.33	0.33	0.11
Technological	0.33	1.00	0.33	0.25	0.11
Economical	3.00	3.00	1.00	3.00	0.25
Environmental	3.00	4.00	0.33	1.00	0.33
Political	9.00	9.00	4.00	3.00	1.00
Sum	16.33	20.00	6.00	7.58	1.81

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.06	0.15	0.06	0.04	0.06	**0.0745**
Technological	0.02	0.05	0.06	0.03	0.06	**0.0441**
Economical	0.18	0.15	0.17	0.40	0.14	**0.2069**
Environmental	0.18	0.20	0.06	0.13	0.18	**0.1511**
Political	0.55	0.45	0.67	0.40	0.55	**0.5234**

Sum	1.00	1.00	1.00	1.00	1.00	
Principal Eigen Value		5.430503				
Consistency Index (CI)		0.107626				
Consistency Ratio (CR)		0.0961				

Pairwise comparison matrix for perspective to goal (8)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	4.00	2.00	2.00
Technological	0.50	1.00	2.00	2.00	0.33
Economical	0.25	0.50	1.00	2.00	0.25
Environmental	0.50	0.50	0.50	1.00	0.25
Political	0.50	3.00	4.00	4.00	1.00
Sum	2.75	7.00	11.50	11.00	3.83

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.36	0.29	0.35	0.18	0.52	**0.3401**
Technological	0.18	0.14	0.17	0.18	0.09	**0.1535**
Economical	0.09	0.07	0.09	0.18	0.07	**0.0993**
Environmental	0.18	0.07	0.04	0.09	0.07	**0.0906**
Political	0.18	0.43	0.35	0.36	0.26	**0.3165**
Sum	1.00	1.00	1.00	1.00	1.00	
Principal Eigen Value		5.360964				
Consistency Index (CI)		0.090241				
Consistency Ratio (CR)		0.0806				

Pairwise comparison matrix for perspective to goal (9)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.50	0.50	0.33	2.00
Technological	2.00	1.00	2.00	0.25	4.00
Economical	2.00	0.50	1.00	0.50	4.00
Environmental	3.00	4.00	2.00	1.00	3.00
Political	0.50	0.25	0.25	0.33	1.00
Sum	8.50	6.25	5.75	2.42	14.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**

Social	0.12	0.08	0.09	0.14	0.14	**0.1131**
Technological	0.24	0.16	0.35	0.10	0.29	**0.2265**
Economical	0.24	0.08	0.17	0.21	0.29	**0.1964**
Environmental	0.35	0.64	0.35	0.41	0.21	**0.3938**
Political	0.06	0.04	0.04	0.14	0.07	**0.0703**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.441871
Consistency Index (CI)	0.110468
Consistency Ratio (CR)	0.0986

Pairwise comparison matrix for perspective to goal (10)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.20	0.20	0.14	1.00
Technological	5.00	1.00	4.00	0.33	6.00
Economical	5.00	0.25	1.00	0.20	3.00
Environmental	7.00	3.00	5.00	1.00	9.00
Political	1.00	0.17	0.33	0.11	1.00
Sum	19.00	4.62	10.53	1.79	20.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.05	0.04	0.02	0.08	0.05	**0.0490**
Technological	0.26	0.22	0.38	0.19	0.30	**0.2692**
Economical	0.26	0.05	0.09	0.11	0.15	**0.1348**
Environmental	0.37	0.65	0.47	0.56	0.45	**0.5005**
Political	0.05	0.04	0.03	0.06	0.05	**0.0465**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.418222
Consistency Index (CI)	0.104556
Consistency Ratio (CR)	0.0934

Pairwise comparison matrix for perspective to goal (11)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	0.50	0.14	2.00
Technological	3.00	1.00	2.00	0.17	6.00
Economical	2.00	0.50	1.00	0.20	5.00
Environmental	7.00	6.00	5.00	1.00	9.00
Political	0.50	0.17	0.20	0.11	1.00

Sum	13.50	8.00	8.70	1.62	23.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.07	0.04	0.06	0.09	0.09	**0.0697**
Technological	0.22	0.13	0.23	0.10	0.26	**0.1882**
Economical	0.15	0.06	0.11	0.12	0.22	**0.1333**
Environmental	0.52	0.75	0.57	0.62	0.39	**0.5703**
Political	0.04	0.02	0.02	0.07	0.04	**0.0386**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.416885
Consistency Index (CI)	0.104221
Consistency Ratio (CR)	0.0931

Pairwise comparison matrix for perspective to goal (12)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	0.33	3.00	3.00
Technological	3.00	1.00	2.00	4.00	8.00
Economical	3.00	0.50	1.00	3.00	6.00
Environmental	0.33	0.25	0.33	1.00	6.00
Political	0.33	0.13	0.17	0.17	1.00
Sum	7.67	2.21	3.83	11.17	24.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.13	0.15	0.09	0.27	0.13	**0.1524**
Technological	0.39	0.45	0.52	0.36	0.33	**0.4115**
Economical	0.39	0.23	0.26	0.27	0.25	**0.2794**
Environmental	0.04	0.11	0.09	0.09	0.25	**0.1166**
Political	0.04	0.06	0.04	0.01	0.04	**0.0400**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.4115
Consistency Index (CI)	0.102875
Consistency Ratio (CR)	0.0919

Pairwise comparison by Political experts Compared with respect to Goal.

Pairwise comparison matrix for perspective to goal (1)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.50	0.33	0.25	0.25
Technological	2.00	1.00	0.33	0.33	0.17
Economical	3.00	3.00	1.00	0.50	0.25
Environmental	4.00	3.00	2.00	1.00	0.25
Political	4.00	6.00	4.00	4.00	1.00
Sum	14.00	13.50	7.67	6.08	1.92

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.07	0.04	0.04	0.04	0.13	**0.0647**
Technological	0.14	0.07	0.04	0.05	0.09	**0.0804**
Economical	0.21	0.22	0.13	0.08	0.13	**0.1559**
Environmental	0.29	0.22	0.26	0.16	0.13	**0.2127**
Political	0.29	0.44	0.52	0.66	0.52	**0.4862**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.412927
Consistency Index (CI)	0.1032318
Consistency Ratio (CR)	0.0922

Pairwise comparison matrix for perspective to goal (2)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	2.00	0.13	4.00
Technological	3.00	1.00	6.00	0.50	5.00
Economical	0.50	0.17	1.00	0.17	1.00
Environmental	8.00	2.00	6.00	1.00	6.00
Political	0.25	0.20	1.00	0.17	1.00
Sum	12.75	3.70	16.00	1.96	17.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.08	0.09	0.13	0.06	0.24	**0.1185**
Technological	0.24	0.27	0.38	0.26	0.29	**0.2860**
Economical	0.04	0.05	0.06	0.09	0.06	**0.0581**
Environmental	0.63	0.54	0.38	0.51	0.35	**0.4813**
Political	0.02	0.05	0.06	0.09	0.06	**0.0560**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.3945424
Consistency Index (CI)	0.0986356

Consistency Ratio (CR)	0.0881

Pairwise comparison matrix for perspective to goal (3)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	0.25	0.33	0.13
Technological	0.50	1.00	0.33	0.25	0.14
Economical	4.00	3.00	1.00	0.33	0.20
Environmental	3.00	4.00	3.00	1.00	0.50
Political	8.00	7.00	5.00	2.00	1.00
Sum	16.50	17.00	9.58	3.92	1.97

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.06	0.12	0.03	0.09	0.06	**0.0706**
Technological	0.03	0.06	0.03	0.06	0.07	**0.0521**
Economical	0.24	0.18	0.10	0.09	0.10	**0.1420**
Environmental	0.18	0.24	0.31	0.26	0.25	**0.2479**
Political	0.48	0.41	0.52	0.51	0.51	**0.4874**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.3409113
Consistency Index (CI)	0.0852278
Consistency Ratio (CR)	0.0761

Pairwise comparison matrix for perspective to goal (4)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.50	0.25	0.25	0.33
Technological	2.00	1.00	0.33	0.50	0.20
Economical	4.00	3.00	1.00	2.00	0.33
Environmental	4.00	2.00	0.50	1.00	0.33
Political	3.00	5.00	3.00	3.00	1.00
Sum	14.00	11.50	5.08	6.75	2.20

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.07	0.04	0.05	0.04	0.15	**0.0705**
Technological	0.14	0.09	0.07	0.07	0.09	**0.0921**
Economical	0.29	0.26	0.20	0.30	0.15	**0.2382**
Environmental	0.29	0.17	0.10	0.15	0.15	**0.1715**

Political	0.21	0.43	0.59	0.44	0.45	**0.4276**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.3558581
Consistency Index (CI)	0.0889645
Consistency Ratio (CR)	0.0794

Pairwise comparison matrix for perspective to goal (5)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	0.33	0.25	0.25	0.25
Technological	3.00	1.00	0.33	0.50	0.17
Economical	4.00	3.00	1.00	2.00	0.50
Environmental	4.00	2.00	0.50	1.00	0.20
Political	4.00	6.00	2.00	5.00	1.00
Sum	16.00	12.33	4.08	8.75	2.12

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.06	0.03	0.06	0.03	0.12	**0.0595**
Technological	0.19	0.08	0.08	0.06	0.08	**0.0972**
Economical	0.25	0.24	0.24	0.23	0.24	**0.2406**
Environmental	0.25	0.16	0.12	0.11	0.09	**0.1487**
Political	0.25	0.49	0.49	0.57	0.47	**0.4540**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.395175
Consistency Index (CI)	0.0987938
Consistency Ratio (CR)	0.0882

Pairwise comparison matrix for perspective to goal (6)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	4.00	2.00	6.00	7.00
Technological	0.25	1.00	2.00	4.00	6.00
Economical	0.50	0.50	1.00	4.00	6.00
Environmental	0.17	0.25	0.25	1.00	3.00
Political	0.14	0.17	0.17	0.33	1.00
Sum	2.06	5.92	5.42	15.33	23.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.49	0.68	0.37	0.39	0.30	**0.4453**

Technological	0.12	0.17	0.37	0.26	0.26	**0.2363**
Economical	0.24	0.08	0.18	0.26	0.26	**0.2067**
Environmental	0.08	0.04	0.05	0.07	0.13	**0.0730**
Political	0.07	0.03	0.03	0.02	0.04	**0.0387**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.4443062
Consistency Index (CI)	0.1110766
Consistency Ratio (CR)	0.0992

Pairwise comparison matrix for perspective to goal (7)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	4.00	2.00	3.00
Technological	0.33	1.00	3.00	3.00	1.00
Economical	0.25	0.33	1.00	2.00	0.50
Environmental	0.50	0.33	0.50	1.00	0.33
Political	0.33	1.00	2.00	3.00	1.00
Sum	2.42	5.67	10.50	11.00	5.83

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.41	0.53	0.38	0.18	0.51	**0.4041**
Technological	0.14	0.18	0.29	0.27	0.17	**0.2089**
Economical	0.10	0.06	0.10	0.18	0.09	**0.1050**
Environmental	0.21	0.06	0.05	0.09	0.06	**0.0923**
Political	0.14	0.18	0.19	0.27	0.17	**0.1898**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.3848228
Consistency Index (CI)	0.0962057
Consistency Ratio (CR)	0.0859

Pairwise comparison matrix for perspective to goal (8)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	3.00	3.00	3.00
Technological	0.50	1.00	0.50	2.00	3.00
Economical	0.33	2.00	1.00	2.00	5.00
Environmental	0.33	0.50	0.50	1.00	4.00
Political	0.33	0.33	0.20	0.25	1.00

Sum	2.50	5.83	5.20	8.25	16.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.40	0.34	0.58	0.36	0.19	**0.3742**
Technological	0.20	0.17	0.10	0.24	0.19	**0.1795**
Economical	0.13	0.34	0.19	0.24	0.31	**0.2447**
Environmental	0.13	0.09	0.10	0.12	0.25	**0.1373**
Political	0.13	0.06	0.04	0.03	0.06	**0.0643**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.4170615
Consistency Index (CI)	0.1042654
Consistency Ratio (CR)	0.0931

Pairwise comparison matrix for perspective to goal (9)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	3.00	6.00	4.00	4.00
Technological	0.33	1.00	4.00	3.00	4.00
Economical	0.17	0.25	1.00	2.00	2.00
Environmental	0.25	0.33	0.50	1.00	2.00
Political	0.25	0.25	0.50	0.50	1.00
Sum	2.00	4.83	12.00	10.50	13.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.50	0.62	0.50	0.38	0.31	**0.4619**
Technological	0.17	0.21	0.33	0.29	0.31	**0.2601**
Economical	0.08	0.05	0.08	0.19	0.15	**0.1125**
Environmental	0.13	0.07	0.04	0.10	0.15	**0.0969**
Political	0.13	0.05	0.04	0.05	0.08	**0.0686**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.4407351
Consistency Index (CI)	0.1101838
Consistency Ratio (CR)	0.0984

Pairwise comparison matrix for perspective to goal (10)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	3.00	4.00	3.00
Technological	0.50	1.00	4.00	4.00	3.00

Economical	0.33	0.25	1.00	2.00	0.33
Environmental	0.25	0.25	0.50	1.00	0.20
Political	0.33	0.33	3.00	5.00	1.00
Sum	2.42	3.83	11.50	16.00	7.53

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.41	0.52	0.26	0.25	0.40	**0.3689**
Technological	0.21	0.26	0.35	0.25	0.40	**0.2928**
Economical	0.14	0.07	0.09	0.13	0.04	**0.0919**
Environmental	0.10	0.07	0.04	0.06	0.03	**0.0602**
Political	0.14	0.09	0.26	0.31	0.13	**0.1862**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.4368708
Consistency Index (CI)	0.1092177
Consistency Ratio (CR)	0.0975

Pairwise comparison matrix for perspective to goal (11)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	2.00	4.00	3.00	4.00
Technological	0.50	1.00	2.00	3.00	4.00
Economical	0.25	0.50	1.00	2.00	4.00
Environmental	0.33	0.33	0.50	1.00	4.00
Political	0.25	0.25	0.25	0.25	1.00
Sum	2.33	4.08	7.75	9.25	17.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.43	0.49	0.52	0.32	0.24	**0.3988**
Technological	0.21	0.24	0.26	0.32	0.24	**0.2554**
Economical	0.11	0.12	0.13	0.22	0.24	**0.1620**
Environmental	0.14	0.08	0.06	0.11	0.24	**0.1265**
Political	0.11	0.06	0.03	0.03	0.06	**0.0573**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.3730431
Consistency Index (CI)	0.0932608
Consistency Ratio (CR)	0.0833

Pairwise comparison matrix for perspective to goal (12)

Criteria	Social	Technological	Economical	Environmental	Political
Social	1.00	4.00	3.00	6.00	3.00
Technological	0.25	1.00	1.00	2.00	4.00
Economical	0.33	1.00	1.00	3.00	4.00
Environmental	0.17	0.50	0.33	1.00	2.00
Political	0.33	0.25	0.25	0.50	1.00
Sum	2.08	6.75	5.58	12.50	14.00

Normalizing the Comparison

Criteria	Social	Technological	Economical	Environmental	Political	**Priority vector**
Social	0.48	0.59	0.54	0.48	0.21	**0.4608**
Technological	0.12	0.15	0.18	0.16	0.29	**0.1786**
Economical	0.16	0.15	0.18	0.24	0.29	**0.2026**
Environmental	0.08	0.07	0.06	0.08	0.14	**0.0873**
Political	0.16	0.04	0.04	0.04	0.07	**0.0706**
Sum	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	5.3773902
Consistency Index (CI)	0.0943476
Consistency Ratio (CR)	0.0842

APPENDIX V: THE MATRICES FOR EACH CRITERIA IN A PERSPECTIVE COMPARED WITH RESPECT TO THE CORRESPONDING PERSPECTIVE

THE MATRICES FOR EACH CRITERIA IN A PERSPECTIVE COMPARED WITH RESPECT TO THE CORRESPONDING PERSPECTIVE

The matrices for social criteria compared with respect to social perspective

Pairwise comparison matrix for a Criteria (1)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	0.20	0.25	2.00	6.00	7.00	0.20
OS	5.00	1.00	1.00	7.00	9.00	9.00	1.00
HE	4.00	1.00	1.00	7.00	9.00	8.00	1.00
TO	0.50	0.14	0.14	1.00	8.00	2.00	0.17
UHE	0.17	0.11	0.11	0.13	1.00	1.00	0.13
MR	0.14	0.11	0.13	0.50	1.00	1.00	0.13
LSP	5.00	1.00	1.00	6.00	8.00	8.00	1.00
Sum	15.81	3.57	3.63	23.63	42.00	36.00	3.62

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.06	0.06	0.07	0.08	0.14	0.19	0.06	**0.0951**
OS	0.32	0.28	0.28	0.30	0.21	0.25	0.28	**0.2728**
HE	0.25	0.28	0.28	0.30	0.21	0.22	0.28	**0.2598**
TO	0.03	0.04	0.04	0.04	0.19	0.06	0.05	**0.0636**
UHE	0.01	0.03	0.03	0.01	0.02	0.03	0.03	**0.0234**
MR	0.01	0.03	0.03	0.02	0.02	0.03	0.03	**0.0260**
LSP	0.32	0.28	0.28	0.25	0.19	0.22	0.28	**0.2594**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.778165
Consistency Index (CI)	0.129694
Consistency Ratio (CR)	0.0983

Pairwise comparison matrix for a criteria (2)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	1.00	1.00	0.25	1.00	1.00	1.00
OS	1.00	1.00	1.00	0.17	1.00	0.50	0.50
HE	1.00	1.00	1.00	0.33	0.50	1.00	1.00
TO	4.00	6.00	3.00	1.00	4.00	2.00	5.00

UHE	1.00	1.00	2.00	0.25	1.00	0.25	0.25
MR	1.00	2.00	1.00	0.50	4.00	1.00	4.00
LSP	1.00	2.00	1.00	0.20	4.00	0.25	1.00
Sum	10.00	14.00	10.00	2.70	15.50	6.00	12.75

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.10	0.07	0.10	0.09	0.06	0.17	0.08	**0.0962**
OS	0.10	0.07	0.10	0.06	0.06	0.08	0.04	**0.0743**
HE	0.10	0.07	0.10	0.12	0.03	0.17	0.08	**0.0960**
TO	0.40	0.43	0.30	0.37	0.26	0.33	0.39	**0.3546**
UHE	0.10	0.07	0.20	0.09	0.06	0.04	0.02	**0.0843**
MR	0.10	0.14	0.10	0.19	0.26	0.17	0.31	**0.1809**
LSP	0.10	0.14	0.10	0.07	0.26	0.04	0.08	**0.1136**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.760449
Consistency Index (CI)	0.126741
Consistency Ratio (CR)	0.0960

Pairwise comparison matrix for a criteria (3)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	1.00	1.00	1.00	1.00	1.00	3.00
OS	1.00	1.00	1.00	1.00	0.33	1.00	3.00
HE	1.00	1.00	1.00	1.00	1.00	0.50	2.00
TO	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UHE	1.00	3.00	1.00	1.00	1.00	1.00	4.00
MR	1.00	1.00	2.00	1.00	1.00	1.00	4.00
LSP	0.33	0.33	0.50	1.00	0.25	0.25	1.00
Sum	6.33	8.33	7.50	7.00	5.58	5.75	18.00

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.16	0.12	0.13	0.14	0.18	0.17	0.17	**0.1534**
OS	0.16	0.12	0.13	0.14	0.06	0.17	0.17	**0.1363**
HE	0.16	0.12	0.13	0.14	0.18	0.09	0.11	**0.1330**
TO	0.16	0.12	0.13	0.14	0.18	0.17	0.06	**0.1375**
UHE	0.16	0.36	0.13	0.14	0.18	0.17	0.22	**0.1956**
MR	0.16	0.12	0.27	0.14	0.18	0.17	0.22	**0.1804**
LSP	0.05	0.04	0.07	0.14	0.04	0.04	0.06	**0.0637**

Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Principal Eigen Value	7.344241							
Consistency Index (CI)	0.057374							
Consistency Ratio (CR)	0.0435							

Pairwise comparison matrix for a criteria (4)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	3.00	1.00	0.20	5.00	1.00	1.00
OS	0.33	1.00	0.20	0.20	3.00	0.20	0.20
HE	1.00	5.00	1.00	1.00	5.00	0.20	1.00
TO	5.00	5.00	1.00	1.00	5.00	1.00	1.00
UHE	0.20	0.33	0.20	0.20	1.00	0.20	0.20
MR	1.00	5.00	5.00	1.00	5.00	1.00	1.00
LSP	1.00	5.00	1.00	1.00	5.00	1.00	1.00
Sum	9.53	24.33	9.40	4.60	29.00	4.60	5.40

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.10	0.12	0.11	0.04	0.17	0.22	0.19	**0.1361**
OS	0.03	0.04	0.02	0.04	0.10	0.04	0.04	**0.0464**
HE	0.10	0.21	0.11	0.22	0.17	0.04	0.19	**0.1479**
TO	0.52	0.21	0.11	0.22	0.17	0.22	0.19	**0.2327**
UHE	0.02	0.01	0.02	0.04	0.03	0.04	0.04	**0.0306**
MR	0.10	0.21	0.53	0.22	0.17	0.22	0.19	**0.2335**
LSP	0.10	0.21	0.11	0.22	0.17	0.22	0.19	**0.1727**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Principal Eigen Value	7.782731							
Consistency Index (CI)	0.130455							
Consistency Ratio (CR)	0.0988							

Pairwise comparison matrix for a criteria (5)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	0.50	0.33	0.25	1.00	1.00	0.50
OS	2.00	1.00	0.50	0.50	3.00	0.50	2.00
HE	3.00	2.00	1.00	0.50	3.00	0.50	0.50

TO	4.00	2.00	2.00	1.00	5.00	1.00	0.50
UHE	1.00	0.33	0.33	0.20	1.00	0.20	0.33
MR	1.00	2.00	2.00	1.00	5.00	1.00	2.00
LSP	2.00	0.50	2.00	2.00	3.00	0.50	1.00
Sum	14.00	8.33	8.17	5.45	21.00	4.70	6.83

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.07	0.06	0.04	0.05	0.05	0.21	0.07	**0.0788**
OS	0.14	0.12	0.06	0.09	0.14	0.11	0.29	**0.1368**
HE	0.21	0.24	0.12	0.09	0.14	0.11	0.07	**0.1416**
TO	0.29	0.24	0.24	0.18	0.24	0.21	0.07	**0.2112**
UHE	0.07	0.04	0.04	0.04	0.05	0.04	0.05	**0.0468**
MR	0.07	0.24	0.24	0.18	0.24	0.21	0.29	**0.2119**
LSP	0.14	0.06	0.24	0.37	0.14	0.11	0.15	**0.1729**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.711532
Consistency Index (CI)	0.118589
Consistency Ratio (CR)	0.0898

Pairwise comparison matrix for a criteria (6)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OS	1.00	1.00	1.00	1.00	9.00	1.00	1.00
HE	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TO	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UHE	1.00	0.11	1.00	1.00	1.00	1.00	1.00
MR	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LSP	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sum	7.00	6.11	7.00	7.00	15.00	7.00	7.00

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.14	0.16	0.14	0.14	0.07	0.14	0.14	**0.1349**
OS	0.14	0.16	0.14	0.14	0.60	0.14	0.14	**0.2111**
HE	0.14	0.16	0.14	0.14	0.07	0.14	0.14	**0.1349**
TO	0.14	0.16	0.14	0.14	0.07	0.14	0.14	**0.1349**

UHE	0.14	0.02	0.14	0.14	0.07	0.14	0.14	**0.1142**
MR	0.14	0.16	0.14	0.14	0.07	0.14	0.14	**0.1349**
LSP	0.14	0.16	0.14	0.14	0.07	0.14	0.14	**0.1349**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.725624
Consistency Index (CI)	0.120937
Consistency Ratio (CR)	0.0916

Pairwise comparison matrix for a criteria (7)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	0.25	1.00	0.25	0.20	0.13	0.50
OS	4.00	1.00	2.00	0.33	0.25	0.13	0.50
HE	1.00	0.50	1.00	0.33	0.17	0.13	0.33
TO	4.00	3.00	3.00	1.00	0.17	0.20	1.00
UHE	5.00	4.00	6.00	6.00	1.00	0.25	2.00
MR	8.00	8.00	8.00	5.00	4.00	1.00	5.00
LSP	2.00	2.00	3.00	1.00	0.50	0.20	1.00
Sum	25.00	18.75	24.00	13.92	6.28	2.03	10.33

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.04	0.01	0.04	0.02	0.03	0.06	0.05	**0.0364**
OS	0.16	0.05	0.08	0.02	0.04	0.06	0.05	**0.0672**
HE	0.04	0.03	0.04	0.02	0.03	0.06	0.03	**0.0361**
TO	0.16	0.16	0.13	0.07	0.03	0.10	0.10	**0.1056**
UHE	0.20	0.21	0.25	0.43	0.16	0.12	0.19	**0.2244**
MR	0.32	0.43	0.33	0.36	0.64	0.49	0.48	**0.4362**
LSP	0.08	0.11	0.13	0.07	0.08	0.10	0.10	**0.0941**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.771956
Consistency Index (CI)	0.128659
Consistency Ratio (CR)	0.0975

Pairwise comparison matrix for a criteria (8)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	4.00	2.00	3.00	5.00	0.50	3.00

OS	0.25	1.00	2.00	2.00	0.50	0.20	1.00
HE	0.50	0.50	1.00	1.00	2.00	0.25	0.50
TO	0.33	0.50	1.00	1.00	3.00	0.33	3.00
UHE	0.20	2.00	0.50	0.33	1.00	0.17	0.50
MR	2.00	5.00	4.00	3.00	6.00	1.00	3.00
LSP	0.33	1.00	2.00	0.33	2.00	0.33	1.00
Sum	4.62	14.00	12.50	10.67	19.50	2.78	12.00

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.22	0.29	0.16	0.28	0.26	0.18	0.25	**0.2328**
OS	0.05	0.07	0.16	0.19	0.03	0.07	0.08	**0.0934**
HE	0.11	0.04	0.08	0.09	0.10	0.09	0.04	**0.0788**
TO	0.07	0.04	0.08	0.09	0.15	0.12	0.25	**0.1150**
UHE	0.04	0.14	0.04	0.03	0.05	0.06	0.04	**0.0586**
MR	0.43	0.36	0.32	0.28	0.31	0.36	0.25	**0.3298**
LSP	0.07	0.07	0.16	0.03	0.10	0.12	0.08	**0.0915**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.753931
Consistency Index (CI)	0.125655
Consistency Ratio (CR)	0.0952

Pairwise comparison matrix for a criteria (9)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	1.00	5.00	5.00	1.00	1.00	0.50
OS	1.00	1.00	2.00	1.00	1.00	1.00	0.33
HE	0.20	0.50	1.00	1.00	1.00	1.00	0.25
TO	0.20	1.00	1.00	1.00	0.25	1.00	0.33
UHE	1.00	1.00	1.00	4.00	1.00	1.00	0.33
MR	1.00	1.00	1.00	1.00	1.00	1.00	0.25
LSP	2.00	3.00	4.00	3.00	3.00	4.00	1.00
Sum	6.40	8.50	15.00	16.00	8.25	10.00	3.00

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.16	0.12	0.33	0.31	0.12	0.10	0.17	**0.1868**
OS	0.16	0.12	0.13	0.06	0.12	0.10	0.11	**0.1146**
HE	0.03	0.06	0.07	0.06	0.12	0.10	0.08	**0.0748**
TO	0.03	0.12	0.07	0.06	0.03	0.10	0.11	**0.0742**

UHE	0.16	0.12	0.07	0.25	0.12	0.10	0.11	**0.1318**
MR	0.16	0.12	0.07	0.06	0.12	0.10	0.08	**0.1011**
LSP	0.31	0.35	0.27	0.19	0.36	0.40	0.33	**0.3167**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.527747
Consistency Index (CI)	0.087958
Consistency Ratio (CR)	0.0666

Pairwise comparison matrix for a criteria (10)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	2.00	2.00	0.50	2.00	1.00	0.33
OS	0.50	1.00	1.00	1.00	0.50	0.50	0.25
HE	0.50	1.00	1.00	0.20	0.33	0.25	0.25
TO	2.00	1.00	5.00	1.00	0.50	1.00	1.00
UHE	0.50	2.00	3.00	2.00	1.00	0.50	0.25
MR	1.00	2.00	4.00	1.00	2.00	1.00	2.00
LSP	3.00	4.00	4.00	1.00	4.00	0.50	1.00
Sum	8.50	13.00	20.00	6.70	10.33	4.75	5.08

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	Priority vector
SEM	0.12	0.15	0.10	0.07	0.19	0.21	0.07	**0.1308**
OS	0.06	0.08	0.05	0.15	0.05	0.11	0.05	**0.0768**
HE	0.06	0.08	0.05	0.03	0.03	0.05	0.05	**0.0500**
TO	0.24	0.08	0.25	0.15	0.05	0.21	0.20	**0.1667**
UHE	0.06	0.15	0.15	0.30	0.10	0.11	0.05	**0.1303**
MR	0.12	0.15	0.20	0.15	0.19	0.21	0.39	**0.2026**
LSP	0.35	0.31	0.20	0.15	0.39	0.11	0.20	**0.2427**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.770007
Consistency Index (CI)	0.128334
Consistency Ratio (CR)	0.0972

Pairwise comparison matrix for a criteria (11)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	3.00	2.00	1.00	3.00	2.00	2.00
OS	0.33	1.00	2.00	2.00	1.00	3.00	3.00

HE	0.50	0.50	1.00	2.00	2.00	2.00	2.00
TO	1.00	0.50	0.50	1.00	2.00	1.00	2.00
UHE	0.33	1.00	0.50	0.50	1.00	4.00	3.00
MR	0.50	0.33	0.50	1.00	0.25	1.00	1.00
LSP	0.50	0.33	0.50	0.50	0.33	1.00	1.00
Sum	4.17	6.67	7.00	8.00	9.58	14.00	14.00

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.24	0.45	0.29	0.13	0.31	0.14	0.14	**0.2428**
OS	0.08	0.15	0.29	0.25	0.10	0.21	0.21	**0.1855**
HE	0.12	0.08	0.14	0.25	0.21	0.14	0.14	**0.1546**
TO	0.24	0.08	0.07	0.13	0.21	0.07	0.14	**0.1335**
UHE	0.08	0.15	0.07	0.06	0.10	0.29	0.21	**0.1383**
MR	0.12	0.05	0.07	0.13	0.03	0.07	0.07	**0.0765**
LSP	0.12	0.05	0.07	0.06	0.03	0.07	0.07	**0.0688**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.758047
Consistency Index (CI)	0.126341
Consistency Ratio (CR)	0.0957

pairwise matrix comparison for a Criteria (12)

Criteria	SEM	OS	HE	TO	UHE	MR	LSP
SEM	1.00	0.20	0.25	2.00	6.00	7.00	0.20
OS	5.00	1.00	1.00	7.00	9.00	9.00	1.00
HE	4.00	1.00	1.00	7.00	9.00	8.00	1.00
TO	0.50	0.14	0.14	1.00	8.00	2.00	0.17
UHE	0.17	0.11	0.11	0.13	1.00	1.00	0.13
MR	0.14	0.11	0.13	0.50	1.00	1.00	0.13
LSP	5.00	1.00	1.00	6.00	8.00	8.00	1.00
Sum	15.81	3.57	3.63	23.63	42.00	36.00	3.62

Normalizing the Comparison

Criteria	SEM	OS	HE	TO	UHE	MR	LSP	**Priority vector**
SEM	0.06	0.06	0.07	0.08	0.14	0.19	0.06	**0.0951**
OS	0.32	0.28	0.28	0.30	0.21	0.25	0.28	**0.2728**
HE	0.25	0.28	0.28	0.30	0.21	0.22	0.28	**0.2598**
TO	0.03	0.04	0.04	0.04	0.19	0.06	0.05	**0.0636**

UHE	0.01	0.03	0.03	0.01	0.02	0.03	0.03	**0.0234**
MR	0.01	0.03	0.03	0.02	0.02	0.03	0.03	**0.0260**
LSP	0.32	0.28	0.28	0.25	0.19	0.22	0.28	**0.2594**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	7.778165
Consistency Index (CI)	0.129694
Consistency Ratio (CR)	0.0983

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Pairwise comparison matrix for a criteria (1)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	3.00	4.00	0.33
SP	0.33	1.00	3.00	0.33
HE-M	0.25	0.33	1.00	0.20
HE-P	3.00	3.00	5.00	1.00
Sum	4.58	7.33	13.00	1.87

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**
JC	0.22	0.41	0.31	0.18	**0.2784**
SP	0.07	0.14	0.23	0.18	**0.1546**
HE-M	0.05	0.05	0.08	0.11	**0.0710**
HE-P	0.65	0.41	0.38	0.54	**0.4960**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.258783508
Consistency Index (CI)	0.086261169
Consistency Ratio (CR)	0.0958

Pairwise comparison matrix for a criteria (2)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	0.33	0.25	0.20
SP	3.00	1.00	0.33	0.25
HE-M	4.00	3.00	1.00	0.33
HE-P	5.00	4.00	3.00	1.00
Sum	13.00	8.33	4.58	1.78

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**
JC	0.08	0.04	0.05	0.11	**0.0709**
SP	0.23	0.12	0.07	0.14	**0.1409**
HE-M	0.31	0.36	0.22	0.19	**0.2682**
HE-P	0.38	0.48	0.65	0.56	**0.5200**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.252630264
Consistency Index (CI)	0.084210088
Consistency Ratio (CR)	0.0936

Pairwise comparison matrix for a criteria (3)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	2.00	4.00	4.00
SP	0.50	1.00	4.00	3.00
HE-M	0.25	0.25	1.00	0.33
HE-P	0.25	0.33	3.00	1.00
Sum	2.00	3.58	12.00	8.33

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**
JC	0.50	0.56	0.33	0.48	**0.4679**
SP	0.25	0.28	0.33	0.36	**0.3056**
HE-M	0.13	0.07	0.08	0.04	**0.0795**

HE-P	0.13	0.09	0.25	0.12	**0.1470**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.210156654
Consistency Index (CI)	0.070052218
Consistency Ratio (CR)	0.0778

Pairwise comparison matrix for criteria (4)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	0.50	0.33	3.00
SP	2.00	1.00	0.33	2.00
HE-M	3.00	3.00	1.00	3.00
HE-P	0.33	0.50	0.33	1.00
Sum	6.33	5.00	2.00	9.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	Priority vector
JC	0.16	0.10	0.17	0.33	**0.1895**
SP	0.32	0.20	0.17	0.22	**0.2262**
HE-M	0.47	0.60	0.50	0.33	**0.4768**
HE-P	0.05	0.10	0.17	0.11	**0.1076**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.252777778
Consistency Index (CI)	0.084259259
Consistency Ratio (CR)	0.0936

Pairwise comparison matrix for sub-criteria(5)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	3.00	5.00	6.00
SP	0.33	1.00	4.00	5.00
HE-M	0.20	0.25	1.00	2.00
HE-P	0.17	0.20	0.50	1.00
Sum	1.70	4.45	10.50	14.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	Priority vector
JC	0.59	0.67	0.48	0.43	**0.5418**
SP	0.20	0.22	0.38	0.36	**0.2897**

HE-M	0.12	0.06	0.10	0.14	**0.1030**
HE-P	0.10	0.04	0.05	0.07	**0.0655**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.208711603
Consistency Index (CI)	0.069570534
Consistency Ratio (CR)	0.0773

Pairwise comparison matrix for sub-criteria(6)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	0.33	2.00	0.33
SP	3.00	1.00	3.00	2.00
HE-M	0.50	0.33	1.00	0.25
HE-P	3.00	0.50	4.00	1.00
Sum	7.50	2.17	10.00	3.58

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	Priority vector
JC	0.13	0.15	0.20	0.09	**0.1451**
SP	0.40	0.46	0.30	0.56	**0.4299**
HE-M	0.07	0.15	0.10	0.07	**0.0976**
HE-P	0.40	0.23	0.40	0.28	**0.3275**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.168470483
Consistency Index (CI)	0.056156828
Consistency Ratio (CR)	0.0624

Pairwise comparison matrix for sub-criteria(7)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	1.00	0.25	2.00
SP	1.00	1.00	0.33	1.00
HE-M	4.00	3.00	1.00	4.00
HE-P	0.50	1.00	0.25	1.00
Sum	6.50	6.00	1.83	8.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	Priority vector
JC	0.15	0.17	0.14	0.25	**0.1767**

SP	0.15	0.17	0.18	0.13	**0.1568**
HE-M	0.62	0.50	0.55	0.50	**0.5402**
HE-P	0.08	0.17	0.14	0.13	**0.1262**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.089962121
Consistency Index (CI)	0.029987374
Consistency Ratio (CR)	0.0333

Pairwise comparison matrix for sub-criteria (8)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	2.00	2.00	2.00
SP	0.50	1.00	1.00	1.00
HE-M	0.50	1.00	1.00	3.00
HE-P	0.50	1.00	0.33	1.00
Sum	2.50	5.00	4.33	7.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**
JC	0.40	0.40	0.46	0.29	**0.3868**
SP	0.20	0.20	0.23	0.14	**0.1934**
HE-M	0.20	0.20	0.23	0.43	**0.2648**
HE-P	0.20	0.20	0.08	0.14	**0.1549**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.166300366
Consistency Index (CI)	0.055433455
Consistency Ratio (CR)	0.0616

Pairwise comparison matrix for sub-criteria (9)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	2.00	3.00	3.00
SP	0.50	1.00	2.00	2.00
HE-M	0.33	0.50	1.00	3.00
HE-P	0.33	0.50	0.33	1.00
Sum	2.17	4.00	6.33	9.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**

JC	0.46	0.50	0.47	0.33	**0.4421**
SP	0.23	0.25	0.32	0.22	**0.2547**
HE-M	0.15	0.13	0.16	0.33	**0.1925**
HE-P	0.15	0.13	0.05	0.11	**0.1106**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.19185785
Consistency Index (CI)	0.063952617
Consistency Ratio (CR)	0.0711

Pairwise comparison matrix for sub-criteria(10)

Criteria	JC	SP	HE-M	HE-P
JC	1.00	3.00	2.00	2.00
SP	0.33	1.00	1.00	3.00
HE-M	0.50	1.00	1.00	2.00
HE-P	0.50	0.33	0.50	1.00
Sum	2.33	5.33	4.50	8.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**
JC	0.43	0.56	0.44	0.25	**0.4214**
SP	0.14	0.19	0.22	0.38	**0.2319**
HE-M	0.21	0.19	0.22	0.25	**0.2185**
HE-P	0.21	0.06	0.11	0.13	**0.1282**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.229042659
Consistency Index (CI)	0.076347553
Consistency Ratio (CR)	0.0848

Pairwise comparison matrix for sub-criteria (11

Criteria	JC	SP	HE-M	HE-P
JC	1.00	2.00	3.00	4.00
SP	0.50	1.00	2.00	2.00
HE-M	0.33	0.50	1.00	4.00
HE-P	0.25	0.50	0.25	1.00
Sum	2.08	4.00	6.25	11.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**

JC	0.48	0.50	0.48	0.36	**0.4559**
SP	0.24	0.25	0.32	0.18	**0.2480**
HE-M	0.16	0.13	0.16	0.36	**0.2022**
HE-P	0.12	0.13	0.04	0.09	**0.0940**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.238873106
Consistency Index (CI)	0.079624369
Consistency Ratio (CR)	0.0885

Pairwise comparison matrix for sub-criteria (12

Criteria	JC	SP	HE-M	HE-P
JC	1.00	3.00	4.00	3.00
SP	0.33	1.00	2.00	4.00
HE-M	0.25	0.50	1.00	2.00
HE-P	0.33	0.25	0.50	1.00
Sum	1.92	4.75	7.50	10.00

Normalizing the Comparison

Criteria	JC	SP	HE-M	HE-P	**Priority vector**
JC	0.52	0.63	0.53	0.30	**0.4967**
SP	0.17	0.21	0.27	0.40	**0.2628**
HE-M	0.13	0.11	0.13	0.20	**0.1423**
HE-P	0.17	0.05	0.07	0.10	**0.0983**
Sum	1.00	1.00	1.00	1.00	

Principal Eigen Value	4.250087401
Consistency Index (CI)	0.083362467
Consistency Ratio (CR)	0.0926

THE MATRICES FOR ECONOMIC CRITERIA IN COMPARISON WITH RESPECT TO THE ECONOMIC PERSPECTIVE

Pairwise comparison matrix for sub-criteria (1)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	8.00	3.00	4.00	5.00	4.00
W	0.13	1.00	0.25	0.50	0.50	0.33
DC	0.33	4.00	1.00	0.50	4.00	0.33
COT	0.25	2.00	2.00	1.00	3.00	2.00
RI	0.20	2.00	0.25	0.33	1.00	0.33
RA	0.25	3.00	3.00	0.50	3.00	1.00
Sum	2.16	20.00	9.50	6.83	16.50	8.00

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	**Priority vector**
COM	0.46	0.40	0.32	0.59	0.30	0.50	**0.4279**
W	0.06	0.05	0.03	0.07	0.03	0.04	**0.0466**
DC	0.15	0.20	0.11	0.07	0.24	0.04	**0.1362**
COT	0.12	0.10	0.21	0.15	0.18	0.25	**0.1674**
RI	0.09	0.10	0.03	0.05	0.06	0.04	**0.0617**
RA	0.12	0.15	0.32	0.07	0.18	0.13	**0.1603**

Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.592122314
Consistency Index (CI)	0.118424463
Consistency Ratio (CR)	0.0955

Pairwise comparison matrix for sub-criteria (2)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	0.17	0.17	0.20	0.13	0.25
W	6.00	1.00	4.00	2.00	0.25	4.00
DC	6.00	0.25	1.00	0.50	0.20	2.00
COT	5.00	0.50	2.00	1.00	0.25	2.00
RI	8.00	4.00	5.00	4.00	1.00	8.00
RA	4.00	0.25	0.50	0.50	0.13	1.00
Sum	30.00	6.17	12.67	8.20	1.95	17.25

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.03	0.03	0.01	0.02	0.06	0.01	**0.0294**
W	0.20	0.16	0.32	0.24	0.13	0.23	**0.2137**
DC	0.20	0.04	0.08	0.06	0.10	0.12	**0.0998**
COT	0.17	0.08	0.16	0.12	0.13	0.12	**0.1286**
RI	0.27	0.65	0.39	0.49	0.51	0.46	**0.4624**
RA	0.13	0.04	0.04	0.06	0.06	0.06	**0.0661**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.560611361
Consistency Index (CI)	0.112122272
Consistency Ratio (CR)	0.0904

Pairwise comparison matrix for sub-criteria (3)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	0.25	0.50	0.25	0.13	0.11
W	4.00	1.00	0.50	1.00	0.25	0.11
DC	2.00	2.00	1.00	1.00	0.33	0.13
COT	4.00	1.00	1.00	1.00	1.00	0.13
RI	8.00	4.00	3.00	1.00	1.00	0.20
RA	9.00	9.00	8.00	8.00	5.00	1.00
Sum	28.00	17.25	14.00	12.25	7.71	1.67

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.04	0.01	0.04	0.02	0.02	0.07	**0.0315**
W	0.14	0.06	0.04	0.08	0.03	0.07	**0.0695**
DC	0.07	0.12	0.07	0.08	0.04	0.07	**0.0764**
COT	0.14	0.06	0.07	0.08	0.13	0.07	**0.0931**
RI	0.29	0.23	0.21	0.08	0.13	0.12	**0.1771**
RA	0.32	0.52	0.57	0.65	0.65	0.60	**0.5524**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.579825146
Consistency Index (CI)	0.115965029
Consistency Ratio (CR)	0.0935

Pairwise comparison matrix for sub-criteria (4)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	1.00	2.00	1.00	0.50	0.17
W	1.00	1.00	1.00	1.00	1.00	0.14
DC	0.50	1.00	1.00	2.00	2.00	0.17
COT	1.00	1.00	0.50	1.00	0.25	0.14
RI	2.00	1.00	0.50	4.00	1.00	0.20
RA	6.00	7.00	6.00	7.00	5.00	1.00
Sum	11.50	12.00	11.00	16.00	9.75	1.82

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.09	0.08	0.18	0.06	0.05	0.09	**0.0929**
W	0.09	0.08	0.09	0.06	0.10	0.08	**0.0841**
DC	0.04	0.08	0.09	0.13	0.21	0.09	**0.1066**
COT	0.09	0.08	0.05	0.06	0.03	0.08	**0.0637**
RI	0.17	0.08	0.05	0.25	0.10	0.11	**0.1275**
RA	0.52	0.58	0.55	0.44	0.51	0.55	**0.5251**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.468959571
Consistency Index (CI)	0.093791914
Consistency Ratio (CR)	0.0756

Pairwise comparison matrix for sub-criteria (5)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	1.00	0.50	1.00	0.11	0.20
W	1.00	1.00	0.33	2.00	0.11	0.11
DC	2.00	3.00	1.00	2.00	0.20	0.11
COT	1.00	0.50	0.50	1.00	0.11	0.11
RI	9.00	9.00	5.00	9.00	1.00	3.00
RA	5.00	9.00	9.00	9.00	0.33	1.00
Sum	19.00	23.50	16.33	24.00	1.87	4.53

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.05	0.04	0.03	0.04	0.06	0.04	**0.0452**
W	0.05	0.04	0.02	0.08	0.06	0.02	**0.0472**
DC	0.11	0.13	0.06	0.08	0.11	0.02	**0.0849**
COT	0.05	0.02	0.03	0.04	0.06	0.02	**0.0384**
RI	0.47	0.38	0.31	0.38	0.54	0.66	**0.4559**
RA	0.26	0.38	0.55	0.38	0.18	0.22	**0.3286**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.614026108
Consistency Index (CI)	0.122805222
Consistency Ratio (CR)	0.0990

Pairwise comparison matrix for sub-criteria (6)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	0.50	2.00	2.00	0.13	0.20
W	2.00	1.00	2.00	2.00	0.20	0.25
DC	0.50	0.50	1.00	0.13	0.11	0.13
COT	0.50	0.50	8.00	1.00	0.17	0.25
RI	8.00	5.00	9.00	6.00	1.00	2.00
RA	5.00	4.00	8.00	4.00	0.50	1.00
Sum	17.00	11.50	30.00	15.13	2.10	3.83

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.06	0.04	0.07	0.13	0.06	0.05	**0.0688**
W	0.12	0.09	0.07	0.13	0.10	0.07	**0.0940**
DC	0.03	0.04	0.03	0.01	0.05	0.03	**0.0333**
COT	0.03	0.04	0.27	0.07	0.08	0.07	**0.0917**

RI	0.47	0.43	0.30	0.40	0.48	0.52	**0.4334**
RA	0.29	0.35	0.27	0.26	0.24	0.26	**0.2787**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.615623879
Consistency Index (CI)	0.123124776
Consistency Ratio (CR)	0.0993

Pairwise comparison matrix for sub-criteria (7)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	3.00	4.00	2.00	2.00	0.33
W	0.33	1.00	3.00	1.00	0.50	0.20
DC	0.25	0.33	1.00	0.33	0.20	0.20
COT	0.50	1.00	3.00	1.00	0.33	0.33
RI	0.50	2.00	5.00	3.00	1.00	2.00
RA	3.00	5.00	5.00	3.00	0.50	1.00
Sum	5.58	12.33	21.00	10.33	4.53	4.07

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	**Priority vector**
COM	0.18	0.24	0.19	0.19	0.44	0.08	**0.2216**
W	0.06	0.08	0.14	0.10	0.11	0.05	**0.0900**
DC	0.04	0.03	0.05	0.03	0.04	0.05	**0.0408**
COT	0.09	0.08	0.14	0.10	0.07	0.08	**0.0943**
RI	0.09	0.16	0.24	0.29	0.22	0.49	**0.2488**
RA	0.54	0.41	0.24	0.29	0.11	0.25	**0.3046**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.544959362
Consistency Index (CI)	0.108991872
Consistency Ratio (CR)	0.0879

Pairwise comparison matrix for sub-criteria (8)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	0.50	0.33	0.50	0.25	0.33
W	2.00	1.00	1.00	0.33	0.50	0.50
DC	3.00	1.00	1.00	2.00	2.00	0.50
COT	2.00	3.00	0.50	1.00	0.50	0.50
RI	4.00	2.00	0.50	2.00	1.00	2.00

RA	3.00	2.00	2.00	2.00	0.50	1.00
Sum	15.00	9.50	5.33	7.83	4.75	4.83

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	**Priority vector**
COM	0.07	0.05	0.06	0.06	0.05	0.07	**0.0612**
W	0.13	0.11	0.19	0.04	0.11	0.10	**0.1129**
DC	0.20	0.11	0.19	0.26	0.42	0.10	**0.2121**
COT	0.13	0.32	0.09	0.13	0.11	0.10	**0.1465**
RI	0.27	0.21	0.09	0.26	0.21	0.41	**0.2418**
RA	0.20	0.21	0.38	0.26	0.11	0.21	**0.2255**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.50793588
Consistency Index (CI)	0.101587176
Consistency Ratio (CR)	0.0819

Pairwise comparison matrix for sub-criteria (9)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	1.00	1.00	1.00	0.17	0.50
W	1.00	1.00	2.00	0.50	0.20	2.00
DC	1.00	0.50	1.00	2.00	0.20	2.00
COT	1.00	2.00	0.50	1.00	0.20	2.00
RI	6.00	5.00	5.00	5.00	1.00	5.00
RA	2.00	0.50	0.50	0.50	0.20	1.00
Sum	12.00	10.00	10.00	10.00	1.97	12.50

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	**Priority vector**
COM	0.08	0.10	0.10	0.10	0.08	0.04	**0.0847**
W	0.08	0.10	0.20	0.05	0.10	0.16	**0.1158**
DC	0.08	0.05	0.10	0.20	0.10	0.16	**0.1158**
COT	0.08	0.20	0.05	0.10	0.10	0.16	**0.1158**
RI	0.50	0.50	0.50	0.50	0.51	0.40	**0.4847**
RA	0.17	0.05	0.05	0.05	0.10	0.08	**0.0831**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.482886064

Consistency Index (CI)	0.096577213
Consistency Ratio (CR)	0.0779

Pairwise comparison matrix for sub-criteria (10)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	0.50	0.25	1.00	0.20	0.50
W	2.00	1.00	0.50	2.00	0.11	1.00
DC	4.00	2.00	1.00	2.00	1.00	1.00
COT	1.00	0.50	0.50	1.00	0.25	1.00
RI	5.00	9.00	1.00	4.00	1.00	3.00
RA	2.00	1.00	1.00	1.00	0.33	1.00
Sum	15.00	14.00	4.25	11.00	2.89	7.50

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	**Priority vector**
COM	0.07	0.04	0.06	0.09	0.07	0.07	**0.0646**
W	0.13	0.07	0.12	0.18	0.04	0.13	**0.1127**
DC	0.27	0.14	0.24	0.18	0.35	0.13	**0.2176**
COT	0.07	0.04	0.12	0.09	0.09	0.13	**0.0884**
RI	0.33	0.64	0.24	0.36	0.35	0.40	**0.3868**
RA	0.13	0.07	0.24	0.09	0.12	0.13	**0.1299**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.538259585
Consistency Index (CI)	0.107651917
Consistency Ratio (CR)	0.0868

Pairwise comparison matrix for sub-criteria (11)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	0.33	0.25	1.00	0.14	0.20
W	3.00	1.00	3.00	6.00	3.00	2.00
DC	4.00	0.33	1.00	2.00	0.20	0.33
COT	1.00	0.17	0.50	1.00	0.33	0.33
RI	7.00	0.33	5.00	3.00	1.00	1.00
RA	5.00	0.50	3.00	3.00	1.00	1.00
Sum	21.00	2.67	12.75	16.00	5.68	4.87

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.05	0.13	0.02	0.06	0.03	0.04	**0.0535**
W	0.14	0.38	0.24	0.38	0.53	0.41	**0.3446**
DC	0.19	0.13	0.08	0.13	0.04	0.07	**0.1038**
COT	0.05	0.06	0.04	0.06	0.06	0.07	**0.0565**
RI	0.33	0.13	0.39	0.19	0.18	0.21	**0.2366**
RA	0.24	0.19	0.24	0.19	0.18	0.21	**0.2050**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.61038675
Consistency Index (CI)	0.12207735
Consistency Ratio (CR)	0.0984

Pairwise comparison matrix for sub-criteria (12)

Criteria	COM	W	DC	COT	RI	RA
COM	1.00	6.00	8.00	4.00	3.00	9.00
W	0.17	1.00	2.00	0.17	0.20	2.00
DC	0.13	0.50	1.00	0.14	0.25	2.00
COT	0.25	6.00	7.00	1.00	0.50	3.00
RI	0.33	5.00	4.00	2.00	1.00	6.00
RA	0.11	0.50	0.50	0.33	0.17	1.00
Sum	1.99	19.00	22.50	7.64	5.12	23.00

Normalizing the Comparison

Criteria	COM	W	DC	COT	RI	RA	Priority vector
COM	0.50	0.32	0.36	0.52	0.59	0.39	**0.4460**
W	0.08	0.05	0.09	0.02	0.04	0.09	**0.0622**
DC	0.06	0.03	0.04	0.02	0.05	0.09	**0.0480**
COT	0.13	0.32	0.31	0.13	0.10	0.13	**0.1853**
RI	0.17	0.26	0.18	0.26	0.20	0.26	**0.2211**
RA	0.06	0.03	0.02	0.04	0.03	0.04	**0.0374**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	6.555443618
Consistency Index (CI)	0.111088724
Consistency Ratio (CR)	0.0896

THE MATRICES FOR THE ENVIRONMENTAL CRITERIA COMPARISON WITH RESPECT TO ENVIROMENTAL PERSPECTIVE

Pairwise comparison matrix for sub-criteria (1)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	0.50	0.17	0.33	0.33	0.25	0.50	1.00
NEF	2.00	1.00	0.20	0.50	0.50	0.50	0.50	1.00
UAL	6.00	5.00	1.00	2.00	2.00	4.00	2.00	2.00
RE	3.00	2.00	0.50	1.00	0.50	3.00	3.00	2.00
WC	3.00	2.00	0.50	2.00	1.00	7.00	2.00	3.00
WG	4.00	2.00	0.25	0.33	0.14	1.00	0.25	0.50
WCO	2.00	2.00	0.50	0.33	0.50	4.00	1.00	3.00
CMP	1.00	1.00	0.50	0.50	0.33	2.00	0.33	1.00
Sum	22.00	15.50	3.62	7.00	5.31	21.75	9.58	13.50

Normalising the comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.05	0.03	0.05	0.05	0.06	0.01	0.05	0.07	**0.0465**
NEF	0.09	0.06	0.06	0.07	0.09	0.02	0.05	0.07	**0.0657**
UAL	0.27	0.32	0.28	0.29	0.38	0.18	0.21	0.15	**0.2594**
RE	0.14	0.13	0.14	0.14	0.09	0.14	0.31	0.15	**0.1550**
WC	0.14	0.13	0.14	0.29	0.19	0.32	0.21	0.22	**0.2038**
WG	0.18	0.13	0.07	0.05	0.03	0.05	0.03	0.04	**0.0705**
WCO	0.09	0.13	0.14	0.05	0.09	0.18	0.10	0.22	**0.1263**
CMP	0.05	0.06	0.14	0.07	0.06	0.09	0.03	0.07	**0.0729**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.873041
Consistency Index (CI)	0.12472
Consistency Ratio (CR)	0.0885

Pairwise comparison matrix for sub-criteria (2)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	2.00	0.33	0.50	3.00	1.00	2.00	0.33
NEF	0.50	1.00	0.50	3.00	2.00	2.00	1.00	1.00
UAL	3.00	2.00	1.00	3.00	2.00	2.00	3.00	3.00
RE	2.00	0.33	0.33	1.00	2.00	1.00	0.50	0.50
WC	0.33	0.50	0.50	0.50	1.00	0.33	0.33	0.50
WG	1.00	0.50	0.50	1.00	3.00	1.00	1.00	2.00
WCO	0.50	1.00	0.33	2.00	3.00	1.00	1.00	2.00

CMP	3.00	1.00	0.33	2.00	2.00	0.50	0.50	1.00
Sum	11.33	8.33	3.83	13.00	18.00	8.83	9.33	10.33

Principal Eigen Value	8.890367
Consistency Index (CI)	0.127195
Consistency Ratio (CR)	0.0902

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.05	0.06	0.05	0.05	0.07	0.06	0.03	0.02	**0.0496**
NEF	0.15	0.19	0.15	0.19	0.21	0.19	0.17	0.19	**0.1816**
UAL	0.05	0.06	0.05	0.09	0.07	0.06	0.03	0.02	**0.0555**
RE	0.05	0.05	0.03	0.05	0.05	0.05	0.03	0.19	**0.0624**
WC	0.15	0.19	0.15	0.19	0.21	0.19	0.34	0.15	**0.1971**
WG	0.15	0.19	0.15	0.19	0.21	0.19	0.17	0.15	**0.1755**
WCO	0.25	0.19	0.26	0.24	0.11	0.19	0.17	0.24	**0.2057**
CMP	0.15	0.05	0.15	0.01	0.07	0.06	0.03	0.05	**0.0726**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Normalising the comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.09	0.24	0.09	0.04	0.17	0.11	0.21	0.03	**0.1225**
NEF	0.04	0.12	0.13	0.23	0.11	0.23	0.11	0.10	**0.1333**
UAL	0.26	0.24	0.26	0.23	0.11	0.23	0.32	0.29	**0.2432**

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.28	0.13	0.17	0.20	0.29	0.42	0.29	0.29	**0.2604**
NEF	0.14	0.07	0.11	0.05	0.03	0.04	0.05	0.12	**0.0761**
UAL	0.09	0.03	0.06	0.05	0.03	0.04	0.05	0.12	**0.0589**
RE	0.14	0.13	0.11	0.10	0.12	0.07	0.19	0.03	**0.1123**
WC	0.06	0.13	0.11	0.05	0.06	0.04	0.10	0.03	**0.0726**
WG	0.14	0.33	0.29	0.30	0.29	0.21	0.19	0.18	**0.2416**
WCO	0.09	0.13	0.11	0.05	0.06	0.10	0.10	0.18	**0.1035**
CMP	0.06	0.03	0.03	0.20	0.12	0.07	0.03	0.06	**0.0746**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

RE	0.18	0.04	0.09	0.08	0.11	0.11	0.05	0.05	**0.0883**
WC	0.03	0.06	0.13	0.04	0.06	0.04	0.04	0.05	**0.0545**
WG	0.09	0.06	0.13	0.08	0.17	0.11	0.11	0.19	**0.1170**
WCO	0.04	0.12	0.09	0.15	0.17	0.11	0.11	0.19	**0.1232**
CMP	0.26	0.12	0.09	0.15	0.11	0.06	0.05	0.10	**0.1179**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Pairwise comparison matrix for sub-criteria (3)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	2.00	2.00	0.50	3.00	3.00	2.00	4.00
NEF	0.50	1.00	0.50	0.25	5.00	2.00	4.00	3.00
UAL	0.50	2.00	1.00	1.00	3.00	3.00	2.00	2.00
RE	2.00	4.00	1.00	1.00	3.00	3.00	3.00	2.00
WC	0.33	0.20	0.33	0.33	1.00	0.25	0.50	0.50
WG	0.33	0.50	0.33	0.33	4.00	1.00	0.33	0.33
WCO	0.50	0.25	0.50	0.33	2.00	3.00	1.00	1.00
CMP	0.25	0.33	0.50	0.50	2.00	3.00	1.00	1.00
Sum	5.42	10.28	6.17	4.25	23.00	18.25	13.83	13.83

Principal Eigen Value	8.981009
Consistency Index (CI)	0.140144
Consistency Ratio (CR)	0.0994

Pairwise comparison matrix for sub-criteria (4)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	2.00	3.00	2.00	5.00	2.00	3.00	5.00
NEF	0.50	1.00	2.00	0.50	0.50	0.20	0.50	2.00
UAL	0.33	0.50	1.00	0.50	0.50	0.20	0.50	2.00
RE	0.50	2.00	2.00	1.00	2.00	0.33	2.00	0.50
WC	0.20	2.00	2.00	0.50	1.00	0.20	1.00	0.50
WG	0.50	5.00	5.00	3.00	5.00	1.00	2.00	3.00
WCO	0.33	2.00	2.00	0.50	1.00	0.50	1.00	3.00
CMP	0.20	0.50	0.50	2.00	2.00	0.33	0.33	1.00
Sum	3.57	15.00	17.50	10.00	17.00	4.77	10.33	17.00

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.28	0.13	0.17	0.20	0.29	0.42	0.29	0.29	**0.2604**
NEF	0.14	0.07	0.11	0.05	0.03	0.04	0.05	0.12	**0.0761**
UAL	0.09	0.03	0.06	0.05	0.03	0.04	0.05	0.12	**0.0589**
RE	0.14	0.13	0.11	0.10	0.12	0.07	0.19	0.03	**0.1123**
WC	0.06	0.13	0.11	0.05	0.06	0.04	0.10	0.03	**0.0726**
WG	0.14	0.33	0.29	0.30	0.29	0.21	0.19	0.18	**0.2416**
WCO	0.09	0.13	0.11	0.05	0.06	0.10	0.10	0.18	**0.1035**
CMP	0.06	0.03	0.03	0.20	0.12	0.07	0.03	0.06	**0.0746**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.946949
Consistency Index (CI)	0.135278
Consistency Ratio (CR)	0.0959

Pairwise comparison matrix for sub-criteria (5)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
NEF	1.00	1.00	1.00	1.00	0.25	1.00	1.00	1.00
UAL	1.00	1.00	1.00	4.00	4.00	1.00	1.00	1.00
RE	1.00	1.00	0.25	1.00	1.00	1.00	1.00	1.00
WC	1.00	4.00	0.25	1.00	1.00	1.00	1.00	1.00
WG	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

WCO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CMP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sum	8.00	11.00	6.50	11.00	10.25	8.00	8.00	8.00

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.13	0.09	0.15	0.09	0.10	0.13	0.13	0.13	**0.1167**
NEF	0.13	0.09	0.15	0.09	0.02	0.13	0.13	0.13	**0.1075**
UAL	0.13	0.09	0.15	0.36	0.39	0.13	0.13	0.13	**0.1873**
RE	0.13	0.09	0.04	0.09	0.10	0.13	0.13	0.13	**0.1022**
WC	0.13	0.36	0.04	0.09	0.10	0.13	0.13	0.13	**0.1363**
WG	0.13	0.09	0.15	0.09	0.10	0.13	0.13	0.13	**0.1167**
WCO	0.13	0.09	0.15	0.09	0.10	0.13	0.13	0.13	**0.1167**
CMP	0.13	0.09	0.15	0.09	0.10	0.13	0.13	0.13	**0.1167**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.654939
Consistency Index (CI)	0.093563
Consistency Ratio (CR)	0.0664

Pairwise comparison matrix for sub-criteria (6)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	0.50	0.20	0.11	0.33	0.33	0.33	0.33
NEF	2.00	1.00	0.17	0.14	0.20	0.33	0.33	0.33
UAL	5.00	6.00	1.00	0.20	2.00	2.00	2.00	2.00
RE	9.00	7.00	5.00	1.00	4.00	4.00	6.00	6.00
WC	3.00	5.00	0.50	0.25	1.00	0.33	3.00	3.00
WG	3.00	3.00	0.50	0.25	3.00	1.00	3.00	3.00
WCO	3.00	3.00	0.50	0.17	0.33	0.33	1.00	0.33
CMP	3.00	3.00	0.50	0.17	0.33	0.33	3.00	1.00
Sum	29.00	28.50	8.37	2.29	11.20	8.67	18.67	16.00

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.03	0.02	0.02	0.05	0.03	0.04	0.02	0.02	**0.0289**
NEF	0.07	0.04	0.02	0.06	0.02	0.04	0.02	0.02	**0.0352**
UAL	0.17	0.21	0.12	0.09	0.18	0.23	0.11	0.13	**0.1539**

RE	0.31	0.25	0.60	0.44	0.36	0.46	0.32	0.38	**0.3882**
WC	0.10	0.18	0.06	0.11	0.09	0.04	0.16	0.19	**0.1155**
WG	0.10	0.11	0.06	0.11	0.27	0.12	0.16	0.19	**0.1387**
WCO	0.10	0.11	0.06	0.07	0.03	0.04	0.05	0.02	**0.0605**
CMP	0.10	0.11	0.06	0.07	0.03	0.04	0.16	0.06	**0.0791**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.907309
Consistency Index (CI)	0.129616
Consistency Ratio (CR)	0.0919

Pairwise comparison matrix for sub-criteria (7)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	4.00	1.00	0.17	1.00	1.00	1.00	1.00
NEF	0.25	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UAL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
RE	6.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WC	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WG	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WCO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CMP	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sum	12.25	11.00	8.00	7.17	8.00	8.00	8.00	8.00

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.08	0.36	0.13	0.02	0.13	0.13	0.13	0.13	**0.1367**
NEF	0.02	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1095**
UAL	0.08	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1171**
RE	0.49	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1682**
WC	0.08	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1171**
WG	0.08	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1171**
WCO	0.08	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1171**
CMP	0.08	0.09	0.13	0.14	0.13	0.13	0.13	0.13	**0.1171**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.76925

Consistency Index (CI)	0.109893
Consistency Ratio (CR)	0.0779

Pairwise comparison matrix for sub-criteria (8)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	2.00	2.00	0.50	1.00	0.50	0.50	3.00
NEF	0.50	1.00	1.00	1.00	1.00	2.00	1.00	0.50
UAL	0.50	1.00	1.00	0.20	0.33	1.00	1.00	1.00
RE	2.00	1.00	5.00	1.00	1.00	2.00	2.00	1.00
WC	1.00	1.00	3.00	1.00	1.00	1.00	2.00	3.00
WG	2.00	0.50	1.00	0.50	1.00	1.00	1.00	1.00
WCO	2.00	1.00	1.00	0.50	0.50	1.00	1.00	2.00
CMP	0.33	2.00	1.00	1.00	0.33	1.00	0.50	1.00
Sum	9.33	9.50	15.00	5.70	6.17	9.50	9.00	12.50

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.11	0.21	0.13	0.09	0.16	0.05	0.06	0.24	**0.1311**
NEF	0.05	0.11	0.07	0.18	0.16	0.21	0.11	0.04	**0.1156**
UAL	0.05	0.11	0.07	0.04	0.05	0.11	0.11	0.08	**0.0764**
RE	0.21	0.11	0.33	0.18	0.16	0.21	0.22	0.08	**0.1879**
WC	0.11	0.11	0.20	0.18	0.16	0.11	0.22	0.24	**0.1647**
WG	0.21	0.05	0.07	0.09	0.16	0.11	0.11	0.08	**0.1100**
WCO	0.21	0.11	0.07	0.09	0.08	0.11	0.11	0.16	**0.1164**
CMP	0.04	0.21	0.07	0.18	0.05	0.11	0.06	0.08	**0.0979**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.870724
Consistency Index (CI)	0.124389
Consistency Ratio (CR)	0.0882

Pairwise comparison matrix for sub-criteria (9)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	0.17	0.17	0.20	0.50	0.33	0.33	0.25
NEF	6.00	1.00	2.00	3.00	4.00	5.00	5.00	6.00
UAL	6.00	0.50	1.00	2.00	2.00	4.00	3.00	4.00

RE	5.00	0.33	0.50	1.00	3.00	4.00	6.00	3.00
WC	2.00	0.25	0.50	0.33	1.00	4.00	2.00	3.00
WG	3.00	0.20	0.25	0.25	0.25	1.00	3.00	2.00
WCO	3.00	0.20	0.33	0.17	0.50	0.33	1.00	2.00
CMP	4.00	0.17	0.25	0.33	0.33	0.50	0.50	1.00
Sum	30.00	2.82	5.00	7.28	11.58	19.17	20.83	21.25

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	Priority vector
EGG	0.03	0.06	0.03	0.03	0.04	0.02	0.02	0.01	**0.0302**
NEF	0.20	0.36	0.40	0.41	0.35	0.26	0.24	0.28	**0.3119**
UAL	0.20	0.18	0.20	0.27	0.17	0.21	0.14	0.19	**0.1957**
RE	0.17	0.12	0.10	0.14	0.26	0.21	0.29	0.14	**0.1774**
WC	0.07	0.09	0.10	0.05	0.09	0.21	0.10	0.14	**0.1042**
WG	0.10	0.07	0.05	0.03	0.02	0.05	0.14	0.09	**0.0709**
WCO	0.10	0.07	0.07	0.02	0.04	0.02	0.05	0.09	**0.0579**
CMP	0.13	0.06	0.05	0.05	0.03	0.03	0.02	0.05	**0.0518**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.927442
Consistency Index (CI)	0.132492
Consistency Ratio (CR)	0.0940

Pairwise comparison matrix for sub-criteria (10)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	0.25	0.14	0.25	0.20	0.33	0.33	0.20
NEF	9	1.00	2.00	0.50	0.50	0.33	0.50	1.00
UAL	9.00	0.50	1.00	2.00	2.00	2.00	1.00	2.00
RE	4.00	2.00	0.50	1.00	2.00	1.00	1.00	1.00
WC	5.00	2.00	0.50	1.00	1.00	1.00	1.00	2.00
WG	3.00	3.00	0.50	1.00	1.00	1.00	2.00	3.00
WCO	3.00	2.00	1.00	1.00	1.00	0.50	1.00	1.00
CMP	5.00	1.00	0.50	1.00	0.50	0.33	1.00	1.00
Sum	39.00	11.75	6.14	7.75	8.20	6.50	7.83	11.20

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.03	0.02	0.02	0.03	0.02	0.05	0.04	0.02	**0.0298**
NEF	0.05	0.09	0.33	0.06	0.06	0.05	0.06	0.09	**0.0990**
UAL	0.23	0.04	0.16	0.26	0.24	0.31	0.13	0.18	**0.1940**
RE	0.10	0.17	0.08	0.13	0.24	0.15	0.13	0.09	**0.1372**
WC	0.13	0.17	0.08	0.13	0.12	0.15	0.13	0.18	**0.1364**
WG	0.08	0.26	0.08	0.13	0.12	0.15	0.26	0.27	**0.1677**
WCO	0.08	0.17	0.16	0.13	0.12	0.08	0.13	0.09	**0.1193**
CMP	0.13	0.09	0.08	0.13	0.06	0.05	0.13	0.09	**0.0941**
Sum	0.82	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.778343
Consistency Index (CI)	0.111192
Consistency Ratio (CR)	0.0789

Pairwise comparison matrix for sub-criteria (11)

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00
NEF	1.00	1.00	1.00	1.00	0.25	2.00	2.00	0.33
UAL	0.50	1.00	1.00	1.00	1.00	0.50	2.00	1.00
RE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
WC	0.50	4.00	1.00	1.00	1.00	0.33	1.00	1.00
WG	1.00	0.50	2.00	1.00	3.00	1.00	1.00	2.00
WCO	1.00	0.50	0.50	1.00	1.00	1.00	1.00	1.00
CMP	1.00	3.00	1.00	1.00	1.00	0.50	1.00	1.00
Sum	7.00	12.00	9.50	8.00	10.25	7.33	10.00	8.33

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.14	0.08	0.21	0.13	0.20	0.14	0.10	0.12	**0.1392**
NEF	0.14	0.08	0.11	0.13	0.02	0.27	0.20	0.04	**0.1242**
UAL	0.07	0.08	0.11	0.13	0.10	0.07	0.20	0.12	**0.1088**
RE	0.14	0.08	0.11	0.13	0.10	0.14	0.10	0.12	**0.1138**
WC	0.07	0.33	0.11	0.13	0.10	0.05	0.10	0.12	**0.1248**
WG	0.14	0.04	0.21	0.13	0.29	0.14	0.10	0.24	**0.1611**
WCO	0.14	0.04	0.05	0.13	0.10	0.14	0.10	0.12	**0.1020**

CMP	0.14	0.25	0.11	0.13	0.10	0.07	0.10	0.12	**0.1261**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.940234
Consistency Index (CI)	0.134319
Consistency Ratio (CR)	0.0953

Pairwise comparison matrix for sub-criteria

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP
EGG	1.00	2.00	0.33	0.50	3.00	1.00	2.00	0.33
NEF	0.50	1.00	0.50	3.00	2.00	2.00	1.00	1.00
UAL	3.00	2.00	1.00	3.00	2.00	2.00	3.00	3.00
RE	2.00	0.33	0.33	1.00	2.00	1.00	0.50	0.50
WC	0.33	0.50	0.50	0.50	1.00	0.33	0.33	0.50
WG	1.00	0.50	0.50	1.00	3.00	1.00	1.00	2.00
WCO	0.50	1.00	0.33	2.00	3.00	1.00	1.00	2.00
CMP	3.00	1.00	0.33	2.00	2.00	0.50	0.50	1.00
Sum	11.33	8.33	3.83	13.00	18.00	8.83	9.33	10.33

Normalizing the Comparison

Criteria	EGG	NEF	UAL	RE	WC	WG	WCO	CMP	**Priority vector**
EGG	0.09	0.24	0.09	0.04	0.17	0.11	0.21	0.03	**0.1225**
NEF	0.04	0.12	0.13	0.23	0.11	0.23	0.11	0.10	**0.1333**
UAL	0.26	0.24	0.26	0.23	0.11	0.23	0.32	0.29	**0.2432**
RE	0.18	0.04	0.09	0.08	0.11	0.11	0.05	0.05	**0.0883**
WC	0.03	0.06	0.13	0.04	0.06	0.04	0.04	0.05	**0.0545**
WG	0.09	0.06	0.13	0.08	0.17	0.11	0.11	0.19	**0.1170**
WCO	0.04	0.12	0.09	0.15	0.17	0.11	0.11	0.19	**0.1232**
CMP	0.26	0.12	0.09	0.15	0.11	0.06	0.05	0.10	**0.1179**
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	

Principal Eigen Value	8.962707
Consistency Index (CI)	0.13753
Consistency Ratio (CR)	0.0975

THE MATRICES FOR THE POLITICAL CRITERIA COMPARISON WITH RESPECT TO POLITICAL PERSPECTIVE

(1)

Pairwise comparison matrix for

Criteria	GB	LS	CEP
GB	1.00	0.33	0.33
LS	3.00	1.00	0.50
CEP	3.00	2.00	1.00
Sum	7.00	3.33	1.83

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.14	0.10	0.18	**0.1416**
LS	0.43	0.30	0.27	**0.3338**
CEP	0.43	0.60	0.55	**0.5247**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.065368
Consistency Index (CI)	0.032684
Consistency Ratio (CR)	0.0564

(2)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	2.00	2.00
LS	0.50	1.00	0.50
CEP	0.50	2.00	1.00
Sum	2.00	5.00	3.50

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.50	0.40	0.57	**0.4905**
LS	0.25	0.20	0.14	**0.1976**
CEP	0.25	0.40	0.29	**0.3119**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.060714
Consistency Index (CI)	0.030357
Consistency Ratio (CR)	0.0523

(3)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	3.00	3.00
LS	0.33	1.00	0.50
CEP	0.33	2.00	1.00
Sum	1.67	6.00	4.50

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.60	0.50	0.67	**0.5889**
LS	0.20	0.17	0.11	**0.1593**
CEP	0.20	0.33	0.22	**0.2519**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.07037
Consistency Index (CI)	0.035185
Consistency Ratio (CR)	0.0607

(4)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	4.00	0.33
LS	0.25	1.00	0.17
CEP	3.00	6.00	1.00
Sum	4.25	11.00	1.50

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.24	0.36	0.22	**0.2737**
LS	0.06	0.09	0.11	**0.0869**
CEP	0.71	0.55	0.67	**0.6393**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.078728
Consistency Index (CI)	0.039364
Consistency Ratio (CR)	0.0679

(5)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	0.50	0.33
LS	2.00	1.00	0.33
CEP	3.00	3.00	1.00
Sum	6.00	4.50	1.67

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.17	0.11	0.20	**0.1593**
LS	0.33	0.22	0.20	**0.2519**
CEP	0.50	0.67	0.60	**0.5889**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.07037
Consistency Index (CI)	0.035185
Consistency Ratio (CR)	0.0607

(6)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	0.50	0.25
LS	2.00	1.00	0.33
CEP	4.00	3.00	1.00
Sum	7.00	4.50	1.58

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.14	0.11	0.16	**0.1373**
LS	0.29	0.22	0.21	**0.2395**
CEP	0.57	0.67	0.63	**0.6232**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.02548
Consistency Index (CI)	0.01274
Consistency Ratio (CR)	0.0220

(7)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	0.33	0.17
LS	3.00	1.00	0.25
CEP	6.00	4.00	1.00
Sum	10.00	5.33	1.42

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.10	0.06	0.12	**0.0934**
LS	0.30	0.19	0.18	**0.2213**
CEP	0.60	0.75	0.71	**0.6853**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.085049
Consistency Index (CI)	0.042525
Consistency Ratio (CR)	0.0733

(8)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	4.00	0.33
LS	0.25	1.00	0.17
CEP	3.00	6.00	1.00
Sum	4.25	11.00	1.50

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.24	0.36	0.22	**0.2737**
LS	0.06	0.09	0.11	**0.0869**

CEP	0.71	0.55	0.67	**0.6393**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.078728
Consistency Index (CI)	0.039364
Consistency Ratio (CR)	0.0679

(9)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	4.00	4.00
LS	0.25	1.00	2.00
CEP	0.25	0.50	1.00
Sum	1.50	5.50	7.00

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.67	0.73	0.57	**0.6551**
LS	0.17	0.18	0.29	**0.2114**
CEP	0.17	0.09	0.14	**0.1335**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.079726
Consistency Index (CI)	0.039863
Consistency Ratio (CR)	0.0687

(10)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	1.00	4.00
LS	1.00	1.00	3.00
CEP	0.25	0.33	1.00
Sum	2.25	2.33	8.00

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.44	0.43	0.50	**0.4577**
LS	0.44	0.43	0.38	**0.4160**
CEP	0.11	0.14	0.13	**0.1263**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.011023
Consistency Index (CI)	0.005511
Consistency Ratio (CR)	0.0095

(11)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	0.50	3.00
LS	2.00	1.00	3.00
CEP	0.33	0.33	1.00
Sum	3.33	1.83	7.00

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.30	0.27	0.43	**0.3338**
LS	0.60	0.55	0.43	**0.5247**
CEP	0.10	0.18	0.14	**0.1416**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.065368
Consistency Index (CI)	0.032684
Consistency Ratio (CR)	0.0564

(12)

Pairwise comparison matrix for sub-criteria

Criteria	GB	LS	CEP
GB	1.00	0.20	0.14
LS	5.00	1.00	0.33
CEP	7.00	3.00	1.00
Sum	13.00	4.20	1.48

Normalizing the Comparison

Criteria	GB	LS	CEP	**Priority vector**
GB	0.08	0.05	0.10	**0.0738**
LS	0.38	0.24	0.23	**0.2828**
CEP	0.54	0.71	0.68	**0.6434**
Sum	1.00	1.00	1.00	

Principal Eigen Value	3.096726
Consistency Index (CI)	0.048363
Consistency Ratio (CR)	0.0834

APPENDIX VI: THE MATRICES OF ALTERNATIVES COMPARED WITH RESPECT TO EACH OF CRITERIA IN THE SOCIAL PERSPECTIVE

THE MATRICES OF ALTERNATIVES COMPARED WITH RESPECT TO EACH OF CRITERIA IN THE SOCIAL PERSPECTIVE

Job Creation (JC)

Pairwise Comparison matrix for alternatives (1)			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.33
Manual	3.00	1.00	2.00
None	3.00	0.50	1.00
Sum	**7**	**1.83**	**3.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.1818	0.1000	**0.1416**
Manual	0.4286	0.5455	0.6000	**0.5247**
None	0.4286	0.2727	0.3000	**0.3338**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	4
Manual	2.00	1.00	4.00
None	0.25	0.25	1.00
Sum	**3.25**	**1.75**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3077	0.2857	0.4444	**0.3460**
Manual	0.6154	0.5714	0.4444	**0.5438**
None	0.0769	0.1429	0.1111	**0.1103**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.5
Manual	4.00	1.00	4.00
None	2.00	0.25	1.00
Sum	**7**	**1.5**	**5.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.1667	0.0909	**0.1335**
Manual	0.5714	0.6667	0.7273	**0.6551**
None	0.2857	0.1667	0.1818	**0.2114**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.333333	0.5
Manual	3.00	1.00	3.00

None	2.00	0.33	1.00
Sum	**6**	**1.666667**	**4.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1667	0.2000	0.1111	**0.1593**
Manual	0.5000	0.6000	0.6667	**0.5889**
None	0.3333	0.2000	0.2222	**0.2519**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Job Creation (JC)

Pairwise Comparison matrix (2)			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.33
Manual	4.00	1.00	3.00
None	3.00	0.33	1.00
Sum	**8**	**1.58**	**4.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.1579	0.0769	**0.1199**
Manual	0.5000	0.6316	0.6923	**0.6080**
None	0.3750	0.2105	0.2308	**0.2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.33
Manual	4.00	1.00	3.00

None	3.00	0.33	1.00
Sum	**8**	**1.58**	**4.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.1579	0.0769	**0.1199**
Manual	0.5000	0.6316	0.6923	**0.6080**
None	0.3750	0.2105	0.2308	**0.2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.33
Manual	4.00	1.00	3.00
None	3.00	0.33	1.00
Sum	**8**	**1.58**	**4.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.1579	0.0769	**0.1199**
Manual	0.5000	0.6316	0.6923	**0.6080**
None	0.3750	0.2105	0.2308	**0.2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	0.33	0.25
Manual	3.00	1.00	0.33
None	4.00	3.00	1.00
Sum	**8**	**4.33**	**1.58**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.0769	0.1579	**0.1199**
Manual	0.3750	0.2308	0.2105	**0.2721**
None	0.5000	0.6923	0.6316	**0.6080**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Job Creation (JC)

Pairwise Comparison matrix (3)			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0.33	1.00	2.00
None	0.33	0.50	1.00
Sum	**1.66**	**4.5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6000	0.6667	0.5000	**0.5889**
Manual	0.2000	0.2222	0.3333	**0.2519**
None	0.2000	0.1111	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0.33	1.00	2.00
None	0.33	0.50	1.00
Sum	**1.66**	**4.5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6000	0.6667	0.5000	**0.5889**
Manual	0.2000	0.2222	0.3333	**0.2519**
None	0.2000	0.1111	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0.33	1.00	2.00
None	0.33	0.50	1.00
Sum	**1.66**	**4.5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6000	0.6667	0.5000	**0.5889**
Manual	0.2000	0.2222	0.3333	**0.2519**
None	0.2000	0.1111	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352

Consistency Ratio (CR)	0.0607

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	3
Manual	2.00	1.00	3.00
None	0.33	0.33	1.00
Sum	**3.333333**	**1.833333**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3000	0.2727	0.4286	**0.3338**
Manual	0.6000	0.5455	0.4286	**0.5247**
None	0.1000	0.1818	0.1429	**0.1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Job Creation (JC)

Pairwise Comparison matrix (4)			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0.25	1.00	0.50
None	0.25	2.00	1.00
Sum	**1.5**	**7**	**5.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.5714	0.7273	**0.6551**
Manual	0.1667	0.1429	0.0909	**0.1335**
None	0.1667	0.2857	0.1818	**0.2114**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	5
Manual	0.33	1.00	3.00
None	0.20	0.33	1.00
Sum	**1.53**	**4.33**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6522	0.6923	0.5556	**0.6333**
Manual	0.2174	0.2308	0.3333	**0.2605**
None	0.1304	0.0769	0.1111	**0.1062**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.5
Manual	0.25	1.00	0.25
None	2.00	4.00	1.00
Sum	**3.25**	**9**	**1.75**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0.3077	0.4444	0.2857	**0.3460**
Manual	0.0769	0.1111	0.1429	**0.1103**
None	0.6154	0.4444	0.5714	**0.5438**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1111	0.0769	0.1304	**0.1062**
Manual	0.3333	0.2308	0.2174	**0.2605**
None	0.5556	0.6923	0.6522	**0.6333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0.33	1.00	3.00
None	0.25	0.33	1.00
Sum	**1.58**	**4.33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.6923	0.5000	**0.6080**
Manual	0.2105	0.2308	0.3750	**0.2721**
None	0.1579	0.0769	0.1250	**0.1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Job Creation (JC)

Pairwise Comparison matrix (5)			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.2
Manual	3.00	1.00	0.33
None	5.00	3.00	1.00
Sum	**9**	**4.33**	**1.53**

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.25
Manual	3.00	1.00	0.33
None	4.00	3.00	1.00
Sum	**8**	**4.33**	**1.58**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.0769	0.1579	**0.1199**
Manual	0.3750	0.2308	0.2105	**0.2721**
None	0.5000	0.6923	0.6316	**0.6080**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0.33	1.00	2.00
None	0.33	0.50	1.00
Sum	**1.66**	**4.5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6000	0.6667	0.5000	**0.5889**
Manual	0.2000	0.2222	0.3333	**0.2519**
None	0.2000	0.1111	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Manual**	**Solar**	**None**
Solar	1	0.25	0.33
Manual	4.00	1.00	3.00
None	3.00	0.33	1.00
Sum	**8**	**1.58**	**4.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.1579	0.0769	**0.1199**
Manual	0.5000	0.6316	0.6923	**0.6080**
None	0.3750	0.2105	0.2308	**0.2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Job Creation (JC)

Pairwise Comparison matrix (6)			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.5
Manual	0.50	1.00	0.50
None	2.00	2.00	1.00

Sum	**3.5**	**5**	**2**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2857	0.4000	0.2500	**0.3119**
Manual	0.1429	0.2000	0.2500	**0.1976**
None	0.5714	0.4000	0.5000	**0.4905**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0607
Consistency Index (CI)	0.0304
Consistency Ratio (CR)	0.0523

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0.33	1.00	3.00
None	0.25	0.33	1.00
Sum	**1.58**	**4.33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.6923	0.5000	**0.6080**
Manual	0.2105	0.2308	0.3750	**0.2721**
None	0.1579	0.0769	0.1250	**0.1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.33
Manual	3.00	1.00	2.00
None	3.00	0.50	1.00

Sum	7	1.83	3.33

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.1818	0.1000	**0.1416**
Manual	0.4286	0.5455	0.6000	**0.5247**
None	0.4286	0.2727	0.3000	**0.3338**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.5
Manual	0.25	1.00	0.17
None	2.00	6.00	1.00
Sum	**3.25**	**11**	**1.66**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3077	0.3636	0.3000	**0.3238**
Manual	0.0769	0.0909	0.1000	**0.0893**
None	0.6154	0.5455	0.6000	**0.5869**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0126
Consistency Index (CI)	0.0063
Consistency Ratio (CR)	0.0108

Job Creation (JC)

Pairwise Comparison matrix (7)			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.25
Manual	0.25	1.00	1.00
None	4.00	1.00	1.00
Sum	**5.25**	**6**	**2.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1905	0.6667	0.1111	**0.3228**
Manual	0.0476	0.1667	0.4444	**0.2196**
None	0.7619	0.1667	0.4444	**0.4577**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	4.0417
Consistency Index (CI)	0.5208
Consistency Ratio (CR)	0.8980

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.5
Manual	0.50	1.00	0.50
None	2.00	2.00	1.00
Sum	**3.5**	**5**	**2**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2857	0.4000	0.2500	**0.3119**
Manual	0.1429	0.2000	0.2500	**0.1976**
None	0.5714	0.4000	0.5000	**0.4905**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0607
Consistency Index (CI)	0.0304
Consistency Ratio (CR)	0.0523

Health Effects - Operations (HE-M)

Pairwise Comparison matrix

Options	Solar	Manual	None
Solar	1	0.5	0.25
Manual	2.00	1.00	0.25
None	4.00	4.00	1.00
Sum	**7**	**5.5**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.0909	0.1667	**0.1335**
Manual	0.2857	0.1818	0.1667	**0.2114**
None	0.5714	0.7273	0.6667	**0.6551**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Pairwise Comparison matrix (8)			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	3
Manual	2.00	1.00	3.00
None	0.33	0.33	1.00
Sum	**3.33**	**1.83**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3000	0.2727	0.4286	**0.3338**
Manual	0.6000	0.5455	0.4286	**0.5247**
None	0.1000	0.1818	0.1429	**0.1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0.25	1.00	3.00
None	0.17	0.33	1.00
Sum	**1.416667**	**5.333333**	**10**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**
Solar	0.7059	0.7500	0.6000	**0.6853**
Manual	0.1765	0.1875	0.3000	**0.2213**
None	0.1176	0.0625	0.1000	**0.0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	3
Manual	3.00	1.00	4.00
None	0.33	0.25	1.00
Sum	**4.33**	**1.58**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2308	0.2105	0.3750	0.2721
Manual	0.6923	0.6316	0.5000	0.6080
None	0.0769	0.1579	0.1250	0.1199
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Job Creation (JC)

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	2
Manual	1.00	1.00	1.00
None	0.50	1.00	1.00
Sum	**2.5**	**3**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.4000	0.3333	0.5000	0.4111
Manual	0.4000	0.3333	0.2500	0.3278
None	0.2000	0.3333	0.2500	0.2611
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0556
Consistency Index (CI)	0.0278
Consistency Ratio (CR)	0.0479

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1.00	1.00	2.00
None	0.20	0.50	1.00
Sum	**2.2**	**2.5**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.4545	0.4000	0.6250	0.4932
Manual	0.4545	0.4000	0.2500	0.3682
None	0.0909	0.2000	0.1250	0.1386
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1145
Consistency Index (CI)	0.0573
Consistency Ratio (CR)	0.0987

Job Creation (JC)

Pairwise Comparison matrix (9)			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0.25	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.5**	**5.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7273	0.5714	0.6551
Manual	0.1667	0.1818	0.2857	0.2114
None	0.1667	0.0909	0.1429	0.1335
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0.25	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.5**	**5.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7273	0.5714	0.6551
Manual	0.1667	0.1818	0.2857	0.2114
None	0.1667	0.0909	0.1429	0.1335

Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.2	0.166667
Manual	5.00	1.00	0.50
None	6.00	2.00	1.00
Sum	**12**	**3.2**	**1.666667**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0833	0.0625	0.1000	0.0819
Manual	0.4167	0.3125	0.3000	0.3431
None	0.5000	0.6250	0.6000	0.5750
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0394
Consistency Index (CI)	0.0197
Consistency Ratio (CR)	0.0340

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	5
Manual	0.20	1.00	2.00
None	0.20	0.50	1.00
Sum	**1.4**	**6.5**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7143	0.7692	0.6250	0.7028
Manual	0.1429	0.1538	0.2500	0.1822
None	0.1429	0.0769	0.1250	0.1149
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0879
Consistency Index (CI)	0.0440
Consistency Ratio (CR)	0.0758

Job Creation (JC)

Pairwise Comparison matrix (10)			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.25
Manual	3.00	1.00	0.33
None	4.00	3.00	1.00
Sum	**8**	**4.33**	**1.58**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.0769	0.1579	0.1199
Manual	0.3750	0.2308	0.2105	0.2721
None	0.5000	0.6923	0.6316	0.6080
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	5
Manual	0.20	1.00	2.00
None	0.20	0.50	1.00
Sum	**1.4**	**6.5**	**8**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0.7143	0.7692	0.6250	0.7028
Manual	0.1429	0.1538	0.2500	0.1822
None	0.1429	0.0769	0.1250	0.1149
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0879
Consistency Index (CI)	0.0440
Consistency Ratio (CR)	0.0758

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0.33	1.00	3.00
None	0.25	0.33	1.00
Sum	**1.58**	**4.33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.6923	0.5000	0.6080
Manual	0.2105	0.2308	0.3750	0.2721
None	0.1579	0.0769	0.1250	0.1199
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Manual**	**Solar**	**None**
Solar	1	3	4
Manual	0.33	1.00	3.00
None	0.25	0.33	1.00
Sum	**1.58**	**4.33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.6923	0.5000	**0.6080**
Manual	0.2105	0.2308	0.3750	**0.2721**
None	0.1579	0.0769	0.1250	**0.1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Job Creation (JC)

Pairwise Comparison matrix (11)			
Options	**Solar**	**Manual**	**None**
Solar	1	2	1
Manual	0.50	1.00	1.00
None	1.00	1.00	1.00
Sum	**2.5**	**4**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.4000	0.5000	0.3333	0.4111
Manual	0.2000	0.2500	0.3333	0.2611
None	0.4000	0.2500	0.3333	0.3278
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0556
Consistency Index (CI)	0.0278
Consistency Ratio (CR)	0.0479

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	0.50

None	1.00	2.00	1.00
Sum	**3**	**4**	**2.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.2500	0.4000	0.3278
Manual	0.3333	0.2500	0.2000	0.2611
None	0.3333	0.5000	0.4000	0.4111
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0556
Consistency Index (CI)	0.0278
Consistency Ratio (CR)	0.0479

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	0.50
None	1.00	2.00	1.00
Sum	**3**	**4**	**2.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.2500	0.4000	0.3278
Manual	0.3333	0.2500	0.2000	0.2611
None	0.3333	0.5000	0.4000	0.4111
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0556
Consistency Index (CI)	0.0278
Consistency Ratio (CR)	0.0479

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	2

Manual	0.33	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.83**	**5**	**4**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**
Solar	0.5455	0.6000	0.5000	**0.5485**
Manual	0.1818	0.2000	0.2500	**0.2106**
None	0.2727	0.2000	0.2500	**0.2409**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0222
Consistency Index (CI)	0.0111
Consistency Ratio (CR)	0.0192

Job Creation (JC)

Pairwise Comparison matrix (12)			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	2
Manual	4.00	1.00	4.00
None	0.50	0.25	1.00
Sum	**5.5**	**1.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1818	0.1667	0.2857	0.2114
Manual	0.7273	0.6667	0.5714	0.6551
None	0.0909	0.1667	0.1429	0.1335
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Safety & Protection (SP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	0.25
None	0.50	4.00	1.00
Sum	**1.75**	**9**	**3.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.4444	0.6154	0.5438
Manual	0.1429	0.1111	0.0769	0.1103
None	0.2857	0.4444	0.3077	0.3460
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Health Effects - Operations (HE-M)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	6
Manual	2.00	1.00	4.00
None	0.17	0.25	1.00
Sum	**3.16**	**1.75**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3158	0.2857	0.5455	0.3823
Manual	0.6316	0.5714	0.3636	0.5222
None	0.0526	0.1429	0.0909	0.0955
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1747
Consistency Index (CI)	0.0873
Consistency Ratio (CR)	0.1506

Health Effects - Processing (HE-P)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	2
Manual	4.00	1.00	5.00
None	0.50	0.20	1.00
Sum	**5.5**	**1.45**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1818	0.1724	0.2500	0.2014
Manual	0.7273	0.6897	0.6250	0.6806
None	0.0909	0.1379	0.1250	0.1179
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0383
Consistency Index (CI)	0.0191
Consistency Ratio (CR)	0.0330

THE MATRICES OF ALTERNATIVES COMPARED WITH RESPECT TO EACH OF CRITERIA IN THE TECHNICAL PERSPECTIVE

Solar Efficiency (SEM)

Pairwise Comparison matrix (1)			
Options	**Solar**	**Manual**	**None**
Solar	1	8	8
Manual	0,13	1,00	1,00
None	0,13	1,00	1,00
Sum	**1,25**	**10**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8000	0,8000	0,8000	**0,8000**
Manual	0,1000	0,1000	0,1000	**0,1000**

None	0,1000	0,1000	0,1000	**0,1000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	8
Manual	0,13	1,00	1,00
None	0,13	1,00	1,00
Sum	**1,25**	**10**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8000	0,8000	0,8000	**0,8000**
Manual	0,1000	0,1000	0,1000	**0,1000**
None	0,1000	0,1000	0,1000	**0,1000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	6
Manual	0,20	1,00	1,00
None	0,17	1,00	1,00
Sum	**1,366667**	**7**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**

Solar	0,7317	0,7143	0,7500	**0,7320**
Manual	0,1463	0,1429	0,1250	**0,1381**
None	0,1220	0,1429	0,1250	**0,1299**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0063
Consistency Index (CI)	0,0032
Consistency Ratio (CR)	0,0055

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	9
Manual	0,11	1,00	1,00
None	0,11	1,00	1,00
Sum	**1,22**	**11**	**11**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0,8182	0,8182	0,8182	**0,8182**
Manual	0,0909	0,0909	0,0909	**0,0909**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	9
Manual	0,11	1,00	2,00
None	0,11	0,50	1,00
Sum	**1,22**	**10,5**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8182	0,8571	0,7500	**0,8084**
Manual	0,0909	0,0952	0,1667	**0,1176**
None	0,0909	0,0476	0,0833	**0,0740**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1104
Consistency Index (CI)	0,0552
Consistency Ratio (CR)	0,0952

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	6
Manual	0,17	1,00	1,00
None	0,17	1,00	1,00
Sum	**1,33**	**8**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7500	0,7500	0,7500	**0,7500**
Manual	0,1250	0,1250	0,1250	**0,1250**
None	0,1250	0,1250	0,1250	**0,1250**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Solar Efficiency (SEM)

Pairwise Comparison matrix (2)			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0,33	1,00	2,00
None	0,33	0,50	1,00
Sum	**1,66**	**4,5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6000	0,6667	0,5000	**0,5889**
Manual	0,2000	0,2222	0,3333	**0,2519**
None	0,2000	0,1111	0,1667	**0,1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00

Sum	2,2	2,2	11

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	4
Manual	1,00	1,00	5,00
None	0,25	0,20	1,00
Sum	**2,25**	**2,2**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4444	0,4545	0,4000	**0,4330**
Manual	0,4444	0,4545	0,5000	**0,4663**
None	0,1111	0,0909	0,1000	**0,1007**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0069
Consistency Index (CI)	0,0035
Consistency Ratio (CR)	0,0060

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Maintenance Requirement (MR)

Pairwise Comparison matrix

Options	Solar	Manual	None
Solar	1	1	4
Manual	1,00	1,00	4,00
None	0,25	0,25	1,00
Sum	**2,25**	**2,25**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4444	0,4444	0,4444	**0,4444**
Manual	0,4444	0,4444	0,4444	**0,4444**
None	0,1111	0,1111	0,1111	**0,1111**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Solar Efficiency (SEM)

Pairwise Comparison matrix (3)			
Options	**Solar**	**Manual**	**None**
Solar	1	5	8
Manual	0,20	1,00	3,00
None	0,13	0,33	1,00
Sum	**1,32**	**6,33**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7547	0,7895	0,6667	**0,7370**
Manual	0,1509	0,1579	0,2500	**0,1863**
None	0,0943	0,0526	0,0833	**0,0768**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0774
Consistency Index (CI)	0,0387
Consistency Ratio (CR)	0,0668

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	9
Manual	0,25	1,00	4,00
None	0,11	0,25	1,00
Sum	**1,36**	**5,25**	**14**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,7619	0,6429	**0,7132**
Manual	0,1837	0,1905	0,2857	**0,2200**
None	0,0816	0,0476	0,0714	**0,0669**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	7
Manual	0,14	1,00	2,00
None	0,14	0,50	1,00
Sum	**1,28**	**8,5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7778	0,8235	0,7000	**0,7671**
Manual	0,1111	0,1176	0,2000	**0,1429**
None	0,1111	0,0588	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	3
Manual	3,00	1,00	5,00
None	0,33	0,20	1,00
Sum	**4,33**	**1,53**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2308	0,2174	0,3333	**0,2605**
Manual	0,6923	0,6522	0,5556	**0,6333**
None	0,0769	0,1304	0,1111	**0,1062**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0554
Consistency Index (CI)	0,0277
Consistency Ratio (CR)	0,0477

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	8
Manual	0,20	1,00	3,00
None	0,13	0,33	1,00
Sum	**1,32**	**6,33**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7547	0,7895	0,6667	**0,7370**
Manual	0,1509	0,1579	0,2500	**0,1863**
None	0,0943	0,0526	0,0833	**0,0768**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0774
Consistency Index (CI)	0,0387
Consistency Ratio (CR)	0,0668

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Solar Efficiency (SEM)

Pairwise Comparison matrix (4)			
Options	**Solar**	**Manual**	**None**
Solar	1	5	8
Manual	0,20	1,00	3,00
None	0,13	0,33	1,00
Sum	**1,32**	**6,33**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7547	0,7895	0,6667	**0,7370**

Manual	0,1509	0,1579	0,2500	**0,1863**
None	0,0943	0,0526	0,0833	**0,0768**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0774
Consistency Index (CI)	0,0387
Consistency Ratio (CR)	0,0668

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	9
Manual	0,25	1,00	4,00
None	0,11	0,25	1,00
Sum	**1,36**	**5,25**	**14**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,7619	0,6429	**0,7132**
Manual	0,1837	0,1905	0,2857	**0,2200**
None	0,0816	0,0476	0,0714	**0,0669**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	7
Manual	0,14	1,00	2,00
None	0,14	0,50	1,00
Sum	**1,28**	**8,5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7778	0,8235	0,7000	**0,7671**
Manual	0,1111	0,1176	0,2000	**0,1429**
None	0,1111	0,0588	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	0,33	3
Manual	3,00	1,00	5,00
None	0,33	0,20	1,00
Sum	**4,33**	**1,53**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2308	0,2174	0,3333	**0,2605**
Manual	0,6923	0,6522	0,5556	**0,6333**
None	0,0769	0,1304	0,1111	**0,1062**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0554
Consistency Index (CI)	0,0277
Consistency Ratio (CR)	0,0477

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	8
Manual	0,20	1,00	3,00
None	0,13	0,33	1,00
Sum	**1,32**	**6,33**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7547	0,7895	0,6667	**0,7370**
Manual	0,1509	0,1579	0,2500	**0,1863**
None	0,0943	0,0526	0,0833	**0,0768**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0774
Consistency Index (CI)	0,0387
Consistency Ratio (CR)	0,0668

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,342857**	**6,333333**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Solar Efficiency (SEM)

Pairwise Comparison matrix (5)			
Options	**Solar**	**Manual**	**None**
Solar	1	8	5
Manual	0,13	1,00	0,50
None	0,20	2,00	1,00
Sum	**1,32**	**11**	**6,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7547	0,7273	0,7692	**0,7504**
Manual	0,0943	0,0909	0,0769	**0,0874**
None	0,1509	0,1818	0,1538	**0,1622**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0099
Consistency Index (CI)	0,0050
Consistency Ratio (CR)	0,0085

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	9
Manual	0,11	1,00	2,00
None	0,11	0,50	1,00
Sum	**1,22**	**10,5**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8182	0,8571	0,7500	**0,8084**
Manual	0,0909	0,0952	0,1667	**0,1176**
None	0,0909	0,0476	0,0833	**0,0740**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1104
Consistency Index (CI)	0,0552
Consistency Ratio (CR)	0,0952

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0,11	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,36**	**14**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,6429	0,7619	**0,7132**
Manual	0,0816	0,0714	0,0476	**0,0669**
None	0,1837	0,2857	0,1905	**0,2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310

Consistency Ratio (CR)	0,0534

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	7
Manual	1,00	1,00	6,00
None	0,14	0,17	1,00
Sum	**2,14**	**2,16**	**14**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4667	0,4615	0,5000	**0,4761**
Manual	0,4667	0,4615	0,4286	**0,4523**
None	0,0667	0,0769	0,0714	**0,0717**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0035
Consistency Index (CI)	0,0017
Consistency Ratio (CR)	0,0030

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0,333333
Manual	0,25	1,00	0,17
None	3,00	6,00	1,00
Sum	**4,25**	**11**	**1,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2353	0,3636	0,2222	**0,2737**
Manual	0,0588	0,0909	0,1111	**0,0869**
None	0,7059	0,5455	0,6667	**0,6393**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0787
Consistency Index (CI)	0,0394
Consistency Ratio (CR)	0,0679

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	7
Manual	0,17	1,00	1,00
None	0,14	1,00	1,00
Sum	**1,31**	**8**	**9**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0,7636	0,7500	0,7778	**0,7638**
Solar	0,1273	0,1250	0,1111	**0,1211**
None	0,1091	0,1250	0,1111	**0,1151**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0049
Consistency Index (CI)	0,0024
Consistency Ratio (CR)	0,0042

Solar Efficiency (SEM)

Pairwise Comparison matrix (6)			
Options	**Solar**	**Manual**	**None**
Solar	1	2	3
Manual	0,50	1,00	3,00
None	0,33	0,33	1,00
Sum	**1,83**	**3,33**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,5455	0,6000	0,4286	**0,5247**
Manual	0,2727	0,3000	0,4286	**0,3338**
None	0,1818	0,1000	0,1429	**0,1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0654
Consistency Index (CI)	0,0327
Consistency Ratio (CR)	0,0564

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	5
Manual	0,20	1,00	2,00
None	0,20	0,50	1,00

Sum	1,4	6,5	8

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7143	0,7692	0,6250	**0,7028**
Manual	0,1429	0,1538	0,2500	**0,1822**
None	0,1429	0,0769	0,1250	**0,1149**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0879
Consistency Index (CI)	0,0440
Consistency Ratio (CR)	0,0758

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0,33	1,00	3,00
None	0,25	0,33	1,00
Sum	**1,58**	**4,33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6316	0,6923	0,5000	**0,6080**
Manual	0,2105	0,2308	0,3750	**0,2721**
None	0,1579	0,0769	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	8
Manual	0,14	1,00	2,00
None	0,13	0,50	1,00
Sum	**1,27**	**8,5**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7887	0,8235	0,7273	**0,7798**
Manual	0,1127	0,1176	0,1818	**0,1374**
None	0,0986	0,0588	0,0909	**0,0828**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0670
Consistency Index (CI)	0,0335
Consistency Ratio (CR)	0,0577

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	5
Manual	3,00	1,00	7,00
None	0,20	0,14	1,00
Sum	**4,2**	**1,48**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2381	0,2258	0,3846	**0,2828**
Manual	0,7143	0,6774	0,5385	**0,6434**
None	0,0476	0,0968	0,0769	**0,0738**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0967
Consistency Index (CI)	0,0484
Consistency Ratio (CR)	0,0834

Solar Efficiency (SEM)

Pairwise Comparison matrix (7)

Options	Solar	Manual	None
Solar	1	7	7
Manual	0,14	1,00	2,00
None	0,14	0,50	1,00
Sum	**1,29**	**8,5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7778	0,8235	0,7000	**0,7671**
Manual	0,1111	0,1176	0,2000	**0,1429**
None	0,1111	0,0588	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	7
Manual	0,14	1,00	2,00
None	0,14	0,50	1,00
Sum	**1,29**	**8,5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7778	0,8235	0,7000	**0,7671**
Manual	0,1111	0,1176	0,2000	**0,1429**
None	0,1111	0,0588	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	6
Manual	0,17	1,00	2,00
None	0,17	0,50	1,00
Sum	**1,33**	**7,5**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7500	0,8000	0,6667	**0,7389**
Manual	0,1250	0,1333	0,2222	**0,1602**
None	0,1250	0,0667	0,1111	**0,1009**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0949
Consistency Index (CI)	0,0475
Consistency Ratio (CR)	0,0818

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	4
Manual	0,13	1,00	1,00
None	0,25	1,00	1,00
Sum	**1,37**	**10**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7273	0,8000	0,6667	**0,7313**
Manual	0,0909	0,1000	0,1667	**0,1192**
None	0,1818	0,1000	0,1667	**0,1495**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0944
Consistency Index (CI)	0,0472
Consistency Ratio (CR)	0,0814

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Manual**	**Solar**	**None**
Solar	1	7	7
Manual	0,14	1,00	2,00
None	0,14	0,50	1,00
Sum	**1,29**	**8,5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7778	0,8235	0,7000	**0,7671**
Manual	0,1111	0,1176	0,2000	**0,1429**
None	0,1111	0,0588	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	7	7
Manual	0,14	1,00	2,00
None	0,14	0,50	1,00
Sum	**1,29**	**8,5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7778	0,8235	0,7000	**0,7671**
Manual	0,1111	0,1176	0,2000	**0,1429**
None	0,1111	0,0588	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	7
Manual	0,13	1,00	1,00
None	0,14	1,00	1,00
Sum	**1,27**	**10**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7887	0,8000	0,7778	**0,7888**
Manual	0,0986	0,1000	0,1111	**0,1032**
None	0,1127	0,1000	0,1111	**0,1079**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0038
Consistency Index (CI)	0,0019
Consistency Ratio (CR)	0,0033

Solar Efficiency (SEM)

Pairwise Comparison matrix (8)			
Options	**Solar**	**Manual**	**None**
Solar	1	5	5
Manual	0,20	1,00	1,00
None	0,20	1,00	1,00
Sum	**1,4**	**7**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7143	0,7143	0,7143	**0,7143**
Manual	0,1429	0,1429	0,1429	**0,1429**
None	0,1429	0,1429	0,1429	**0,1429**

Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	5
Manual	0,20	1,00	2,00
None	0,20	0,50	1,00
Sum	**1,4**	**6,5**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7143	0,7692	0,6250	**0,7028**
Manual	0,1429	0,1538	0,2500	**0,1822**
None	0,1429	0,0769	0,1250	**0,1149**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0879
Consistency Index (CI)	0,0440
Consistency Ratio (CR)	0,0758

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	5
Manual	0,20	1,00	2,00
None	0,20	0,50	1,00
Sum	**1,4**	**6,5**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7143	0,7692	0,6250	**0,7028**
Manual	0,1429	0,1538	0,2500	**0,1822**
None	0,1429	0,0769	0,1250	**0,1149**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0879
Consistency Index (CI)	0,0440
Consistency Ratio (CR)	0,0758

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0,25	1,00	3,00
None	0,17	0,33	1,00
Sum	**1,42**	**5,33**	**10**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0,7059	0,7500	0,6000	**0,6853**
Manual	0,1765	0,1875	0,3000	**0,2213**
None	0,1176	0,0625	0,1000	**0,0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425
Consistency Ratio (CR)	0,0733

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0,25	1,00	3,00
None	0,17	0,33	1,00
Sum	**1,42**	**5,33**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,7500	0,6000	**0,6853**
Manual	0,1765	0,1875	0,3000	**0,2213**
None	0,1176	0,0625	0,1000	**0,0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425
Consistency Ratio (CR)	0,0733

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0,25	1,00	3,00
None	0,17	0,33	1,00
Sum	**1,42**	**5,33**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,7500	0,6000	**0,6853**
Manual	0,1765	0,1875	0,3000	**0,2213**
None	0,1176	0,0625	0,1000	**0,0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425
Consistency Ratio (CR)	0,0733

Solar Efficiency (SEM) **(9)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0,33	1,00	3,00
None	0,25	0,33	1,00
Sum	**1,58**	**4,33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6316	0,6923	0,5000	**0,6080**
Manual	0,2105	0,2308	0,3750	**0,2721**
None	0,1579	0,0769	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4

Manual	0,33	1,00	3,00
None	0,25	0,33	1,00
Sum	**1,58**	**4,33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6316	0,6923	0,5000	**0,6080**
Manual	0,2105	0,2308	0,3750	**0,2721**
None	0,1579	0,0769	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0,25	1,00	2,00
None	0,25	0,50	1,00
Sum	**1,5**	**5,5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,7273	0,5714	**0,6551**
Manual	0,1667	0,1818	0,2857	**0,2114**
None	0,1667	0,0909	0,1429	**0,1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0797
Consistency Index (CI)	0,0399
Consistency Ratio (CR)	0,0687

Training Operations (TO)

Pairwise Comparison matrix

Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0,33	1,00	3,00
None	0,25	0,33	1,00
Sum	**1,58**	**4,33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6316	0,6923	0,5000	**0,6080**
Manual	0,2105	0,2308	0,3750	**0,2721**
None	0,1579	0,0769	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	0,25
Manual	3,00	1,00	0,33
None	4,00	3,00	1,00
Sum	**8**	**4,33**	**1,58**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**
Solar	0,1250	0,0769	0,1579	**0,1199**
Manual	0,3750	0,2308	0,2105	**0,2721**
None	0,5000	0,6923	0,6316	**0,6080**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	3	4
Manual	0,33	1,00	3,00
None	0,25	0,33	1,00
Sum	**1,58**	**4,33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6316	0,6923	0,5000	**0,6080**
Manual	0,2105	0,2308	0,3750	**0,2721**
None	0,1579	0,0769	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	3
Manual	0,50	1,00	3,00
None	0,33	0,33	1,00
Sum	**1,83**	**3,33**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,5455	0,6000	0,4286	**0,5247**
Manual	0,2727	0,3000	0,4286	**0,3338**
None	0,1818	0,1000	0,1429	**0,1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0654

Consistency Index (CI)	0,0327
Consistency Ratio (CR)	0,0564

Solar Efficiency (SEM)

Pairwise Comparison matrix			(10)
Options	**Solar**	**Manual**	**None**
Solar	1	6	8
Manual	0,17	1,00	1,00
None	0,13	1,00	1,00
Sum	**1,29**	**8**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7742	0,7500	0,8000	**0,7747**
Manual	0,1290	0,1250	0,1000	**0,1180**
None	0,0968	0,1250	0,1000	**0,1073**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0174
Consistency Index (CI)	0,0087
Consistency Ratio (CR)	0,0150

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0,25	1,00	2,00
None	0,17	0,50	1,00
Sum	**1,42**	**5,5**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,7273	0,6667	**0,6999**
Manual	0,1765	0,1818	0,2222	**0,1935**
None	0,1176	0,0909	0,1111	**0,1066**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0149
Consistency Index (CI)	0,0074
Consistency Ratio (CR)	0,0128

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0,25	1,00	1,00
None	0,25	1,00	1,00
Sum	**1,5**	**6**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,6667	0,6667	**0,6667**
Manual	0,1667	0,1667	0,1667	**0,1667**
None	0,1667	0,1667	0,1667	**0,1667**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0,25	1,00	2,00
None	0,25	0,50	1,00
Sum	**1,5**	**5,5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,7273	0,5714	**0,6551**
Manual	0,1667	0,1818	0,2857	**0,2114**
None	0,1667	0,0909	0,1429	**0,1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0797
Consistency Index (CI)	0,0399
Consistency Ratio (CR)	0,0687

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	6
Manual	0,17	1,00	2,00
None	0,17	0,50	1,00
Sum	**1,33**	**7,5**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7500	0,8000	0,6667	**0,7389**
Manual	0,1250	0,1333	0,2222	**0,1602**
None	0,1250	0,0667	0,1111	**0,1009**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0949
Consistency Index (CI)	0,0475
Consistency Ratio (CR)	0,0818

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	7
Manual	0,13	1,00	1,00
None	0,14	1,00	1,00
Sum	**1,27**	**10**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7887	0,8000	0,7778	**0,7888**
Manual	0,0986	0,1000	0,1111	**0,1032**

None	0,1127	0,1000	0,1111	**0,1079**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0038
Consistency Index (CI)	0,0019
Consistency Ratio (CR)	0,0033

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	4
Manual	0,14	1,00	0,50
None	0,25	2,00	1,00
Sum	**1,39**	**10**	**5,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7179	0,7000	0,7273	**0,7151**
Manual	0,1026	0,1000	0,0909	**0,0978**
None	0,1795	0,2000	0,1818	**0,1871**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0033
Consistency Index (CI)	0,0016
Consistency Ratio (CR)	0,0028

Solar Efficiency (SEM)

Pairwise Comparison matrix (11)			
Options	**Solar**	**Manual**	**None**
Solar	1	8	8
Manual	0,13	1,00	1,00
None	0,13	1,00	1,00
Sum	**1,25**	**10**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8000	0,8000	0,8000	**0,8000**
Manual	0,1000	0,1000	0,1000	**0,1000**
None	0,1000	0,1000	0,1000	**0,1000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	8
Manual	0,13	1,00	1,00
None	0,13	1,00	1,00
Sum	**1,25**	**10**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8000	0,8000	0,8000	**0,8000**
Manual	0,1000	0,1000	0,1000	**0,1000**
None	0,1000	0,1000	0,1000	**0,1000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	6
Manual	0,20	1,00	1,00
None	0,17	1,00	1,00

Sum	**1,37**	**7**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7317	0,7143	0,7500	**0,7320**
Manual	0,1463	0,1429	0,1250	**0,1381**
None	0,1220	0,1429	0,1250	**0,1299**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0063
Consistency Index (CI)	0,0032
Consistency Ratio (CR)	0,0055

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	7
Manual	0,20	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,34**	**6,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7895	0,6364	**0,7235**
Manual	0,1489	0,1579	0,2727	**0,1932**
None	0,1064	0,0526	0,0909	**0,0833**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	9
Manual	0,11	1,00	1,00
None	0,11	1,00	1,00
Sum	**1,22**	**11**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8182	0,8182	0,8182	**0,8182**
Manual	0,0909	0,0909	0,0909	**0,0909**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	9
Manual	0,11	1,00	2,00
None	0,11	0,50	1,00
Sum	**1,22**	**10,5**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,8182	0,8571	0,7500	**0,8084**
Manual	0,0909	0,0952	0,1667	**0,1176**
None	0,0909	0,0476	0,0833	**0,0740**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1104
Consistency Index (CI)	0,0552
Consistency Ratio (CR)	0,0952

Life of solar panel (LSP)

Pairwise Comparison matrix

Options	Solar	Manual	None
Solar	1	6	6
Manual	0,17	1,00	1,00
None	0,17	1,00	1,00
Sum	**1,33**	**8**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7500	0,7500	0,7500	**0,7500**
Manual	0,1250	0,1250	0,1250	**0,1250**
None	0,1250	0,1250	0,1250	**0,1250**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Solar Efficiency (SEM)

Pairwise Comparison matrix (12)			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0,33	1,00	2,00
None	0,33	0,50	1,00
Sum	**1,67**	**4,5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6000	0,6667	0,5000	**0,5889**
Manual	0,2000	0,2222	0,3333	**0,2519**
None	0,2000	0,1111	0,1667	**0,1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Operational Sophistication (OS)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Human Ergonomics (HE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Training Operations (TO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	4
Manual	1,00	1,00	5,00
None	0,25	0,20	1,00
Sum	**2,25**	**2,2**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4444	0,4545	0,4000	**0,4330**
Manual	0,4444	0,4545	0,5000	**0,4663**
None	0,1111	0,0909	0,1000	**0,1007**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0069
Consistency Index (CI)	0,0035
Consistency Ratio (CR)	0,0060

Use of Hazardous Equipment (UHE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Maintenance Requirement (MR)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	4
Manual	1,00	1,00	4,00
None	0,25	0,25	1,00
Sum	**2,25**	**2,25**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4444	0,4444	0,4444	**0,4444**
Manual	0,4444	0,4444	0,4444	**0,4444**
None	0,1111	0,1111	0,1111	**0,1111**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Life of solar panel (LSP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	5
Manual	1,00	1,00	5,00
None	0,20	0,20	1,00
Sum	**2,2**	**2,2**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4545	0,4545	0,4545	**0,4545**
Manual	0,4545	0,4545	0,4545	**0,4545**
None	0,0909	0,0909	0,0909	**0,0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

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Cost of Mining per ton (CoM) **(1)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	4
Manual	0,13	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,375**	**13**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7273	0,6154	0,7619	**0,7015**
Manual	0,0909	0,0769	0,0476	**0,0718**
None	0,1818	0,3077	0,1905	**0,2267**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0882
Consistency Index (CI)	0,0441
Consistency Ratio (CR)	0,0760

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0,11	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,36**	**14**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,6429	0,7619	**0,7132**
Manual	0,0816	0,0714	0,0476	**0,0669**
None	0,1837	0,2857	0,1905	**0,2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0,11	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,36**	**14**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,6429	0,7619	**0,7132**
Manual	0,0816	0,0714	0,0476	**0,0669**
None	0,1837	0,2857	0,1905	**0,2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	4

Manual	0,17	1,00	0,33
None	0,25	3,00	1,00
Sum	**1,42**	**10**	**5,33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,6000	0,7500	**0,6853**
Manual	0,1176	0,1000	0,0625	**0,0934**
None	0,1765	0,3000	0,1875	**0,2213**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425
Consistency Ratio (CR)	0,0733

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0,11	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,36**	**14**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,6429	0,7619	**0,7132**
Manual	0,0816	0,0714	0,0476	**0,0669**
None	0,1837	0,2857	0,1905	**0,2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0,5
Manual	0,33	1,00	0,25
None	2,00	4,00	1,00
Sum	**3,33**	**8**	**1,75**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3000	0,3750	0,2857	**0,3202**
Manual	0,1000	0,1250	0,1429	**0,1226**
None	0,6000	0,5000	0,5714	**0,5571**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0234
Consistency Index (CI)	0,0117
Consistency Ratio (CR)	0,0202

Cost of Mining per ton (CoM) **(2)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,25	4
Manual	4,00	1,00	8,00
None	0,25	0,13	1,00
Sum	**5,25**	**1,375**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1905	0,1818	0,3077	**0,2267**
Manual	0,7619	0,7273	0,6154	**0,7015**
None	0,0476	0,0909	0,0769	**0,0718**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0882
Consistency Index (CI)	0,0441

Consistency Ratio (CR)	0,0760

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,333333	5
Manual	3,00	1,00	7,00
None	0,20	0,14	1,00
Sum	**4,2**	**1,48**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2381	0,2258	0,3846	**0,2828**
Manual	0,7143	0,6774	0,5385	**0,6434**
None	0,0476	0,0968	0,0769	**0,0738**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0967
Consistency Index (CI)	0,0484
Consistency Ratio (CR)	0,0834

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,25	4
Manual	4,00	1,00	8,00
None	0,25	0,13	1,00
Sum	**5,25**	**1,37**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1905	0,1818	0,3077	**0,2267**
Manual	0,7619	0,7273	0,6154	**0,7015**
None	0,0476	0,0909	0,0769	**0,0718**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0882

Consistency Index (CI)	0,0441
Consistency Ratio (CR)	0,0760

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	4
Manual	3,00	1,00	7,00
None	0,25	0,14	1,00
Sum	**4,25**	**1,48**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2353	0,2258	0,3333	**0,2648**
Manual	0,7059	0,6774	0,5833	**0,6555**
None	0,0588	0,0968	0,0833	**0,0796**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0489
Consistency Index (CI)	0,0244
Consistency Ratio (CR)	0,0421

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,17	2
Manual	6,00	1,00	7,00
None	0,50	0,14	1,00
Sum	**7,5**	**1,31**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1333	0,1273	0,2000	**0,1535**
Manual	0,8000	0,7636	0,7000	**0,7545**

None	0,0667	0,1091	0,1000	**0,0919**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0588
Consistency Index (CI)	0,0294
Consistency Ratio (CR)	0,0507

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,2	2
Manual	5,00	1,00	6,00
None	0,50	0,17	1,00
Sum	**6,5**	**1,37**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1538	0,1463	0,2222	**0,1741**
Manual	0,7692	0,7317	0,6667	**0,7225**
None	0,0769	0,1220	0,1111	**0,1033**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0493
Consistency Index (CI)	0,0247
Consistency Ratio (CR)	0,0425

Cost of Mining per ton (CoM) **(3)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,11	0,11
Manual	9,00	1,00	1,00
None	9,00	1,00	1,00
Sum	**19**	**2,11**	**2,11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**

Solar	0,0526	0,0526	0,0526	**0,0526**
Manual	0,4737	0,4737	0,4737	**0,4737**
None	0,4737	0,4737	0,4737	**0,4737**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,142857	2
Manual	7,00	1,00	7,00
None	0,50	0,14	1,00
Sum	**8,5**	**1,285714**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1176	0,1111	0,2000	**0,1429**
Manual	0,8235	0,7778	0,7000	**0,7671**
None	0,0588	0,1111	0,1000	**0,0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1009
Consistency Index (CI)	0,0504
Consistency Ratio (CR)	0,0870

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	3
Manual	3,00	1,00	4,00
None	0,33	0,25	1,00
Sum	**4,33**	**1,59**	**8**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0,2308	0,2105	0,3750	**0,2721**
Manual	0,6923	0,6316	0,5000	**0,6080**
None	0,0769	0,1579	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,17	2
Manual	6,00	1,00	7,00
None	0,50	0,14	1,00
Sum	**7,5**	**1,31**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1333	0,1273	0,2000	**0,1535**
Manual	0,8000	0,7636	0,7000	**0,7545**
None	0,0667	0,1091	0,1000	**0,0919**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0588
Consistency Index (CI)	0,0294
Consistency Ratio (CR)	0,0507

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,125	2
Manual	8,00	1,00	8,00
None	0,50	0,13	1,00
Sum	**9,5**	**1,25**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1053	0,1000	0,1818	**0,1290**
Manual	0,8421	0,8000	0,7273	**0,7898**
None	0,0526	0,1000	0,0909	**0,0812**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1060
Consistency Index (CI)	0,0530
Consistency Ratio (CR)	0,0914

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,2	2
Manual	5,00	1,00	5,00
None	0,50	0,20	1,00
Sum	**6,5**	**1,4**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1538	0,1429	0,2500	**0,1822**
Manual	0,7692	0,7143	0,6250	**0,7028**
None	0,0769	0,1429	0,1250	**0,1149**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0879
Consistency Index (CI)	0,0440
Consistency Ratio (CR)	0,0758

Cost of Mining per ton (CoM) **(4)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	5
Manual	0,14	1,00	1,00
None	0,20	1,00	1,00

Sum	**1,34**	**9**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,7778	0,7143	**0,7456**
Manual	0,1064	0,1111	0,1429	**0,1201**
None	0,1489	0,1111	0,1429	**0,1343**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0224
Consistency Index (CI)	0,0112
Consistency Ratio (CR)	0,0193

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	2,00
None	1,00	0,50	1,00
Sum	**3**	**2,5**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,4000	0,2500	**0,3278**
Manual	0,3333	0,4000	0,5000	**0,4111**
None	0,3333	0,2000	0,2500	**0,2611**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0556
Consistency Index (CI)	0,0278
Consistency Ratio (CR)	0,0479

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	4
Manual	0,50	1,00	4,00
None	0,25	0,25	1,00
Sum	**1,75**	**3,25**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,5714	0,6154	0,4444	**0,5438**
Manual	0,2857	0,3077	0,4444	**0,3460**
None	0,1429	0,0769	0,1111	**0,1103**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0686
Consistency Index (CI)	0,0343
Consistency Ratio (CR)	0,0591

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0,25	1,00	1,00
None	0,50	1,00	1,00
Sum	**1,75**	**6**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,5714	0,6667	0,5000	**0,5794**
Manual	0,1429	0,1667	0,2500	**0,1865**
None	0,2857	0,1667	0,2500	**0,2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0694
Consistency Index (CI)	0,0347
Consistency Ratio (CR)	0,0599

Return on Investment (RoI)

Pairwise Comparison matrix

Options	Solar	Manual	None
Solar	1	4	8
Manual	0,25	1,00	4,00
None	0,13	0,25	1,00
Sum	**1,375**	**5,25**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7273	0,7619	0,6154	**0,7015**
Manual	0,1818	0,1905	0,3077	**0,2267**
None	0,0909	0,0476	0,0769	**0,0718**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0882
Consistency Index (CI)	0,0441
Consistency Ratio (CR)	0,0760

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	0,5
Manual	1,00	1,00	1,00
None	2,00	1,00	1,00
Sum	**4**	**3**	**2,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2500	0,3333	0,2000	**0,2611**
Manual	0,2500	0,3333	0,4000	**0,3278**
None	0,5000	0,3333	0,4000	**0,4111**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0556
Consistency Index (CI)	0,0278
Consistency Ratio (CR)	0,0479

Cost of Mining per ton (CoM) **(5)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	4
Manual	0,13	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,375**	**13**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7273	0,6154	0,7619	**0,7015**
Manual	0,0909	0,0769	0,0476	**0,0718**
None	0,1818	0,3077	0,1905	**0,2267**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0882
Consistency Index (CI)	0,0441
Consistency Ratio (CR)	0,0760

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0,11	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,36**	**14**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7347	0,6429	0,7619	**0,7132**
Manual	0,0816	0,0714	0,0476	**0,0669**
None	0,1837	0,2857	0,1905	**0,2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	9
Manual	0,17	1,00	3,00
None	0,11	0,33	1,00
Sum	**1,28**	**7,33**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7826	0,8182	0,6923	**0,7644**
Manual	0,1304	0,1364	0,2308	**0,1659**
None	0,0870	0,0455	0,0769	**0,0698**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1001
Consistency Index (CI)	0,0500
Consistency Ratio (CR)	0,0863

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	3
Manual	0,17	1,00	0,25
None	0,33	4,00	1,00
Sum	**1,5**	**11**	**4,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,5455	0,7059	**0,6393**
Manual	0,1111	0,0909	0,0588	**0,0869**
None	0,2222	0,3636	0,2353	**0,2737**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0787
Consistency Index (CI)	0,0394
Consistency Ratio (CR)	0,0679

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	9
Manual	1,00	1,00	9,00
None	0,11	0,11	1,00
Sum	**2,11**	**2,11**	**19**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4737	0,4737	0,4737	**0,4737**
Manual	0,4737	0,4737	0,4737	**0,4737**
None	0,0526	0,0526	0,0526	**0,0526**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	9
Manual	1,00	1,00	9,00
None	0,11	0,11	1,00
Sum	**2,11**	**2,11**	**19**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4737	0,4737	0,4737	**0,4737**
Manual	0,4737	0,4737	0,4737	**0,4737**
None	0,0526	0,0526	0,0526	**0,0526**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Cost of Mining per ton (CoM) **(6)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0,2
Manual	0,33	1,00	0,13
None	5,00	8,00	1,00
Sum	**6,33**	**12**	**1,33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1579	0,2500	0,1509	**0,1863**
Manual	0,0526	0,0833	0,0943	**0,0768**
None	0,7895	0,6667	0,7547	**0,7370**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0774
Consistency Index (CI)	0,0387
Consistency Ratio (CR)	0,0668

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	7
Manual	0,25	1,00	3,00
None	0,14	0,33	1,00
Sum	**1,40**	**5,33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7179	0,7500	0,6364	**0,7014**
Manual	0,1795	0,1875	0,2727	**0,2132**
None	0,1026	0,0625	0,0909	**0,0853**

Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0528
Consistency Index (CI)	0,0264
Consistency Ratio (CR)	0,0456

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,25	2
Manual	4,00	1,00	4,00
None	0,50	0,25	1,00
Sum	**5,5**	**1,5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1818	0,1667	0,2857	**0,2114**
Manual	0,7273	0,6667	0,5714	**0,6551**
None	0,0909	0,1667	0,1429	**0,1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0797
Consistency Index (CI)	0,0399
Consistency Ratio (CR)	0,0687

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	3
Manual	0,17	1,00	0,25
None	0,33	4,00	1,00
Sum	**1,5**	**11**	**4,25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,5455	0,7059	**0,6393**

Manual	0,1111	0,0909	0,0588	**0,0869**
None	0,2222	0,3636	0,2353	**0,2737**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0787
Consistency Index (CI)	0,0394
Consistency Ratio (CR)	0,0679

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0,25
Manual	0,25	1,00	0,13
None	4,00	8,00	1,00
Sum	**5,25**	**13**	**1,37**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1905	0,3077	0,1818	**0,2267**
Manual	0,0476	0,0769	0,0909	**0,0718**
None	0,7619	0,6154	0,7273	**0,7015**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0882
Consistency Index (CI)	0,0441
Consistency Ratio (CR)	0,0760

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	5
Manual	0,14	1,00	0,33
None	0,20	3,00	1,00
Sum	**1,35**	**11**	**6,33**

Normalization of comparison

Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7447	0,6364	0,7895	**0,7235**
Manual	0,1064	0,0909	0,0526	**0,0833**
None	0,1489	0,2727	0,1579	**0,1932**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1115
Consistency Index (CI)	0,0557
Consistency Ratio (CR)	0,0961

Cost of Mining per ton (CoM) **(7)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	0,33
Manual	0,17	1,00	0,11
None	3,00	9,00	1,00
Sum	**4,17**	**16**	**1,44**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2400	0,3750	0,2308	**0,2819**
Manual	0,0400	0,0625	0,0769	**0,0598**
None	0,7200	0,5625	0,6923	**0,6583**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0824
Consistency Index (CI)	0,0412
Consistency Ratio (CR)	0,0711

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	0,33
Manual	0,17	1,00	0,13
None	3,00	8,00	1,00
Sum	**4,17**	**15**	**1,46**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2400	0,4000	0,2286	**0,2895**
Manual	0,0400	0,0667	0,0857	**0,0641**
None	0,7200	0,5333	0,6857	**0,6463**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1108
Consistency Index (CI)	0,0554
Consistency Ratio (CR)	0,0956

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0,33	1,00	2,00
None	0,33	0,50	1,00
Sum	**1,67**	**4,5**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6000	0,6667	0,5000	**0,5889**
Manual	0,2000	0,2222	0,3333	**0,2519**
None	0,2000	0,1111	0,1667	**0,1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	0,125	2
Manual	8,00	1,00	8,00
None	0,50	0,13	1,00
Sum	**9,5**	**1,25**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1053	0,1000	0,1818	**0,1290**
Manual	0,8421	0,8000	0,7273	**0,7898**
None	0,0526	0,1000	0,0909	**0,0812**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1060
Consistency Index (CI)	0,0530
Consistency Ratio (CR)	0,0914

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Manual**	**Solar**	**None**
Solar	1	3	3
Manual	0,33	1,00	0,50
None	0,33	2,00	1,00
Sum	**1,67**	**6**	**4,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6000	0,5000	0,6667	**0,5889**
Manual	0,2000	0,1667	0,1111	**0,1593**
None	0,2000	0,3333	0,2222	**0,2519**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Risk Assessment (RA)

Pairwise Comparison matrix

Options	**Solar**	**Solar**	**None**
Solar	1	3	6
Manual	0,33	1,00	4,00
None	0,17	0,25	1,00
Sum	**1,5**	**4,25**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,7059	0,5455	**0,6393**
Manual	0,2222	0,2353	0,3636	**0,2737**
None	0,1111	0,0588	0,0909	**0,0869**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0787
Consistency Index (CI)	0,0394
Consistency Ratio (CR)	0,0679

Cost of Mining per ton (CoM) **(8)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	3
Manual	0,20	1,00	0,33
None	0,33	3,00	1,00
Sum	**1,53**	**9**	**4,33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6522	0,5556	0,6923	**0,6333**
Manual	0,1304	0,1111	0,0769	**0,1062**
None	0,2174	0,3333	0,2308	**0,2605**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0554
Consistency Index (CI)	0,0277
Consistency Ratio (CR)	0,0477

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0,25	1,00	2,00
None	0,25	0,50	1,00
Sum	**1,5**	**5,5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6667	0,7273	0,5714	**0,6551**
Manual	0,1667	0,1818	0,2857	**0,2114**
None	0,1667	0,0909	0,1429	**0,1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0797
Consistency Index (CI)	0,0399
Consistency Ratio (CR)	0,0687

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0,33
Manual	0,50	1,00	0,33
None	3,00	3,00	1,00
Sum	**4,5**	**6**	**1,67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2222	0,3333	0,2000	**0,2519**
Manual	0,1111	0,1667	0,2000	**0,1593**
None	0,6667	0,5000	0,6000	**0,5889**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	3
Manual	1,00	1,00	3,00
None	0,33	0,33	1,00
Sum	**2,33**	**2,33**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,4286	0,4286	0,4286	**0,4286**
Manual	0,4286	0,4286	0,4286	**0,4286**
None	0,1429	0,1429	0,1429	**0,1429**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0,33	1,00	3,00
None	0,25	0,33	1,00
Sum	**1,58**	**4,33**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6316	0,6923	0,5000	**0,6080**
Manual	0,2105	0,2308	0,3750	**0,2721**
None	0,1579	0,0769	0,1250	**0,1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	2
Manual	3,00	1,00	3,00
None	0,50	0,33	1,00
Sum	**4,5**	**1,67**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2222	0,2000	0,3333	**0,2519**
Manual	0,6667	0,6000	0,5000	**0,5889**
None	0,1111	0,2000	0,1667	**0,1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Cost of Mining per ton (CoM) **(9)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	5
Manual	0,33	1,00	1,00
None	0,20	1,00	1,00
Sum	**1,53**	**5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6522	0,6000	0,7143	**0,6555**
Manual	0,2174	0,2000	0,1429	**0,1867**
None	0,1304	0,2000	0,1429	**0,1578**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0432
Consistency Index (CI)	0,0216
Consistency Ratio (CR)	0,0372

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	0,33
Manual	3,00	1,00	0,50
None	3,00	2,00	1,00
Sum	**7**	**3,33**	**1,83**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1429	0,1000	0,1818	**0,1416**
Manual	0,4286	0,3000	0,2727	**0,3338**
None	0,4286	0,6000	0,5455	**0,5247**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0654
Consistency Index (CI)	0,0327
Consistency Ratio (CR)	0,0564

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0,33	1,00	0,50
None	0,33	2,00	1,00
Sum	**1,67**	**6**	**4,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6000	0,5000	0,6667	**0,5889**
Manual	0,2000	0,1667	0,1111	**0,1593**
None	0,2000	0,3333	0,2222	**0,2519**

Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	0,50
None	1,00	2,00	1,00
Sum	**3**	**4**	**2,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,2500	0,4000	**0,3278**
Manual	0,3333	0,2500	0,2000	**0,2611**
None	0,3333	0,5000	0,4000	**0,4111**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0556
Consistency Index (CI)	0,0278
Consistency Ratio (CR)	0,0479

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,33	0,33
Manual	3,00	1,00	1,00
None	3,00	1,00	1,00
Sum	**7**	**2,33**	**2,33**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**
Solar	0,1429	0,1429	0,1429	**0,1429**

Manual	0,4286	0,4286	0,4286	**0,4286**
None	0,4286	0,4286	0,4286	**0,4286**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	0,33	4
Manual	3,00	1,00	6,00
None	0,25	0,17	1,00
Sum	**4,25**	**1,5**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2353	0,2222	0,3636	**0,2737**
Manual	0,7059	0,6667	0,5455	**0,6393**
None	0,0588	0,1111	0,0909	**0,0869**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0787
Consistency Index (CI)	0,0394
Consistency Ratio (CR)	0,0679

Cost of Mining per ton (CoM) (10)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	5
Manual	0,50	1,00	2,00
None	0,20	0,50	1,00
Sum	**1,7**	**3,5**	**8**

Normalization of comparison

Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,5882	0,5714	0,6250	**0,5949**
Manual	0,2941	0,2857	0,2500	**0,2766**
None	0,1176	0,1429	0,1250	**0,1285**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0075
Consistency Index (CI)	0,0037
Consistency Ratio (CR)	0,0064

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,5	0,5
Manual	2,00	1,00	2,00
None	2,00	0,50	1,00
Sum	**5**	**2**	**3,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2000	0,2500	0,1429	**0,1976**
Manual	0,4000	0,5000	0,5714	**0,4905**
None	0,4000	0,2500	0,2857	**0,3119**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0607
Consistency Index (CI)	0,0304
Consistency Ratio (CR)	0,0523

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0,25	1,00	3,00
None	0,17	0,33	1,00
Sum	**1,42**	**5,33**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,7500	0,6000	**0,6853**
Manual	0,1765	0,1875	0,3000	**0,2213**
None	0,1176	0,0625	0,1000	**0,0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425
Consistency Ratio (CR)	0,0733

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0,33
Manual	0,50	1,00	0,33
None	3,00	3,00	1,00
Sum	**4,5**	**6**	**1,67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2222	0,3333	0,2000	**0,2519**
Manual	0,1111	0,1667	0,2000	**0,1593**
None	0,6667	0,5000	0,6000	**0,5889**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0704
Consistency Index (CI)	0,0352
Consistency Ratio (CR)	0,0607

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0,5
Manual	0,50	1,00	0,50
None	2,00	2,00	1,00
Sum	**3,5**	**5**	**2**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,2857	0,4000	0,2500	**0,3119**
Manual	0,1429	0,2000	0,2500	**0,1976**
None	0,5714	0,4000	0,5000	**0,4905**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0607
Consistency Index (CI)	0,0304
Consistency Ratio (CR)	0,0523

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0,25	1,00	1,00
None	0,50	1,00	1,00
Sum	**1,75**	**6**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,5714	0,6667	0,5000	**0,5794**
Manual	0,1429	0,1667	0,2500	**0,1865**
None	0,2857	0,1667	0,2500	**0,2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0694
Consistency Index (CI)	0,0347
Consistency Ratio (CR)	0,0599

Cost of Mining per ton (CoM)
(11)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0,2	0,33
Manual	5,00	1,00	1,00
None	3,00	1,00	1,00

Sum	9	2,2	2,33

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1111	0,0909	0,1429	**0,1150**
Manual	0,5556	0,4545	0,4286	**0,4796**
None	0,3333	0,4545	0,4286	**0,4055**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0358
Consistency Index (CI)	0,0179
Consistency Ratio (CR)	0,0309

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Return on Investment (RoI)

Pairwise Comparison matrix

Options	Solar	Manual	None
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	0,25	0,333333
Manual	4,00	1,00	3,00
None	3,00	0,33	1,00
Sum	**8**	**1,58**	**4,33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,1250	0,1579	0,0769	**0,1199**
Manual	0,5000	0,6316	0,6923	**0,6080**
None	0,3750	0,2105	0,2308	**0,2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,1012
Consistency Index (CI)	0,0506
Consistency Ratio (CR)	0,0873

Cost of Mining per ton (CoM) (12)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	5
Manual	0,13	1,00	0,33
None	0,20	3,00	1,00
Sum	**1,325**	**12**	**6,33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7547	0,6667	0,7895	**0,7370**
Manual	0,0943	0,0833	0,0526	**0,0768**
None	0,1509	0,2500	0,1579	**0,1863**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0774
Consistency Index (CI)	0,0387
Consistency Ratio (CR)	0,0668

Maintenance Cost (MC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	4
Manual	0,17	1,00	0,33
None	0,25	3,00	1,00
Sum	**1,416667**	**10**	**5,333333**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,6000	0,7500	**0,6853**
Manual	0,1176	0,1000	0,0625	**0,0934**
None	0,1765	0,3000	0,1875	**0,2213**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425

Consistency Ratio (CR)	0,0733

Disposal Cost (DC)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1,00	1,00	1,00
None	1,00	1,00	1,00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,3333	0,3333	0,3333	**0,3333**
Manual	0,3333	0,3333	0,3333	**0,3333**
None	0,3333	0,3333	0,3333	**0,3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0000
Consistency Index (CI)	0,0000
Consistency Ratio (CR)	0,0000

Cost of Transportation (CoT)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	4
Manual	0,17	1,00	0,33
None	0,25	3,00	1,00
Sum	**1,42**	**10**	**5,33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,7059	0,6000	0,7500	**0,6853**
Manual	0,1176	0,1000	0,0625	**0,0934**
None	0,1765	0,3000	0,1875	**0,2213**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0850
Consistency Index (CI)	0,0425
Consistency Ratio (CR)	0,0733

Return on Investment (RoI)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	4
Manual	0,20	1,00	0,50
None	0,25	2,00	1,00
Sum	**1,45**	**8**	**5,5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0,6897	0,6250	0,7273	**0,6806**
Manual	0,1379	0,1250	0,0909	**0,1179**
None	0,1724	0,2500	0,1818	**0,2014**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0383
Consistency Index (CI)	0,0191
Consistency Ratio (CR)	0,0330

Risk Assessment (RA)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0,11	1,00	0,25
None	0,25	4,00	1,00
Sum	**1,36**	**14**	**5,25**

Normalization of comparison				
Options	**Solar**	**Manua l**	**None**	**Priority vector**

Solar	0,7347	0,6429	0,7619	**0,7132**
Manual	0,0816	0,0714	0,0476	**0,0669**
None	0,1837	0,2857	0,1905	**0,2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3,0619
Consistency Index (CI)	0,0310
Consistency Ratio (CR)	0,0534

THE MATRICES OF ALTERNATIVES COMPARED WITH RESPECT TO EACH OF CRITERIA IN THE ENVIRONMENTAL PERSPECTIVE

GHG Emission (GHG) **(1)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	3
Manual	0.33	1.00	1.00
None	0.33	1.00	1.00
Sum	**1.67**	**5**	**5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6000	0.6000	0.6000	**0.6000**
Manual	0.2000	0.2000	0.2000	**0.2000**
None	0.2000	0.2000	0.2000	**0.2000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.33
Manual	0.50	1.00	0.33
None	3.00	3.00	1.00
Sum	**4.5**	**6**	**1.67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2222	0.3333	0.2000	**0.2519**
Manual	0.1111	0.1667	0.2000	**0.1593**
None	0.6667	0.5000	0.6000	**0.5889**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.33
Manual	3.00	1.00	0.50
None	3.00	2.00	1.00
Sum	**7**	**3.33**	**1.83**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.1000	0.1818	**0.1416**
Manual	0.4286	0.3000	0.2727	**0.3338**
None	0.4286	0.6000	0.5455	**0.5247**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.33
Manual	3.00	1.00	0.50
None	3.00	2.00	1.00
Sum	**7**	**3.33**	**1.83**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**

Solar	0.1429	0.1000	0.1818	**0.1416**
Manual	0.4286	0.3000	0.2727	**0.3338**
None	0.4286	0.6000	0.5455	**0.5247**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.25
Manual	2.00	1.00	0.25
None	4.00	4.00	1.00
Sum	**7**	**5.5**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.0909	0.1667	**0.1335**
Manual	0.2857	0.1818	0.1667	**0.2114**
None	0.5714	0.7273	0.6667	**0.6551**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.33
Manual	4.00	1.00	1.00
None	3.00	1.00	1.00
Sum	**8**	**2.25**	**2.33**

Normalization of comparison

Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.1111	0.1429	**0.1263**
Manual	0.5000	0.4444	0.4286	**0.4577**
None	0.3750	0.4444	0.4286	**0.4160**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0110
Consistency Index (CI)	0.0055
Consistency Ratio (CR)	0.0095

Water Consumption During Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.2
Manual	2.00	1.00	0.20
None	5.00	5.00	1.00
Sum	**8**	**6.5**	**1.4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1250	0.0769	0.1429	**0.1149**
Manual	0.2500	0.1538	0.1429	**0.1822**
None	0.6250	0.7692	0.7143	**0.7028**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0879
Consistency Index (CI)	0.0440
Consistency Ratio (CR)	0.0758

Consumption of Other Materials During Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.33
Manual	3.00	1.00	1.00
None	3.00	1.00	1.00
Sum	**7**	**2.33**	**2.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.1429	0.1429	**0.1429**
Manual	0.4286	0.4286	0.4286	**0.4286**
None	0.4286	0.4286	0.4286	**0.4286**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

GHG Emission (GHG) (2)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.2
Manual	0.50	1.00	0.20
None	5.00	5.00	1.00
Sum	**6.5**	**8**	**1.4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1538	0.2500	0.1429	**0.1822**
Manual	0.0769	0.1250	0.1429	**0.1149**
None	0.7692	0.6250	0.7143	**0.7028**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0879
Consistency Index (CI)	0.0440
Consistency Ratio (CR)	0.0758

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.2
Manual	0.50	1.00	0.20
None	5.00	5.00	1.00
Sum	**6.5**	**8**	**1.4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1538	0.2500	0.1429	**0.1822**
Manual	0.0769	0.1250	0.1429	**0.1149**
None	0.7692	0.6250	0.7143	**0.7028**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0879
Consistency Index (CI)	0.0440
Consistency Ratio (CR)	0.0758

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.33
Manual	0.33	1.00	0.20
None	3.00	5.00	1.00
Sum	**4.33**	**9**	**1.53**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2308	0.3333	0.2174	**0.2605**
Manual	0.0769	0.1111	0.1304	**0.1062**
None	0.6923	0.5556	0.6522	**0.6333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.33
Manual	0.50	1.00	0.33
None	3.00	3.00	1.00
Sum	**4.5**	**6**	**1.67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2222	0.3333	0.2000	**0.2519**
Manual	0.1111	0.1667	0.2000	**0.1593**
None	0.6667	0.5000	0.6000	**0.5889**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.5
Manual	0.25	1.00	0.25
None	2.00	4.00	1.00
Sum	**3.25**	**9**	**1.75**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3077	0.4444	0.2857	**0.3460**
Manual	0.0769	0.1111	0.1429	**0.1103**
None	0.6154	0.4444	0.5714	**0.5438**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.25
Manual	0.50	1.00	0.25
None	4.00	4.00	1.00
Sum	**5.5**	**7**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1818	0.2857	0.1667	**0.2114**
Manual	0.0909	0.1429	0.1667	**0.1335**
None	0.7273	0.5714	0.6667	**0.6551**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Water Consumption During Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.50
Manual	0.25	1.00	0.25
None	2.00	4.00	1.00
Sum	**3.25**	**9**	**1.75**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3077	0.4444	0.2857	**0.3460**
Manual	0.0769	0.1111	0.1429	**0.1103**
None	0.6154	0.4444	0.5714	**0.5438**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343

Consistency Ratio (CR)	0.0591

Consumption of Other Materials During Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.5
Manual	0.25	1.00	0.25
None	2.00	4.00	1.00
Sum	**3.25**	**9**	**1.75**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3077	0.4444	0.2857	**0.3460**
Manual	0.0769	0.1111	0.1429	**0.1103**
None	0.6154	0.4444	0.5714	**0.5438**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

GHG Emission (GHG) **(3)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.125
Manual	0.50	1.00	0.13
None	8.00	8.00	1.00
Sum	**9.5**	**11**	**1.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1053	0.1818	0.1000	**0.1290**
Manual	0.0526	0.0909	0.1000	**0.0812**
None	0.8421	0.7273	0.8000	**0.7898**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1060
Consistency Index (CI)	0.0530
Consistency Ratio (CR)	0.0914

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.2
Manual	0.33	1.00	0.13
None	5.00	8.00	1.00
Sum	**6.33**	**12**	**1.32**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1579	0.2500	0.1509	**0.1863**
Manual	0.0526	0.0833	0.0943	**0.0768**
None	0.7895	0.6667	0.7547	**0.7370**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0774
Consistency Index (CI)	0.0387
Consistency Ratio (CR)	0.0668

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.25
Manual	0.33	1.00	0.13
None	4.00	8.00	1.00
Sum	**5.33**	**12**	**1.37**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1875	0.2500	0.1818	**0.2064**
Manual	0.0625	0.0833	0.0909	**0.0789**
None	0.7500	0.6667	0.7273	**0.7146**

Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0306
Consistency Index (CI)	0.0153
Consistency Ratio (CR)	0.0264

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.125
Manual	0.50	1.00	0.13
None	8.00	8.00	1.00
Sum	**9.5**	**11**	**1.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1053	0.1818	0.1000	**0.1290**
Manual	0.0526	0.0909	0.1000	**0.0812**
None	0.8421	0.7273	0.8000	**0.7898**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1060
Consistency Index (CI)	0.0530
Consistency Ratio (CR)	0.0914

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	0.33
Manual	0.17	1.00	0.11
None	3.00	9.00	1.00
Sum	**4.17**	**16**	**1.44**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2400	0.3750	0.2308	**0.2819**
Manual	0.0400	0.0625	0.0769	**0.0598**
None	0.7200	0.5625	0.6923	**0.6583**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0824
Consistency Index (CI)	0.0412
Consistency Ratio (CR)	0.0711

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	0.5
Manual	0.17	1.00	0.14
None	2.00	7.00	1.00
Sum	**3.17**	**14**	**1.64**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3158	0.4286	0.3043	**0.3496**
Manual	0.0526	0.0714	0.0870	**0.0703**
None	0.6316	0.5000	0.6087	**0.5801**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0447
Consistency Index (CI)	0.0224
Consistency Ratio (CR)	0.0386

Water Consumption During Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.2
Manual	0.33	1.00	0.13
None	5.00	8.00	1.00
Sum	**6.33**	**12**	**1.32**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0.1579	0.2500	0.1509	**0.1863**
Manual	0.0526	0.0833	0.0943	**0.0768**
None	0.7895	0.6667	0.7547	**0.7370**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0774
Consistency Index (CI)	0.0387
Consistency Ratio (CR)	0.0668

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.125
Manual	2.00	1.00	0.13
None	8.00	8.00	1.00
Sum	**11**	**9.5**	**1.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0526	0.1000	**0.0812**
Manual	0.1818	0.1053	0.1000	**0.1290**
None	0.7273	0.8421	0.8000	**0.7898**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1060
Consistency Index (CI)	0.0530
Consistency Ratio (CR)	0.0914

GHG Emission (GHG) **(4)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	4
Manual	0.13	1.00	0.25
None	0.25	4.00	1.00
Sum	**1.37**	**13**	**5.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7273	0.6154	0.7619	**0.7015**
Manual	0.0909	0.0769	0.0476	**0.0718**
None	0.1818	0.3077	0.1905	**0.2267**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0882
Consistency Index (CI)	0.0441
Consistency Ratio (CR)	0.0760

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00

None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.2
Manual	0.33	1.00	0.13
None	5.00	8.00	1.00
Sum	**6.33**	**12**	**1.32**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1579	0.2500	0.1509	**0.1863**
Manual	0.0526	0.0833	0.0943	**0.0768**
None	0.7895	0.6667	0.7547	**0.7370**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0774
Consistency Index (CI)	0.0387
Consistency Ratio (CR)	0.0668

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.33
Manual	0.25	1.00	0.17
None	3.00	6.00	1.00
Sum	**4.25**	**11**	**1.50**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2353	0.3636	0.2222	**0.2737**
Manual	0.0588	0.0909	0.1111	**0.0869**
None	0.7059	0.5455	0.6667	**0.6393**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0787
Consistency Index (CI)	0.0394
Consistency Ratio (CR)	0.0679

Water Consumption During Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Consumption of Other Materials During Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0.25	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.5**	**5.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7273	0.5714	**0.6551**
Manual	0.1667	0.1818	0.2857	**0.2114**
None	0.1667	0.0909	0.1429	**0.1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

GHG Emission (GHG) **(5)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.2
Manual	0.50	1.00	0.20
None	5.00	5.00	1.00
Sum	**6.5**	**8**	**1.4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1538	0.2500	0.1429	**0.1822**
Manual	0.0769	0.1250	0.1429	**0.1149**
None	0.7692	0.6250	0.7143	**0.7028**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0879
Consistency Index (CI)	0.0440
Consistency Ratio (CR)	0.0758

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.33
Manual	0.33	1.00	0.20
None	3.00	5.00	1.00
Sum	**4.33**	**9**	**1.53**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2308	0.3333	0.2174	**0.2605**
Manual	0.0769	0.1111	0.1304	**0.1062**
None	0.6923	0.5556	0.6522	**0.6333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.33
Manual	0.33	1.00	0.20
None	3.00	5.00	1.00
Sum	**4.33**	**9**	**1.53**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2308	0.3333	0.2174	**0.2605**
Manual	0.0769	0.1111	0.1304	**0.1062**
None	0.6923	0.5556	0.6522	**0.6333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	3
Manual	0.25	1.00	0.33
None	0.33	3.00	1.00
Sum	**1.58**	**8**	**4.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.5000	0.6923	**0.6080**

Manual	0.1579	0.1250	0.0769	**0.1199**
None	0.2105	0.3750	0.2308	**0.2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	4
Manual	0.50	1.00	1.00
None	0.25	1.00	1.00
Sum	**1.75**	**4**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.5000	0.6667	**0.5794**
Manual	0.2857	0.2500	0.1667	**0.2341**
None	0.1429	0.2500	0.1667	**0.1865**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0694
Consistency Index (CI)	0.0347
Consistency Ratio (CR)	0.0599

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	0.25
None	0.50	4.00	1.00
Sum	**1.75**	**9**	**3.25**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0.5714	0.4444	0.6154	**0.5438**
Manual	0.1429	0.1111	0.0769	**0.1103**
None	0.2857	0.4444	0.3077	**0.3460**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	0.5
Manual	0.25	1.00	0.25
None	2.00	4.00	1.00
Sum	**3.25**	**9**	**1.75**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3077	0.4444	0.2857	**0.3460**
Solar	0.0769	0.1111	0.1429	**0.1103**
None	0.6154	0.4444	0.5714	**0.5438**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.33
Manual	0.33	1.00	0.20
None	3.00	5.00	1.00
Sum	**4.33**	**9**	**1.53**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2308	0.3333	0.2174	**0.2605**
Solar	0.0769	0.1111	0.1304	**0.1062**
None	0.6923	0.5556	0.6522	**0.6333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

GHG Emission (GHG) **(6)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00

None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

GHG Emission (GHG) **(7)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.2	0.17
Manual	5.00	1.00	0.50
None	6.00	2.00	1.00
Sum	**12**	**3.2**	**1.67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0833	0.0625	0.1000	**0.0819**
Manual	0.4167	0.3125	0.3000	**0.3431**
None	0.5000	0.6250	0.6000	**0.5750**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0394
Consistency Index (CI)	0.0197

Consistency Ratio (CR)	0.0340

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.17	0.33
Manual	6.00	1.00	4.00
None	3.00	0.25	1.00
Sum	**10**	**1.42**	**5.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1000	0.1176	0.0625	**0.0934**
Manual	0.6000	0.7059	0.7500	**0.6853**
None	0.3000	0.1765	0.1875	**0.2213**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.14	0.33
Manual	7.00	1.00	5.00
None	3.00	0.20	1.00
Sum	**11**	**1.34**	**6.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.1064	0.0526	**0.0833**
Manual	0.6364	0.7447	0.7895	**0.7235**
None	0.2727	0.1489	0.1579	**0.1932**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1115
Consistency Index (CI)	0.0557
Consistency Ratio (CR)	0.0961

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	7
Manual	0.25	1.00	3.00
None	0.14	0.33	1.00
Sum	**1.39**	**5.33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7179	0.7500	0.6364	**0.7014**
Manual	0.1795	0.1875	0.2727	**0.2132**
None	0.1026	0.0625	0.0909	**0.0853**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0528
Consistency Index (CI)	0.0264
Consistency Ratio (CR)	0.0456

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Manual**	**Solar**	**None**
Solar	1	2	0.17
Manual	0.50	1.00	0.17
None	6.00	6.00	1.00
Sum	**7.5**	**9**	**1.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1333	0.2222	0.1250	**0.1602**
Manual	0.0667	0.1111	0.1250	**0.1009**
None	0.8000	0.6667	0.7500	**0.7389**

Normalised	1	1	1	

Principal Eigen Value	3.0949
Consistency Index (CI)	0.0475
Consistency Ratio (CR)	0.0818

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	4	0.33
Manual	0.25	1.00	0.14
None	3.00	7.00	1.00
Sum	**4.25**	**12**	**1.48**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2353	0.3333	0.2258	**0.2648**
Manual	0.0588	0.0833	0.0968	**0.0796**
None	0.7059	0.5833	0.6774	**0.6555**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0489
Consistency Index (CI)	0.0244
Consistency Ratio (CR)	0.0421

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	3
Manual	0.14	1.00	0.20
None	0.33	5.00	1.00
Sum	**1.46**	**13**	**4.2**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6774	0.5385	0.7143	**0.6434**
Manual	0.0968	0.0769	0.0476	**0.0738**
None	0.2258	0.3846	0.2381	**0.2828**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0967
Consistency Index (CI)	0.0484
Consistency Ratio (CR)	0.0834

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.14	0.33
Manual	7.00	1.00	4.00
None	3.00	0.25	1.00
Sum	**11**	**1.39**	**5.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.1026	0.0625	**0.0853**
Manual	0.6364	0.7179	0.7500	**0.7014**
None	0.2727	0.1795	0.1875	**0.2132**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0528
Consistency Index (CI)	0.0264
Consistency Ratio (CR)	0.0456

GHG Emission (GHG) **(8)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	0.5
Manual	1.00	1.00	1.00
None	2.00	1.00	1.00
Sum	**4**	**3**	**2.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2500	0.3333	0.2000	**0.2611**
Manual	0.2500	0.3333	0.4000	**0.3278**
None	0.5000	0.3333	0.4000	**0.4111**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0556
Consistency Index (CI)	0.0278
Consistency Ratio (CR)	0.0479

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.25
Manual	2.00	1.00	0.25
None	4.00	4.00	1.00
Sum	**7**	**5.5**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.0909	0.1667	**0.1335**
Manual	0.2857	0.1818	0.1667	**0.2114**
None	0.5714	0.7273	0.6667	**0.6551**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.25
Manual	2.00	1.00	0.25
None	4.00	4.00	1.00
Sum	**7**	**5.5**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1429	0.0909	0.1667	**0.1335**
Manual	0.2857	0.1818	0.1667	**0.2114**
None	0.5714	0.7273	0.6667	**0.6551**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.33
Manual	2.00	1.00	0.33
None	3.00	3.00	1.00
Sum	**6**	**4.5**	**1.67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1667	0.1111	0.2000	**0.1593**
Manual	0.3333	0.2222	0.2000	**0.2519**
None	0.5000	0.6667	0.6000	**0.5889**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.14

Manual	0.50	1.00	0.14
None	7.00	7.00	1.00
Sum	**8.5**	**10**	**1.29**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1176	0.2000	0.1111	**0.1429**
Manual	0.0588	0.1000	0.1111	**0.0900**
None	0.8235	0.7000	0.7778	**0.7671**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1009
Consistency Index (CI)	0.0504
Consistency Ratio (CR)	0.0870

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	1
Manual	1.00	1.00	1.00
None	1.00	1.00	1.00
Sum	**3**	**3**	**3**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3333	0.3333	0.3333	**0.3333**
Manual	0.3333	0.3333	0.3333	**0.3333**
None	0.3333	0.3333	0.3333	**0.3333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Water Consumption during Operations (WCO)

Pairwise Comparison matrix

Options	**Solar**	**Manual**	**None**
Solar	1	1	0.25
Manual	1.00	1.00	0.25
None	4.00	4.00	1.00
Sum	**6**	**6**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1667	0.1667	0.1667	**0.1667**
Manual	0.1667	0.1667	0.1667	**0.1667**
None	0.6667	0.6667	0.6667	**0.6667**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	0.14
Manual	0.50	1.00	0.14
None	7.00	7.00	1.00
Sum	**8.5**	**10**	**1.29**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1176	0.2000	0.1111	**0.1429**
Manual	0.0588	0.1000	0.1111	**0.0900**
None	0.8235	0.7000	0.7778	**0.7671**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1009
Consistency Index (CI)	0.0504

Consistency Ratio (CR)	0.0870

GHG Emission (GHG) **(9)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	2
Manual	0.33	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.83**	**5**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5455	0.6000	0.5000	**0.5485**
Manual	0.1818	0.2000	0.2500	**0.2106**
None	0.2727	0.2000	0.2500	**0.2409**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0222
Consistency Index (CI)	0.0111
Consistency Ratio (CR)	0.0192

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.75**	**6**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.6667	0.5000	**0.5794**
Manual	0.1429	0.1667	0.2500	**0.1865**
None	0.2857	0.1667	0.2500	**0.2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0694
Consistency Index (CI)	0.0347
Consistency Ratio (CR)	0.0599

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	2
Manual	0.50	1.00	2.00
None	0.50	0.50	1.00
Sum	**2**	**3.50**	**5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5000	0.5714	0.4000	**0.4905**
Manual	0.2500	0.2857	0.4000	**0.3119**
None	0.2500	0.1429	0.2000	**0.1976**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0607
Consistency Index (CI)	0.0304
Consistency Ratio (CR)	0.0523

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.75**	**6**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.6667	0.5000	**0.5794**
Manual	0.1429	0.1667	0.2500	**0.1865**

None	0.2857	0.1667	0.2500	**0.2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0694
Consistency Index (CI)	0.0347
Consistency Ratio (CR)	0.0599

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.75**	**6**	**4**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.6667	0.5000	**0.5794**
Manual	0.1429	0.1667	0.2500	**0.1865**
None	0.2857	0.1667	0.2500	**0.2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0694
Consistency Index (CI)	0.0347
Consistency Ratio (CR)	0.0599

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	7	7
Manual	0.14	1.00	2.00
None	0.14	0.50	1.00
Sum	**1.29**	**8.5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7778	0.8235	0.7000	**0.7671**
Manual	0.1111	0.1176	0.2000	**0.1429**
None	0.1111	0.0588	0.1000	**0.0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1009
Consistency Index (CI)	0.0504
Consistency Ratio (CR)	0.0870

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.75**	**6**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.6667	0.5000	**0.5794**
Manual	0.1429	0.1667	0.2500	**0.1865**
None	0.2857	0.1667	0.2500	**0.2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0694
Consistency Index (CI)	0.0347
Consistency Ratio (CR)	0.0599

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	2
Manual	0.25	1.00	1.00
None	0.50	1.00	1.00
Sum	**1.75**	**6**	**4**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5714	0.6667	0.5000	**0.5794**
Manual	0.1429	0.1667	0.2500	**0.1865**
None	0.2857	0.1667	0.2500	**0.2341**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0694
Consistency Index (CI)	0.0347
Consistency Ratio (CR)	0.0599

GHG Emission (GHG) **(10)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	7
Manual	0.25	1.00	3.00
None	0.14	0.33	1.00
Sum	**1.39**	**5.33**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7179	0.7500	0.6364	**0.7014**
Manual	0.1795	0.1875	0.2727	**0.2132**
None	0.1026	0.0625	0.0909	**0.0853**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0528
Consistency Index (CI)	0.0264
Consistency Ratio (CR)	0.0456

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.5
Manual	2.00	1.00	2.00
None	2.00	0.50	1.00
Sum	**5**	**2**	**3.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2000	0.2500	0.1429	**0.1976**
Manual	0.4000	0.5000	0.5714	**0.4905**
None	0.4000	0.2500	0.2857	**0.3119**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0607
Consistency Index (CI)	0.0304
Consistency Ratio (CR)	0.0523

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	8
Manual	0.25	1.00	4.00
None	0.13	0.25	1.00
Sum	**1.375**	**5.25**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7273	0.7619	0.6154	**0.7015**
Manual	0.1818	0.1905	0.3077	**0.2267**
None	0.0909	0.0476	0.0769	**0.0718**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0882
Consistency Index (CI)	0.0441
Consistency Ratio (CR)	0.0760

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	6
Manual	0.33	1.00	4.00
None	0.17	0.25	1.00
Sum	**1.5**	**4.25**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7059	0.5455	**0.6393**
Manual	0.2222	0.2353	0.3636	**0.2737**
None	0.1111	0.0588	0.0909	**0.0869**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0787
Consistency Index (CI)	0.0394
Consistency Ratio (CR)	0.0679

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	3
Manual	2.00	1.00	3.00
None	0.33	0.33	1.00
Sum	**3.33**	**1.83**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3000	0.2727	0.4286	**0.3338**
Manual	0.6000	0.5455	0.4286	**0.5247**
None	0.1000	0.1818	0.1429	**0.1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	8
Manual	0.25	1.00	4.00
None	0.13	0.25	1.00
Sum	**1.375**	**5.25**	**13**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7273	0.7619	0.6154	**0.7015**
Manual	0.1818	0.1905	0.3077	**0.2267**
None	0.0909	0.0476	0.0769	**0.0718**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0882
Consistency Index (CI)	0.0441
Consistency Ratio (CR)	0.0760

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	5	8
Manual	0.20	1.00	3.00
None	0.13	0.33	1.00
Sum	**1.32**	**6.33**	**12**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7547	0.7895	0.6667	**0.7370**
Manual	0.1509	0.1579	0.2500	**0.1863**
None	0.0943	0.0526	0.0833	**0.0768**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0774
Consistency Index (CI)	0.0387
Consistency Ratio (CR)	0.0668

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	8
Manual	0.33	1.00	6.00
None	0.13	0.17	1.00
Sum	**1.46**	**4.17**	**15**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6857	0.7200	0.5333	**0.6463**
Manual	0.2286	0.2400	0.4000	**0.2895**
None	0.0857	0.0400	0.0667	**0.0641**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1108
Consistency Index (CI)	0.0554
Consistency Ratio (CR)	0.0956

GHG Emission (GHG) **(11)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	9
Manual	1.00	1.00	9.00
None	0.11	0.11	1.00
Sum	**2.11**	**2.11**	**19**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.4737	0.4737	0.4737	**0.4737**
Manual	0.4737	0.4737	0.4737	**0.4737**
None	0.0526	0.0526	0.0526	**0.0526**

Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.11	0.5
Manual	9.00	1.00	6.00
None	2.00	0.17	1.00
Sum	**12**	**1.28**	**7.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0833	0.0870	0.0667	**0.0790**
Manual	0.7500	0.7826	0.8000	**0.7775**
None	0.1667	0.1304	0.1333	**0.1435**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0174
Consistency Index (CI)	0.0087
Consistency Ratio (CR)	0.0150

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	4
Manual	4.00	1.00	9.00
None	0.25	0.11	1.00
Sum	**5.25**	**1.36**	**14**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1905	0.1837	0.2857	**0.2200**

Manual	0.7619	0.7347	0.6429	**0.7132**
None	0.0476	0.0816	0.0714	**0.0669**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0619
Consistency Index (CI)	0.0310
Consistency Ratio (CR)	0.0534

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0.11	1.00	0.25
None	0.25	4.00	1.00
Sum	**1.36**	**14**	**5.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7347	0.6429	0.7619	**0.7132**
Manual	0.0816	0.0714	0.0476	**0.0669**
None	0.1837	0.2857	0.1905	**0.2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0619
Consistency Index (CI)	0.0310
Consistency Ratio (CR)	0.0534

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	3
Manual	0.25	1.00	0.33
None	0.33	3.00	1.00
Sum	**1.58**	**8**	**4.33**

Normalization of comparison				
Options	**Manuel**	**Manual**	**None**	**Priority vector**

Solar	0.6316	0.5000	0.6923	**0.6080**
Manual	0.1579	0.1250	0.0769	**0.1199**
None	0.2105	0.3750	0.2308	**0.2721**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Solar**	**None**
Solar	1	6	4
Manual	0.17	1.00	0.33
None	0.25	3.00	1.00
Sum	**1.42**	**10**	**5.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7059	0.6000	0.7500	**0.6853**
Manual	0.1176	0.1000	0.0625	**0.0934**
None	0.1765	0.3000	0.1875	**0.2213**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.17	0.25
Manual	6.00	1.00	3.00
None	4.00	0.33	1.00
Sum	**11**	**1.5**	**4.25**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0.0909	0.1111	0.0588	**0.0869**
Manual	0.5455	0.6667	0.7059	**0.6393**
None	0.3636	0.2222	0.2353	**0.2737**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0787
Consistency Index (CI)	0.0394
Consistency Ratio (CR)	0.0679

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.111111	1
Manual	9.00	1.00	9.00
None	1.00	0.11	1.00
Sum	**11**	**1.222222**	**11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0909	0.0909	**0.0909**
Manual	0.8182	0.8182	0.8182	**0.8182**
None	0.0909	0.0909	0.0909	**0.0909**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

GHG Emission (GHG)

(12)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.25
Manual	0.33	1.00	0.17
None	4.00	6.00	1.00
Sum	**5.33**	**10**	**1.42**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1875	0.3000	0.1765	**0.2213**
Manual	0.0625	0.1000	0.1176	**0.0934**
None	0.7500	0.6000	0.7059	**0.6853**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Negative Ecological Footprint (NEF)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	3
Manual	0.13	1.00	0.17
None	0.33	6.00	1.00
Sum	**1.46**	**15**	**4.17**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6857	0.5333	0.7200	**0.6463**
Manual	0.0857	0.0667	0.0400	**0.0641**
None	0.2286	0.4000	0.2400	**0.2895**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1108
Consistency Index (CI)	0.0554
Consistency Ratio (CR)	0.0956

Use of Available Land (UAL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	7	7

Manual	0.14	1.00	2.00
None	0.14	0.50	1.00
Sum	**1.29**	**8.5**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7778	0.8235	0.7000	**0.7671**
Manual	0.1111	0.1176	0.2000	**0.1429**
None	0.1111	0.0588	0.1000	**0.0900**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1009
Consistency Index (CI)	0.0504
Consistency Ratio (CR)	0.0870

Recyclability at End of Life (REL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	8	3
Manual	0.13	1.00	0.25
None	0.33	4.00	1.00
Sum	**1.46**	**13**	**4.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6857	0.6154	0.7059	**0.6690**
Manual	0.0857	0.0769	0.0588	**0.0738**
None	0.2286	0.3077	0.2353	**0.2572**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0283
Consistency Index (CI)	0.0142
Consistency Ratio (CR)	0.0244

Waste Chemicals at End of Life (WCE)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	6
Manual	0.11	1.00	0.33
None	0.17	3.00	1.00
Sum	**1.28**	**13**	**7.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7826	0.6923	0.8182	**0.7644**
Manual	0.0870	0.0769	0.0455	**0.0698**
None	0.1304	0.2308	0.1364	**0.1659**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1001
Consistency Index (CI)	0.0500
Consistency Ratio (CR)	0.0863

Gases at End of Life (GEL)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	4
Manual	0.11	1.00	0.25
None	0.25	4.00	1.00
Sum	**1.36**	**14**	**5.25**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7347	0.6429	0.7619	**0.7132**
Manual	0.0816	0.0714	0.0476	**0.0669**
None	0.1837	0.2857	0.1905	**0.2200**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0619

Consistency Index (CI)	0.0310
Consistency Ratio (CR)	0.0534

Principal Eigen Value	3.1001
Consistency Index (CI)	0.0500
Consistency Ratio (CR)	0.0863

Water Consumption during Operations (WCO)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	9
Manual	0.11	1.00	0.11
None	0.11	9.00	1.00
Sum	**1.22**	**19**	**10.11**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.8182	0.4737	0.8901	**0.7273**
Manual	0.0909	0.0526	0.0110	**0.0515**
None	0.0909	0.4737	0.0989	**0.2212**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	4.1039
Consistency Index (CI)	0.5519
Consistency Ratio (CR)	0.9516

Consumption of Other Materials during Operations (COM)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	9	6
Manual	0.11	1.00	0.33
None	0.17	3.00	1.00
Sum	**1.28**	**13**	**7.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7826	0.6923	0.8182	**0.7644**
Manual	0.0870	0.0769	0.0455	**0.0698**
None	0.1304	0.2308	0.1364	**0.1659**
Normalised	**1**	**1**	**1**	

THE MATRICES OF ALTERNATIVES COMPARED WITH RESPECT TO EACH OF CRITERIA IN THE POLITICAL PERSPECTIVE

overnment Backing (GB) **(1)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.17
Manual	4.00	1.00	0.33
None	6.00	3.00	1.00
Sum	**11**	**4.25**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0588	0.1111	**0.0869**
Manual	0.3636	0.2353	0.2222	**0.2737**
None	0.5455	0.7059	0.6667	**0.6393**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0787
Consistency Index (CI)	0.0394
Consistency Ratio (CR)	0.0679

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.17
Manual	4.00	1.00	0.33
None	6.00	3.00	1.00
Sum	**11**	**4.25**	**1.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0588	0.1111	**0.0869**
Manual	0.3636	0.2353	0.2222	**0.2737**
None	0.5455	0.7059	0.6667	**0.6393**

Normalised	1	1	1	

Principal Eigen Value	3.0787
Consistency Index (CI)	0.0394
Consistency Ratio (CR)	0.0679

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.14
Manual	3.00	1.00	0.25
None	7.00	4.00	1.00
Sum	**11**	**5.33**	**1.40**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0625	0.1026	**0.0853**
Manual	0.2727	0.1875	0.1795	**0.2132**
None	0.6364	0.7500	0.7179	**0.7014**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0528
Consistency Index (CI)	0.0264
Consistency Ratio (CR)	0.0456

Government Backing (GB) **(2)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	2
Manual	4.00	1.00	5.00
None	0.50	0.20	1.00
Sum	**5.5**	**1.45**	**8**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**

Solar	0.1818	0.1724	0.2500	**0.2014**
Manual	0.7273	0.6897	0.6250	**0.6806**
None	0.0909	0.1379	0.1250	**0.1179**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0383
Consistency Index (CI)	0.0191
Consistency Ratio (CR)	0.0330

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	0.25
Manual	0.33	1.00	0.17
None	4.00	6.00	1.00
Sum	**5.33**	**10**	**1.42**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1875	0.3000	0.1765	**0.2213**
Manual	0.0625	0.1000	0.1176	**0.0934**
None	0.7500	0.6000	0.7059	**0.6853**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	4
Manual	0.17	1.00	0.33
None	0.25	3.00	1.00
Sum	**1.42**	**10**	**5.33**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7059	0.6000	0.7500	**0.6853**
Manual	0.1176	0.1000	0.0625	**0.0934**
None	0.1765	0.3000	0.1875	**0.2213**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Government Backing (GB) **(3)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.14
Manual	3.00	1.00	0.33
None	7.00	3.00	1.00
Sum	**11**	**4.33**	**1.48**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0769	0.0968	**0.0882**
Manual	0.2727	0.2308	0.2258	**0.2431**
None	0.6364	0.6923	0.6774	**0.6687**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0108
Consistency Index (CI)	0.0054
Consistency Ratio (CR)	0.0093

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	3

Manual	0.50	1.00	3.00
None	0.33	0.33	1.00
Sum	**1.83**	**3.33**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5455	0.6000	0.4286	**0.5247**
Manual	0.2727	0.3000	0.4286	**0.3338**
None	0.1818	0.1000	0.1429	**0.1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.2	0.17
Manual	5.00	1.00	0.50
None	6.00	2.00	1.00
Sum	**12**	**3.2**	**1.67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0833	0.0625	0.1000	**0.0819**
Manual	0.4167	0.3125	0.3000	**0.3431**
None	0.5000	0.6250	0.6000	**0.5750**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0394
Consistency Index (CI)	0.0197
Consistency Ratio (CR)	0.0340

Government Backing (GB) **(4)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.13
Manual	4.00	1.00	0.25
None	8.00	4.00	1.00
Sum	**13**	**5.25**	**1.38**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0769	0.0476	0.0909	**0.0718**
Manual	0.3077	0.1905	0.1818	**0.2267**
None	0.6154	0.7619	0.7273	**0.7015**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0882
Consistency Index (CI)	0.0441
Consistency Ratio (CR)	0.0760

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.2	0.142857
Manual	5.00	1.00	0.33
None	7.00	3.00	1.00
Sum	**13**	**4.2**	**1.48**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0769	0.0476	0.0968	**0.0738**
Manual	0.3846	0.2381	0.2258	**0.2828**
None	0.5385	0.7143	0.6774	**0.6434**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0967
Consistency Index (CI)	0.0484

Consistency Ratio (CR)	0.0834

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.2	0.13
Manual	5.00	1.00	0.33
None	8.00	3.00	1.00
Sum	**14**	**4.2**	**1.46**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0714	0.0476	0.0857	**0.0683**
Manual	0.3571	0.2381	0.2286	**0.2746**
None	0.5714	0.7143	0.6857	**0.6571**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0672
Consistency Index (CI)	0.0336
Consistency Ratio (CR)	0.0580

Government Backing (GB) (5)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	0.2
Manual	3.00	1.00	0.33
None	5.00	3.00	1.00
Sum	**9**	**4.33**	**1.53**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1111	0.0769	0.1304	**0.1062**
Manual	0.3333	0.2308	0.2174	**0.2605**
None	0.5556	0.6923	0.6522	**0.6333**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	6	6
Manual	0.17	1.00	2.00
None	0.17	0.50	1.00
Sum	**1.33**	**7.5**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7500	0.8000	0.6667	**0.7389**
Manual	0.1250	0.1333	0.2222	**0.1602**
None	0.1250	0.0667	0.1111	**0.1009**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0949
Consistency Index (CI)	0.0475
Consistency Ratio (CR)	0.0818

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.17
Manual	4.00	1.00	0.33
None	6.00	3.00	1.00
Sum	**11**	**4.25**	**1.50**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.0909	0.0588	0.1111	**0.0869**

Manual	0.3636	0.2353	0.2222	**0.2737**
None	0.5455	0.7059	0.6667	**0.6393**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0787
Consistency Index (CI)	0.0394
Consistency Ratio (CR)	0.0679

Government Backing (GB) **(6)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	2
Manual	3.00	1.00	3.00
None	0.50	0.33	1.00
Sum	**4.5**	**1.67**	**6**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2222	0.2000	0.3333	**0.2519**
Manual	0.6667	0.6000	0.5000	**0.5889**
None	0.1111	0.2000	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.33	2
Manual	3.00	1.00	3.00
None	0.50	0.33	1.00
Sum	**4.5**	**1.67**	**6**

Normalization of comparison

Options	Solar	Manual	None	Priority vector
Solar	0.2222	0.2000	0.3333	**0.2519**
Manual	0.6667	0.6000	0.5000	**0.5889**
None	0.1111	0.2000	0.1667	**0.1593**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0704
Consistency Index (CI)	0.0352
Consistency Ratio (CR)	0.0607

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.25	0.25
Manual	4.00	1.00	0.50
None	4.00	2.00	1.00
Sum	**9**	**3.25**	**1.75**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.1111	0.0769	0.1429	**0.1103**
Manual	0.4444	0.3077	0.2857	**0.3460**
None	0.4444	0.6154	0.5714	**0.5438**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0686
Consistency Index (CI)	0.0343
Consistency Ratio (CR)	0.0591

Government Backing (GB) (7)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	5
Manual	0.33	1.00	3.00
None	0.20	0.33	1.00

Sum	1.53	4.33	9

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6522	0.6923	0.5556	**0.6333**
Manual	0.2174	0.2308	0.3333	**0.2605**
None	0.1304	0.0769	0.1111	**0.1062**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.5
Manual	2.00	1.00	1.00
None	2.00	1.00	1.00
Sum	**5**	**2.5**	**2.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2000	0.2000	0.2000	**0.2000**
Manual	0.4000	0.4000	0.4000	**0.4000**
None	0.4000	0.4000	0.4000	**0.4000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	4	4
Manual	0.25	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.5**	**5.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7273	0.5714	**0.6551**
Manual	0.1667	0.1818	0.2857	**0.2114**
None	0.1667	0.0909	0.1429	**0.1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Government Backing (GB) **(8)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.5
Manual	2.00	1.00	0.50
None	2.00	2.00	1.00
Sum	**5**	**3.5**	**2**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2000	0.1429	0.2500	**0.1976**
Manual	0.4000	0.2857	0.2500	**0.3119**
None	0.4000	0.5714	0.5000	**0.4905**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0607
Consistency Index (CI)	0.0304
Consistency Ratio (CR)	0.0523

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	5
Manual	0.33	1.00	3.00
None	0.20	0.33	1.00
Sum	**1.53**	**4.33**	**9**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6522	0.6923	0.5556	**0.6333**
Manual	0.2174	0.2308	0.3333	**0.2605**
None	0.1304	0.0769	0.1111	**0.1062**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0554
Consistency Index (CI)	0.0277
Consistency Ratio (CR)	0.0477

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	0.5
Manual	2.00	1.00	0.50
None	2.00	2.00	1.00
Sum	**5**	**3.5**	**2**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2000	0.1429	0.2500	**0.1976**
Manual	0.4000	0.2857	0.2500	**0.3119**
None	0.4000	0.5714	0.5000	**0.4905**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0607
Consistency Index (CI)	0.0304

Consistency Ratio (CR)	0.0523

Government Backing (GB) **(9)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	0.33
Manual	1.00	1.00	0.33
None	3.00	3.00	1.00
Sum	**5**	**5**	**1.67**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2000	0.2000	0.2000	**0.2000**
Manual	0.2000	0.2000	0.2000	**0.2000**
None	0.6000	0.6000	0.6000	**0.6000**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0000
Consistency Index (CI)	0.0000
Consistency Ratio (CR)	0.0000

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	3
Manual	0.50	1.00	3.00
None	0.33	0.33	1.00
Sum	**1.83**	**3.33**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5455	0.6000	0.4286	**0.5247**
Manual	0.2727	0.3000	0.4286	**0.3338**
None	0.1818	0.1000	0.1429	**0.1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Conformance **to Existing Political Legal and Mgt Rules (CEP)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	0.5	3
Manual	2.00	1.00	3.00
None	0.33	0.33	1.00
Sum	**3.33**	**1.83**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.3000	0.2727	0.4286	**0.3338**
Manual	0.6000	0.5455	0.4286	**0.5247**
None	0.1000	0.1818	0.1429	**0.1416**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0654
Consistency Index (CI)	0.0327
Consistency Ratio (CR)	0.0564

Government Backing (GB) **(10)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0.25	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.5**	**5.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7273	0.5714	**0.6551**
Manual	0.1667	0.1818	0.2857	**0.2114**

None	0.1667	0.0909	0.1429	**0.1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	4
Manual	0.25	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.5**	**5.5**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6667	0.7273	0.5714	**0.6551**
Manual	0.1667	0.1818	0.2857	**0.2114**
None	0.1667	0.0909	0.1429	**0.1335**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0797
Consistency Index (CI)	0.0399
Consistency Ratio (CR)	0.0687

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0.33	1.00	3.00
None	0.25	0.33	1.00
Sum	**1.58**	**4.33**	**8**

Normalization of comparison

Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.6923	0.5000	**0.6080**
Manual	0.2105	0.2308	0.3750	**0.2721**
None	0.1579	0.0769	0.1250	**0.1199**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.1012
Consistency Index (CI)	0.0506
Consistency Ratio (CR)	0.0873

Government Backing (GB) **(11)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	3	4
Manual	0.33	1.00	2.00
None	0.25	0.50	1.00
Sum	**1.58**	**4.50**	**7**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.6316	0.6667	0.5714	**0.6232**
Manual	0.2105	0.2222	0.2857	**0.2395**
None	0.1579	0.1111	0.1429	**0.1373**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0255
Consistency Index (CI)	0.0127
Consistency Ratio (CR)	0.0220

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	2	3
Manual	0.50	1.00	2.00
None	0.33	0.50	1.00

Sum	1.83	3.5	6

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.5455	0.5714	0.5000	**0.5390**
Manual	0.2727	0.2857	0.3333	**0.2973**
None	0.1818	0.1429	0.1667	**0.1638**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0112
Consistency Index (CI)	0.0056
Consistency Ratio (CR)	0.0096

Conformance to Existing Political Legal and Mgt Rules (CEP)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	1	0.5
Manual	1.00	1.00	1.00
None	2.00	1.00	1.00
Sum	**4**	**3**	**2.5**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.2500	0.3333	0.2000	**0.2611**
Manual	0.2500	0.3333	0.4000	**0.3278**
None	0.5000	0.3333	0.4000	**0.4111**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0556
Consistency Index (CI)	0.0278
Consistency Ratio (CR)	0.0479

Government Backing (GB) **(12)**

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**

Solar	1	4	6
Manual	0.25	1.00	3.00
None	0.17	0.33	1.00
Sum	**1.42**	**5.33**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7059	0.7500	0.6000	**0.6853**
Manual	0.1765	0.1875	0.3000	**0.2213**
None	0.1176	0.0625	0.1000	**0.0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Local Sourcing of Dimension Stone (LSD)

Pairwise Comparison matrix			
Options	**Solar**	**Manual**	**None**
Solar	1	4	6
Manual	0.25	1.00	3.00
None	0.17	0.33	1.00
Sum	**1.42**	**5.33**	**10**

Normalization of comparison				
Options	**Solar**	**Manual**	**None**	**Priority vector**
Solar	0.7059	0.7500	0.6000	**0.6853**
Manual	0.1765	0.1875	0.3000	**0.2213**
None	0.1176	0.0625	0.1000	**0.0934**
Normalised	**1**	**1**	**1**	

Principal Eigen Value	3.0850
Consistency Index (CI)	0.0425
Consistency Ratio (CR)	0.0733

Conformance to Existing Political Legal and Mgt Rules (CEP)