A SUSTAINABILITY ASSESSMENT FRAMEWORK FOR EVALUATION OF COAL MINING SECTOR PLANS IN AFŞİN-ELBİSTAN COAL BASIN WITH A SPECIAL EMPHASIS ON LAND DISTURBANCE

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

EVREN DENİZ YAYLACI

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
MINING ENGINEERING

SEPTEMBER 2015

Approval of the thesis:

A SUSTAINABILITY ASSESSMENT FRAMEWORK FOR EVALUATION OF COAL MINING SECTOR PLANS IN AFŞIN-ELBISTAN COAL BASIN WITH A SPECIAL EMPHASIS ON LAND DISTURBANCE

submitted by **EVREN DENIZ YAYLACI** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Mining Engineering Department, Middle East Technical University** by,

Prof. Dr. Gülbin Dural Ünver ______________________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Ali İhsan Arol ______________________
Head of Department, **Mining Engineering**

Prof. Dr. H. Şebnem Düzgün ______________________
Supervisor, **Mining Engineering Dept., METU**

Examining Committee Members:

Prof. Dr. Ali İhsan Arol ______________________
Mining Engineering Dept., METU

Prof. Dr. H. Şebnem Düzgün ______________________
Mining Engineering Dept., METU

Prof. Dr. Suphi Ural ______________________
Mining Engineering Dept., Çukuroava University

Assoc. Prof. Dr. Ayşegül Aksoy ______________________
Environmental Engineering Dept., METU

Assoc. Prof. Dr. Nuray Demirel ______________________
Mining Engineering Dept., METU

Date: 11.09.2015

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Evren Deniz YAYLACI

Signature:

ABSTRACT

A SUSTAINABILITY ASSESSMENT FRAMEWORK FOR EVALUATION OF COAL MINING SECTOR PLANS IN AFŞIN-ELBISTAN COAL BASIN WITH A SPECIAL EMPHASIS ON LAND DISTURBANCE

Yaylacı, Evren Deniz

Ph.D., Department of Mining Engineering

Supervisor: Prof. Dr. H. Şebnem Düzgün

September 2015, 334 pages

The mining sector has negative and positive impacts on the environment, society and economy at the local and national levels. Mitigating and minimizing the negative impacts while maximizing the social and economic benefits of the mining sector are significantly important for contributing to sustainable development in practice. For this purpose, different assessment tools, which can be applied at different decision-making levels, are used in the mining sector and sustainability assessment (SA) is one of these tools.

However, sustainability and the mining sector are generally seen as two conflicting concepts. Additionally, integrating the sustainability criteria into assessment practices is a challenge for the decision-making authorities at the strategic level. Moreover, in many cases the application of public participation and stakeholder consultation and the consideration of the outcomes could not be practiced effectively during the strategic-level decision-making process.

Regarding these, the thesis aims to integrate the sustainability into strategic-level decision-making in the mining sector planning through operationalization of the concept methodologically and systematically in order to prevent using the term of sustainability as a green-washing practice for social license to operate. In order to do this, an indicator-based sustainability assessment framework is suggested as a decision support tool for the mining sector in this thesis. The framework is applied for evaluating the sustainability of the mining plans in the Afşin-Elbistan Coal Basin (AECB) in Turkey with a specific focus of land disturbance at the local level and also the security of energy supply criteria at the national level.

Keywords: Sustainability in the Mining Sector, Sustainability Assessment, Land Disturbance, Sustainability Indicators, Public Participation, Multi-Criteria Decision Analysis

ÖZ

AFŞİN-ELBİSTAN KÖMÜR HAVZASINDA KÖMÜR MADENCİLİĞİ SEKTÖR PLANLARI İÇİN ARAZİ BOZULUMUNA ODAKLANAN SÜRDÜRÜLEBİLİRLİK ANALİZİ ÇERÇEVESİ

Yaylacı, Evren Deniz

Doktora, Maden Mühendisliği Bölümü

Tez Yöneticisi: Prof. Dr. H. Şebnem Düzgün

Eylül 2015, 334 sayfa

Madencilik sektörünün yerel ve ulusal ölçekte çevre, toplum ve ekonomi üzerinde olumsuz ve olumlu etkileri vardır. Bundan dolayı, madencilik sektörünün olumsuz etkilerinin azaltılması ve ortadan kaldırılması ile toplumsal ve ekonomik faydalarının da en üst seviyeye çıkartılması sürdürülebilir kalkınmanın uygulamada desteklenmesi açısından önemlidir. Maden sektöründe bunun gerçekleştirilmesi için farklı karar-alma seviyelerinde uygulanabilir farklı değerlendirme araçları kullanılmaktadır ve sürdürülebilirlik analizi (SA) bu araçlardan birtanesidir.

Fakat çoğu zaman sürdürülebilirlik ve madencilik sektörü birbirleri ile çelişen iki kavram olarak değerlendirilmektedir. Buna ek olarak, stratejik seviyede sürdürülebilirlik kriterlerinin değerlendirme sürecine dâhil edilmesi karar-alıcılar için oldukça zorlayıcıdır. Ayrıca, mevcut uygulamalarda stratejik seviyede gerçekleştirilen karar-alma süreçlerinde halkın katılımı ve paydaşlara danışma uygulanması ve çıktıların dikkate alınması da etkin şekilde uygulanamamaktadır.

Bunlar dikkate alındığında, tezin amacı sürdürülebilirlik kavramının bir yönteme dayalı ve sistematik olarak stratejik seviyede karar-alma süreçlerine entegrasyonun sağlanmasıdır. Böylece kavramın madencilik planlarının faaliyete geçirilmesi için toplumsal onay alınması için 'çevreci' imaj yaratılması amacıyla kullanılmasının önlenmesi sağlanacaktır. Amacın gerçekleştirilmesi için madencilik sektörü için karar-alma destek aracı olarak göstergelere dayalı bir sürdürülebilirlik analiz çerçevesi bu tez kapsmında önerilmektedir. Önerilen sürdürülebilirlik analiz çerçevesi, Türkiye'de bulunan Afşin-Elbistan Kömür Havzası'nda planlanan madencilik faaliyetlerinin sürdürülebilirlik seviyelerinin değerlendirilmesinde kullanılmıştır. Bu değerlendirme yerel ölçekte arazi bozunumu ve ulusal ölçekte enerji arz güvenliğine odaklanan iki örnek uygulama ile gerçekleştirilmiştir.

Anahtar Kelimeler: Madencilik Sektöründe Sürdürülebilirlik, Sürdürülebilirlik Analizi, Arazi Bozulunumu, Sürdürülebilirlik Göstergeleri, Halkın Katılımı, Çok Kriterli Karar Analizi

To my wife and parents

ACKNOWLEDGMENTS

I would like to extend my genuine gratitude to the supervisor of my research Prof. Dr. H. Şebnem Düzgün. This dissertation would not have been possible without her support, continued encouragement, patience, supportive attitude and precious guidance throughout this work.

I would specially like to express my sincere gratitude to Assoc. Prof. Dr. Nuray Demirel and Prof. Dr. Ayşegül Aksoy for their valuable advice and guidance for pushing me to stay focused and to proceed continuously with my thesis from the beginning to the end of my research. I would also like to acknowledge Prof. Dr. Ali İhsan Arol for his valuable comments for improving my research.

The basis of the research of this thesis is built on the project numbered 113M463, which has been granted under TUBİTAK 1001 Program. Therefore, I would also like to offer my appreciation to Prof. Dr. Suphi Ural, from Çukurova University, Prof. Dr. Sibel Kalaycıoğlu, Assoc. Prof. Dr. Emre Alp and Assoc. Prof. Dr. Elçin Kentel, for their valuable contributions during the implementation of the project.

During two years of the thesis research parallel to the project numbered 113M463, especially Prof. Dr. Suphi Ural has generously shared technical information and also he has been always supportive for accessing the data, needed for the research, and for building an effective coordination with colleagues at EÜAŞ both in the Ankara and Elbistan offices. Additionally, Prof. Dr. Sibel Kalaycıoğlu has taken a significant role during the development and practice of the questionnaire survey and focus group meetings in the Afşin-Elbistan Coal Basin in order to practice the public participation and stakeholder consultation within the research. Therefore, I would especially like to acknowledge Prof. Dr. Suphi Ural and Prof. Dr. Sibel Kalaycıoğlu for their kind support and valuable comments.

Moreover, I am thankful to my colleague Ms. İlke Arıcan for her support and dedicated work during the implementation of the project numbered 113M463 and I am also grateful to Mr. Mustafa Tokoğlu for his time and support given to the preparation of the data and to development of the reserve model during my research.

Last but not the least, I must admit that my most sincerely gratitude goes to my love, Ş. Tuna Yaylacı and also my mother, Ayfer Yaylacı; my father, Sebehattin Yaylacı and my sister, Seçil Dere for their incredible understanding, pure love, great patience and emotional support during my PhD study.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

ABBREVIATIONS

AECB	Afşin-Elbistan Coal Basin
AHP	Analytical-hierarchy process
BWE	Bucket-wheel-excavator
CI	Consistency index
CIA	Cumulative Impact Assessment
CR	Consistency ratio
DSİ	Turkish abbreviation of General Directorate of State Water Works (of Turkish Republic)
DCLG	Department for Communities and Local Government of United Kingdom
EC	European Commission
EIA	Environmental Impact Assessment
EIR	Extractive Industries Review
EMDA	Eastern Mediterranean Development Agency
EU	European Union
EUROMINES	European Association of Mining Industries, Metal Ores and Industrial Minerals
EÜAŞ	Turkish abbreviation of Electricity Generation Company (under MoENR)
EQW	Equal weighting method

FAO	Food and Agriculture Organization of United Nations
GDP	Gross Domestic Product
GoI	Government of Ireland
GoK	Governor’s Office of Kahramanmaraş
GRI	Global Reporting Initiative
ICMM	International Council on Mining and Metallurgy
IDW	Inverse Distance Weighted
IIED	International Institute for Environment and Development
IS	Index score
ISO	International Organization for Standardization
MCA	Multi-criteria analysis
MCDA	Multi-criteria decision analysis
MoD	Ministry of Development (of Turkish Republic)
MoENR	Ministry of Energy and Natural Resources (of Turkish Republic)
MoEUP	Ministry of Environment and Urban Planning (of Turkish Republic)
MoSIT	Ministry of Science, Industry and Technology (of Turkish Republic)
MTA	Turkish abbreviation of General Directorate of Mineral Research and Exploration (under MoENR)
NGO	Non-governmental organization
OECD	Organization for Economic Co-operation and Development
ODPM	Office of the Deputy Prime Minister of United Kingdom
OHSAS	Occupational Health- and Safety Assessment Series
PL	project-level
PPP	Policy, Plan, Program

RI	Random index
RSPB	Royal Society for the Protection of Birds
SA	Sustainability Assessment
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SL	strategic-level
SME	Small and medium size enterprise
Strategy	Policy, plan and program (used in the thesis)
SIS	Sustainability Index Score
TEİAŞ	Turkish abbreviation of Turkish Electricity Transmission Company (under MoENR)
TKİ	Turkish abbreviation of General Directorate of Turkish Coal Enterprise (under MoENR)
TMMOB	Union of Turkish Engineer and Architecture Chambers
TURKSTAT	Turkish Statistics Institution
TÜBİTAK	Turkish abbreviation of The Scientific and Technological Research Council of Turkey
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission on Sustainable Development
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNFCCC	Framework Convention on Climate Change of UN

WB	World Bank
WBCSD	World Business Council on Sustainable Development
WCED	World Commission on Environment and Development
WEF	World Economic Forum
WSSD	World Summit on Sustainable Development

CHAPTER 1

INTRODUCTION

1.1. Background Information

Investments in the mining sector and in some cases in the energy sector, such as lignite-burning power plants and hydro-plants, must be practiced in regions where the natural resources are located or near these resources due to economic and engineering reasons. Positive and negative impacts on environment, society and economy emerge as a result of these investments. The continuity along the time, the affected area and the intensity of the positive and negative impacts depend on the characteristics of the project and the region where it has been implemented (Bell and Donnelly, 2006).

Starting from the early 1970's, different tools have been used by decision-makers and investors for mitigating and/or minimizing the negative impacts while increasing the positive outcomes of such investments. Among these tools, the one that was most widely used and studied is the Environmental Impact Assessment (EIA) (Wood, 1995; Kiss and Shelton, 1997; Hens, 1998; Glasson *et al.*, 2002; IAIA, 2003; Dutta *et al.*, 2004; Vanclay, 2010). Indeed, because of the rise of discussions on sustainable development with the first Earth Summit in Rio in 1992, "EIA has become a mandatory tool also in developing countries and countries in transition for the purpose of environmental protection and impact mitigation" (Lee and George, 1999 cited in Yaylacı, 2005, p.8).

Nevertheless, besides the mandatory use of the EIA in developed and most of the developing countries starting from the early 90's, the outcomes of the Rio Summit have also other effects on project-level environmental assessment studies and frameworks. For instance, the need for evaluation and integration of the cumulative and transboundary impacts, early public participation and also the assessment of possible impacts of policy-, plan- and program-level (strategic-level) decisions are important factors leading to an increase in the criticisms about the limitations of the project-level assessment approaches. In addition to this, a growing emphasis on integrating the concept of sustainability into decision-making in practice also brings about the development of new frameworks and approaches. Considering these, the following issues are seen as the insufficiencies about the project-level assessment and evaluation.

Firstly, since the project-level tools, i.e. the EIA, aim to mitigate and minimize the negative environmental impacts of a specific project, they have a limited capacity and also no objective for considering and integrating the three pillars of sustainability (environmental, social, economic) into decision-making equally. Therefore, motivation to use integrated approaches to overcome this issue rises globally (Vanclay, 2010).

Secondly, the project-level assessment tools focus on a single targeted project at a time and discuss it in detail with a comprehensive report. However, all the strategic decisions have already been given before the project scale, so consideration of the strategic-level alternatives cannot be possible in practice. For instance, the EIA can evaluate the possible impacts of a thermal power plant in a specific location in detail and explain how to mitigate and minimize these in practice. However, the EIA cannot and aim not to discuss the possible outcomes and effects of investing in renewable energy alternatives instead of thermal power plants or what the mixture of these should be in the energy portfolio of a country for securing energy supply at the strategic-level (Wood, 2003).

In this respect, a strategic-level approach is important in order to inform the decision-makers about the different outcomes of possible alternatives as well as to operationalize the concept of sustainability in practice. Regarding the consideration of possible alternatives and the three pillars of sustainability in decision-making, two main issues should be summarized.

The first one is the need for systematic, quantitative, time- and cost-effective frameworks and approaches, applicable at the strategic-level, for developing socially responsible, environmentally sensitive and cost-effective strategies. In other words, besides the academic study and discussions, the framework/approach should have a capacity to integrate the concept of sustainable development into practice in a systematical, cost- and time–effective manner on sectoral basis.

The second one is that even if the implementation methodology and practical experiences on the project-level tools, especially the EIA, have been well developed for years, the lacking strategic decision-making capacity leads to future problems as all the significant and strategic decisions have been defined in early stages of the decision-making process (Wood, 2003).

Therefore, the integration of sustainability into practice and also the compression of different alternatives based on the sustainability criteria at strategic-level are still up-to-date discussions in the literature. Moreover, strategic-level assessment practices on a sectoral basis, which integrate sustainability principles into decision-making at strategic-level, are especially lacking for the mining sector.

However, the impact of the mining industry on land and also the size of the soil moved from point to another are significantly higher than any other human-sourced actions Kirsch (2009). In addition to this according to US Environmental Protection Agency, the mining sector is the main source of toxic pollution in USA Kirsch (2009). Therefore, achieving the integration of sustainability principles into strategic-level decision-making with sector-specific frameworks is also highly important for the mining sector.

Regarding all these discussions, the need for a wider integration of environmental, social and economic pillars of the sustainability into a single framework is highlighted by Vanclay (2010, p.108) as;

- Everything is inherently interconnected so a complete understanding of all the impacts can only be achieved by a comprehensive and integrated assessment and
- Decision-making authorities have limited resources, so conducting many different forms of assessment for a single action is problematic, such as the EIA as well as the Social Impact Assessment (SIA) and the Cumulative Impact Assessment (CIA) or the Strategic Environmental Assessment (SEA); and the Sustainability Assessment (SA).

Respectively, a sectoral decision-making support framework with integrated assessment characteristics, applicable for different sectors, will be useful. Additionally, such a framework has a potential for "rapidly spreading as a practice at different levels of governance and also seen as necessary procedures to improve and inform decision-making at strategic- and project-levels" (Ridder *et al*., 2010, p.126).

In fact, such strategic-level decision-support frameworks must achieve more than to generate the aimed outcomes in favor of the decision-makers to present the actions as environmentally friendly. As Kirsch (2009) stresses, the mining companies and governments use terms like 'clean coal', 'social responsibility', 'transparency', 'sustainable mining', and 'conservation projects and auditing' to conceal harm and neutralize the critics. Therefore, without the quantification or operationalization of the sustainability into impact assessment approaches successfully, the obtained results would not be considered more than "some green-washing of big business/investments and the use of sustainability concepts could not go further than academic discussions" (Vanclay, 2010, p.106).

Besides the above given discussions about how the concept of sustainability is used as a 'marketing' feature, and how some of these concepts are conflicting with the actions of sectors like mining, the complexity of integration and operationalization of sustainability into decision-making process is also an important concern in the literature. For instance, Ridder *et al.* (2010, p.126) argues that "the overlapping and conflicting priorities, value systems, complexities of interlinked systems and sectors, make planning and analysis for more sustainable policies a difficult and complex issue".

Due to such complexity, a lack of actual methodological and analytical guidance about integrated assessment tools as well as the problems faced during actual practice of integrated assessments are mentioned by several researchers, such as Wood *et al.* (1996), Lee and Kirkpatrick (2004), Wilkinson *et al.* (2004) and Balantine and Devonald (2006, cited in Ridder *et al.*, 2010, p.126).

Based on the above given discussions, the main issues about consideration and integration of sustainability into decision-making process of the sectors, especially those with significant negative impact, i.e. the mining sector, can be summarized as;

- Early practicing of strategic-level assessment tools is necessary for evaluation and comparison of the sustainability of the alternatives in order to mitigate the approval of sustainably unsound projects in the future;
- The strategic-level approaches and frameworks should be compatible with the concept of strong sustainability that mainly involves mitigating environmental degradation (for details of sustainability levels please see Kirsch, 2009);
- Integrating the sustainability into decision-making by operationalization of the concept methodologically and analytically in order to prevent using the term of sustainability as green-washing practice for social license to operate.

1.2. Objective

The overall objective of this thesis is developing an indicator-based sustainability assessment framework for operationalizing and integrating the sustainability criteria into the strategic-level decision-making of the mining sector plans.

1.3. Scope

The systematic use of the strategic-level sustainability indicators within the developed framework constitutes the scope. The framework is implemented for the Afşin-Elbistan Coal Basin in order to evaluate and compare the surface coal mining plan alternatives by utilizing study-specific sustainability criteria with a specific focus of land degradation.

1.4. Main Contributions

Within the designated scope, the study is intended to contribute to the knowledge in the field of the strategic-level and sector-specific sustainability assessment by;

- Early application of public and stakeholder consultations as a bottom-up approach for determination of the local sustainability criteria;
- Using the sustainability indicators systematically for the assessment of the mining sector plans at the strategic-level,
- Classification of the indicators in order to apply the framework at the strategic- and project-level assessment practices;
- Proposing indicators, which are not given in the literature and which are specifically appropriate for the mining sector and Turkish conditions at the strategic-level.

CHAPTER 2

THE SUSTAINABILITY CONCEPT AND THE MINING SECTOR

Sustainability and mining might be considered as two conflicting subjects due to the non-renewable and depleting nature of the resources that are subject to mining operations. Besides these, the negative impacts of mining operations on local communities and on the environment are other important factors, which contribute to the argument that these two issues are opposing and counterintuitive.

Indeed, there are many facts that support these arguments. For instance, as Kirsch (2009) points out, enormous amounts of land are moved during mining industry operations compared to any other man-made venture. Moreover, Gibson (2006a) states that the limited timeframe of operations based on the orebody characteristics and market fluctuations causes a fast improvement in the local economic and social factors and is often followed by a bust that causes severe environmental, social and economic negative effects at the local level.

Worrall et al. (2009) highlight how the sector stakeholders are also approaching suspiciously to the integration of sustainability into the mining sector compared to other natural resource-exploiting sectors, for instance forestry, fisheries and agriculture. Contributing to these, Hilson and Basu (2003) argue that even if there are numerous studies, frameworks, and approach discussions about the concept of sustainable development in the literature, defining sustainable development in the mining context is highly challenging.

In short, as these previous studies emphasize the conflicting nature of the sustainability and the mining sector, this has been hardly tried towards application by the investing and also decision-making bodies in order to maintain social license to operate (Worrall *et al.*, 2009; Gibson, 2006a). The mining sector and sustainability can better be analyzed by understanding the characteristics of the sustainability and also the mining sector, specifically surface coal mining. In this respect these two are discussed in Section 2.1 and Section 2.2 respectively. Based on these discussions the sustainability concept for the mining sector is discussed in Section 2.3.

2.1. Background Information on the Sustainability Concept

The term of sustainability has its roots in the 1972 UN Conference on the Human Environment in Stockholm as "maintaining earth as place suitable for human life not only now but for future generations" (Ward and Dubos, 1972 cited in Kirsch 2009, p.89). According to Kirsch (2009), the term sustainability has been modified to sustainable development as a result of different studies and international conferences after its first emergence. Kirsh (2009, p.89) highlights the World Conservation Strategy, which was published by International Union for Conservation of Nature in 1980 as the first action to link sustainability to development. So this action is considered as a 'conservation-centered' approach for balancing economic and environmental concerns (Reed, 2002 cited in Kirsch, 2009, p.89).

Even if it was first mentioned in 1980, the term sustainable development has become globally known after Our Common Future Report (Brundtland Report), which was prepared for the World Commission on Environment and Development (WCED) in 1987. As a result of the study and the definition given in this study on sustainable development, the term has become more 'human- and equity-centered' (Reed, 2002 cited in Kirsch, 2009, p.89). Regarding the Brundtland Report, Hilson and Basu (2003) highlight that even the does not provide a solid background for the operationalization of the concept; it manages to create a solid foundation for the approaches like legislation and policy, regulating the man-made actions to avoid conflicting with the concept.

Also, the United Nations Conference on Environment and Development (UNCED) in Rio de Jenerio in 1992 (also known as the Rio Conference or Earth Summit) was the second important action in terms of its agenda and outcomes in the field of sustainability-related actions. The outcomes of the Earth Summit had an important impact on the concept of sustainability as the term sustainable development has become more ‘growth-centered’ (Reed, 2002 cited in Kirsch, 2009, p.89).

During the following years, several other actions, conferences, reports and projects were indicated by different actors. Some examples to these are the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa in 2002 (also known as the Earth Summit 2002), the United Nations Conference on Sustainable Development (also known as the Earth summit 2012, Rio +20).

As a result of above given milestone actions in the field of sustainability and also many other studies, sustainability has been defined in several ways. Regarding this, Bell and Morse (1999 cited in Moles *et al.*., 2008, p.145), define the sustainability as;

> *“a dynamic balance among three mutually interdependent elements:*
>
> - *Protection and enhancement of natural ecosystems and resources;*
> - *Economic productivity; and*
> - *Provision of social infrastructure such as jobs, housing, education, medical care and cultural opportunities”*

2.2. Surface Coal Mining Sector and Its Impacts

Different methods are used in the mining sector due to the different characteristics, i.e. mineralogical, geological, topographical, of these natural resources. These are mainly surface and underground mining methods for extracting the economically valuable and feasible minerals. Surface mining methods are classified into two, which are mechanical and hydraulic methods. Mechanical methods involve open pit mining, strip mining and terrace mining. Hydraulic methods, on the other hand, are placer and solution mining (Doyle, 1976).

The advantages of surface mining over underground mining are mainly given as higher recovery and grade control, economic feasibility in terms of cost-per-unit of production, flexibility of operations, safety in work place and a better working environment (Düzgün and Demirel, 2011; Allsman, 1968; Doyle, 1976). The disadvantages of surface mining over underground mining, in general, are summarized as the disturbance of wide surface areas, the destruction of original vegetation, changes in original topography, issues of land acquisition and resettlement, deforestation and visual deterioration (Dontala *et al*., 2015; Düzgün and Demirel, 2011; Sengupta, 1993; Doyle, 1976).

Environmental impacts, which are caused by the extractive industries, comprise the main issues about the conflict between the mining sector and the public. This is especially true for surface mining operations as their impacts are visible and wider in terms of surface land areas (Chikkatur *et al.*, 2009). The main factors for this might be due to increases in mining excavation capacity with higher capacity equipment.

Such development has impacted the sector operations by allowing the operators to dig deeper economically, to generate more overburden and so to extend the mine operation areas. Regarding this, it is given that the total gross material mass that was moved due to the surface mining operations, including overburden and mass, increased by 48% from 1975 to 2000 (Douglas and Lawson, 2005).

As a result, the significant increase in the excavation capacity of the sector has also led to an increasing visibility of negative impacts of the mining sector. Additionally, another consequence of such an increase in the excavation capacity is that mining operations are getting closer to communities, settlements and also they expand towards economically, socially or ecologically more sensitive areas (Sawyer and Crowl, 1968).

Indeed, besides the negative ones, the mining sector operations have also positive impacts on the society and economies. Most of the time, the positive impacts of the sector are seen at the national level, such as taxes, royalty payments. Furthermore, limited stakeholders at the local level, such as employees and sub-contracting companies, also benefit from the positive outcomes of the sector. Regarding these, the impacts of the mining sector are discussed in detail under environmental, social and economic pillars with a specific focus on surface coal mining operations below.

2.2.1. The Major Environmental Impacts of the Surface Coal Mining

The negative environmental impacts of the surface mining operations are the primary concern of the stakeholders because the visibility of the impacts are high and clear as all the mining activities are conducted on the surface. The environmental impacts are investigated under five dimensions, namely water, land, ecosystem, air and miscellaneous, including noise, vibration and traffic.

2.2.1.1. Water

Mining operations significantly interact with and have an impact on water resources (Chikkatur *et al.*, 2009). The disturbance of both surface and groundwater resources mainly originates from the extraction operations because of an intensive dewatering need for the practice of mining (Hilson and Murck, 2000). The pollution of water resources is mainly caused from the processing activities and/or management of wastes and tailings, though. Water pollution might also be seen after mine closure if it is not practiced properly. Regarding these, the impacts of surface coal mining operations are discussed specifically in terms of surface water disturbance, groundwater disturbance and water pollution.

- **Surface Water Disturbance**

The control of water is one of the main issues for practicing mining operations safely. Moreover, water is used for different purposes in a mining operation. The management practices of the surface waters vary from simple methods like continuous monitoring and controlling without any intervention to changing the original surface water bed (Hilson and Murck, 2000). In this respect, surface mining operations have a direct impact on surface water resources.

- **Groundwater Disturbance**

The drainage of ground water is a very common and most of the time obligatory practice for surface mining operations and it is a must for underground operations. Therefore, groundwater aquifers are negatively affected by both surface and underground mining operations significantly (Chikkatur *et al.*, 2009). In terms of surface mining operations, the alteration of water tables is practiced in order to create safe conditions for mineral extraction (Hilson and Murck, 2000). As a result of the dewatering operations, groundwater resources are disturbed, which may cause a negative integration with other ecosystems entities in and around the mining area.

- **Water Pollution**

Water pollution mainly results from the runoff or discharge of the mining operations, including extraction, processing, tailing, and disposal sites as well as repair and service buildings. Additionally, acid mine drainage is another source of water pollution, which is a result of mining and processing operations during the active mining and after the mine closure periods. So, all these sources of pollution affect both surface and groundwater resources if necessary precautions are not taken (Hilson and Murck, 2000).

2.2.1.2. Land

In addition to water resources, land is the other environmental parameter that is highly distressed due to surface mining operations. This is mainly because surface mining operations, in particular coal and lignite mining operations, require large areas of land primarily for extraction and overburden dumps (Chikkatur *et al.*, 2009). So, this intense land use of surface mining operations may result in the following negative impacts.

- **Land Disturbance**

Even if underground mining operations also cause land disturbance as a result of surface subsidence and the constructed facilities on the surface, surface mining operations cause a comparatively much higher land disturbance in terms of used area. According to Douglas and Lawson (2005, p.68) coal (hard, brown and lignite) excavations caused 47% of the total gross material movements among all the other mineral excavations in 2000. Besides excavations, overburden dumping is also a significant source of land disturbance, which arises from surface mining operations. As a result, the disturbed surface land becomes much larger than the excavated mining site itself. (Azapagic, 2004).

- **Erosion**

The loss of topsoil, which contains the highest concentration of organic matter in soil, creates suitable conditions for erosion. The loss of topsoil generally occurs because of its mixing with waste rock during the removal of overburden, deforestation and the loss of vegetation. All these causes occur intensively during surface mining operations. The above given factors, which occur due to the topsoil loss, trigger the loss of more topsoil, so the negative impact occurs continuously (Hilson and Murck, 2000).

- **Soil Pollution**

The excavation activities performed during mining operations do not cause soil pollution. Nevertheless, soil pollution arises from polluted or waste waters of runoff or leakages from tailing ponds, waste dumps, processing and repair workshops as well as from waste systems of other mining facilities. In addition to this, acid mine drainage occurs during or after mining operations if the necessary precautions are not taken and it causes soil pollution.

2.2.1.3. Air

The impacts of mining operations on the air might arise from the operation itself, including blasting, excavation, transportation, stock piling and crushing, and also from the energy used for different operations in an integrated mining investment, including exploitation and processing. These are discussed in two sub-sections as air quality and pollution and climate change.

- **Air Quality and Pollution**

The main issue about the air quality and pollution is the release of total suspended particles and particulate matter (PM_{10}) from the dust during excavation, transportation, disposal and stock piling of the waste rock and mineral resources within the mining area (Chikkatur *et al.*, 2009; Hilson and Murck, 2000).

- **Climate Change**

Methane (CH_4) is one of the primary greenhouse gases, which is released during the coal mining (Chikkatur *et al.*, 2009). Even if the emitted amount from coal mining is not significant compared to other greenhouse gasses emitted by other industrial activities, it should still be considered as an important negative environmental impact. The main reason for considering such an emission as an important source of negative environmental impact is that CH_4 has a comparative impact on the climate change that is more than 20 times greater than carbon dioxide (CO_2) over a 100-year period (EPA, 2015).

Mining operations are highly energy intensive; either petroleum or electricity is used for the excavation and haulage equipment in the mining sites. Therefore, greenhouse emissions from these or electricity from fossil fuels also have a significant effect on the climate change (Azapagic, 2004). Additionally, besides the exploitation actions, the processing of the runoff mine demands a considerable amount of energy that negatively contributes to the climate change.

2.2.1.4. Ecosystem

The negative impacts of mining operations on local ecosystems are discussed under deforestation and flora and fauna. These issues are important in terms of the environmental quality, because the changes and losses of forestry and the original characteristics of the flora and fauna in a region affect the biodiversity. Therefore, in many cases mining operations causes or significantly contributes to biodiversity loss (Azapagic, 2004).

- **Deforestation**

As it is mentioned in land disturbance section above, the mining sector is an important factor for deforestation in the operation region. Due to the extensive land use, deforestation is much higher for surface mining operations than underground operations. Besides the operation itself, the construction of infrastructure and facilities near the excavation area also cause deforestation.

- **Flora and Fauna**

Change in water resources and natural land structures, as well as deforestation, erosion, pollution of air, water and soil, vibration and noise cause a negative pressure on the flora and fauna around mining operations. Such impacts result in either a complete loss of original flora and fauna or changes from original to adopted forms, which depends on the impact characteristics of mining operations and the level of negative impacts on ecosystems.

2.2.1.5. Miscellaneous

- **Noise and Vibration**

Heavy earth-moving equipment and blasting practices in order to loosen the material cause noise and vibration that can be observed from the surrounding of operational mining areas. Moreover, the transportation of material also causes noise pollution for the surrounding systems (Hilson and Murck, 2000). So, noise and vibration negatively affect the natural environment and also the local population near the area of mining operations depending on frequency and intensity of being exposed.

- **Traffic**

Traffic may occur in rural and even remote areas due to mining activities. Activities such as exploration, material haulage and marketing operations create subsequent traffic load in the operational area. This has two types of negative environmental impacts. This first group is pollution, resulting from vehicles, noise, and the construction of infrastructure. The second issue is safety problems for wild life and local communities.

2.2.2. The Major Social Impacts of the Surface Coal Mining

Similar to environmental impacts, the mining sector also affects local communities in positive and negative social aspects (Badera and Kocoń, 2014). Different from environmental impacts, the majority of the below discussed social impacts are observed during and after mining operations regardless of being underground or surface mining as well as the extracted mineral. In fact, those impacts, given in this section, are discussed with respect to surface coal mining operations. These are investigated under six topics, which are local economy, ownership of the locals, human rights and business ethics, infrastructure, health and safety, and finally culture and customs.

2.2.2.1. Local Economy

In order to contribute to sustainable development, one of the primary concerns of the mining sector should be providing economic benefits and contributing to the well-being of local communities (Eggert, 2000 cited in Hilson and Murck, 2000, p.230, Azapagic, 2004, Badera and Kocoń, 2014, Söderholm and Svahn, 2015). To achieve this, understanding the needs and expectations of local communities on local economic conditions is crucial for the operationalization of sustainability in sectoral decision-making. Therefore, local economic issues are discussed under employment, traditional economic activities and local economic activities in detail.

- **Employment**

In addition to the researches like Hilson and Murck (2000) and Söderholm and Svahn (2015), the main argument of the sector about locally created economic benefits is providing employment to local communities and residents of the host country and region. In fact, it must also be considered that the operations of the mining sector have recently become highly mechanized and the need of manpower is lower compared to mining operations decades ago. While the amount of manpower decreases in the mining sector, the expectation of specific skills and the need for experienced employees in the sector increase. Therefore, the real numbers of employees from the local communities should be considered while discussing the positive or negative impacts of mining operations on the local communities in terms of employment.

Nevertheless, the mining sector also contributes to the development of other sectors, where employment opportunities rise (Söderholm and Svahn, 2015). Some examples of these are service sector, including catering services, transportation and logistics services, small and medium size (SME) workshops, security services, hotels, pubs and similar accommodation- and spare-time activity-related services. In fact, all these are highly dependent on the life span of mining operations.

- **Traditional Economic Activities**

Mineral exploration is shifting towards rural areas in different parts of the globe. This is affecting the locals, who are highly depending on agricultural or other natural resource-dependent economic activities. As a result of the increase in land degradation and the change in land use due to mining operations, traditional economic activities are affected negatively (Yong-feng et al., 2009). This effect forces local communities to leave the local traditional economic activities, including agriculture, livestock breeding, fishing or forestry. Also, these traditional economic activities are mostly based on low technology and they require no educational skills. Therefore, once the land, forests, lakes or other such natural resources, which support the traditional economic activities, are damaged or changed, almost all the local traditional economy is affected negatively. Hence, such situations create conflicts between the locals and investors and decision-making authorities and trade-offs appear.

- **Local Economic Activities**

Changes in and the dependency of local economies on mining operations is another important social impact at the local level. The reason for this is the limited life time of mining operations. Once the mining industry invests in a region, the local economy of the region grows based on the mining operations. As it is given previously, some examples of this are the services sector, such as hotels, restaurants, and pubs, the construction sector, the logistic sector and the real-estate market. However, once mining ends and the mine is closed, these businesses usually start to collapse. Therefore, economic welfare and life quality that is provided by the mining sector is lost (Azapagic, 2004).

Consequently, a heavy dependence on natural resources in local economic activities causes important negative social impacts on local communities after the operations end. Besides dependence on natural resources, the level of income and wealth among the locals and also newcomers changes dramatically compared to traditional local economic activities. Due to the change from traditional to highly commercial and technology-based local economy, the disparities in income increase between mining-dependent and non-mining-related individuals and groups within a region (Kotey and Rolfe, 2014).

2.2.2.2. Ownership

Among others, ownership-related impacts are very important because the owned properties, including land, livestock and houses, are particularly important and valuable belongings of individuals due to not only their economic values but also social and cultural reasons. As an example, Verma (2004 cited in Chikkatur *et al.*, 2009, p.947) discusses the negative impacts resulting from resettlement, the acquisition of land and displacement practices based on the Indian experience as;

- Changes in the family and society structures,
- Crating vulnerable groups, such as women, elders and children,

- Loss of employment and income,
- Decline in economic conditions due to disturbance.

These impacts, all or some, also occur due to surface coal mining operations. That is because, like other industrial and infrastructure development activities that exert an impact on the surface area, surface mining operations use wide areas that must be expropriated and so it must be civil human- and livestock-free for safety reasons. These impacts can be discussed under two subjects, which are resettlement and the acquisition of land.

- **Resettlement**

Resettlement is a major issue for mining operations, because all the mining actions must be implemented where the reserve is located. Therefore, if a reserve is planned and approved to be mined with surface mining operations, whatever is located on the surface of the reserve, either an individual house or a village, has to be displaced. Especially strip mining operations are operated on wide areas, thus in most cases, the use of land area is much higher than open pit operations. An example is given by Chikkatur *et al.* (2009, p.947) as "mining of all minerals has been the second-largest cause of displacement with an estimation of 2.55 million people" in India. For this reason, resettlement is a really important subject for surface mining operations.

- **Acquisition of Land**

As it has been discussed previously, the management and ownership of land is one of the primary issues for the mining sector especially for surface mining operations. Therefore, land acquisitions are practiced in areas where the reserve is located. As a result of this, agricultural areas, forests or other economically and/or ecologically important resources are completely damaged during the active mining period (Yong-feng *et al.*, 2009).

Even if the cost of such an action is compensated by the mining company by making a lump-sum payment to the owners, land acquisition causes significant changes in the life styles and the traditionally practiced professions of the local individuals. As a result of such practices, their only skill and profession, i.e. farming or forestry, is lost. Depending on this, the life quality of the locals is affected negatively sometime after they lose their land as they do not have the necessary skills to manage the lump-sum money in order to establish a new business or qualifications to be employed in other sectors.

2.2.2.3. Human Rights and Business Ethics

Regarding the above given issues, it is clear that the mining sector is highly interacting with the people in the hosting region. Additionally, due to its conflict-generating nature among the benefiting and negatively affected local populations and safety risks, Azapagic (2004) discusses human rights and business ethics-related sustainability issues in connection with the operations of the mining sector under three subjects as decent working conditions, forced, child labor and unfair payment, and bribery and corruption.

- **Decent Working Conditions**

Mining operations are practiced in hostile environments under high safety and health risks. Therefore, providing the necessary individual health and safety equipment and the necessary training to improve the skills of employees and also internalizing the issue within the company and all its operations are important factors. Moreover, providing equal opportunities for the present and future employees regardless of their gender, race and disabilities are important issues considered under the sustainability concept of the sector (Azapagic, 2004).

- **Forced, Child Labor and Unfair Payment**

Another important possible negative impact of the mining sector in terms of human rights and business ethics is forced labor, child labor and unfair payment. It is known that such practices are mainly seen in the underdeveloped countries and practiced especially by small mining companies as these companies are not subject to any kind of auditing, i.e. by finance organizations. Furthermore, the use of force to control over land, the violation of local groups, and the rights of indigenous people are hugely important accusations that the sector faces (Azapagic, 2004).

- **Bribery and Corruption**

The occurrence of bribery and corruption is the third subject related to the negative impacts of the mining sector, considered under the human rights and business ethics. Like the previous two, this impact is also not specifically related to surface coal mining, but it is an issue of all the extractive industry, including mining, oil and gas sectors.

These sectors significantly affect the wealth of the nations in a positive way within a very short time. However, this may also create a potential corrupted environment about the distribution of the obtained wealth from the extractive sector among the stakeholders transparently and equally (Söderholm and Svahn, 2015). In case of bad practices in the wealth distribution, the negative impact appears based on deterioration in the social structure through inequality within the society and also the national economy due to the loss of taxes and royalties, a lack in competition among the investing companies and poor natural resource management and beneficiation (Söderholm and Svahn, 2015).

Therefore, in case of corrupted, anti-democratic and conflicted management and exploitation of natural resources, both the environment and the financial structure of the communities are damaged (Söderholm and Svahn, 2015). Hence, such cases are named as natural resource curse (Gyfason, 2011; Humphreys *et al.*, 2007 cited in Söderholm and Svahn, 2015, p.80).

2.2.2.4. Infrastructure

Dorian and Humphyreys (1994 cited in Hilson and Murck, 2000, p.230) discuss that mining operations can provide a number of economic benefits to the hosting communities such as employment, local service points, financial contribution for infrastructure projects. Such local services and development projects may include several sub-categories as follows;

- Improvement of transportation and physical accessibility
- Higher energy accessibility
- Better educational, health and similar public services' infrastructures
- Information accessibility, such as internet infrastructure.

Some of these improvements about the infrastructure occur since these are directly needed for mining operations located in the remote areas of the world. Such services include the improvement of physical accessibility, such as well-maintained roads, harbors or railways. Like transportation, energy is another must-to-have input for mining operations. This means providing electricity to local communities in remote areas. Also internet and telephone lines are necessary for today's mining camps and management offices. Such information and communication infrastructure is also benefited by the local communities.

Besides these infrastructure services related to mining operations, infrastructure related to public service may also be established or improved in the host communities. This may be aimed towards the improvement of the company's image within the host community in order to gain social license to operate. In fact, in certain cases towns are established as a result of mining operations (Australian Bureau of Statistics, 2013), so the infrastructure, including hospitals and school buildings, is founded to provide better living conditions for the families of mining company employees as well.

2.2.2.5. Health and Safety

Health and safety is the fifth subject considered under the social impacts of the mining sector. Indeed, health and safety of two groups are discussed in detail below. The first group is the employees of mining operations as the sectoral activities are practiced in hostile environments (Azapagic, 2004). The second group is the local communities living in areas close to mining operations.

- **Labor Health and Safety**

Occupational health and safety is a very important issue for the mining sector because the risks posed to employees are above the average when compared to other sectors. Especially underground mining operations suffer from the highest incidence of fatalities and the highest average fatality ratio compared to other sectors. Besides these safety problems, labor health problems are also common due to tough working environments, particularly in underground operations (Azapagic, 2004). Especially when the surface coal mines and underground coal mines are compared, although surface mining operations involve relatively lower risks than underground mining operations, mining operations inherently involve health and safety risks in terms of its laborers.

- **Public Health and Safety Risks**

Public health is another important focus for the investments of the mining sector because environmental impacts of mining operations may also threaten the public health in local communities. For instance, water scarcity, water pollution, air pollution and also soil pollution, erosion and deforestation are factors that may create public health risks (Chikkatur *et al.*, 2009). These may directly affect the health conditions of local communities and also these have a potential to exert serious impacts at regional and national levels if such pollution factors affect the agricultural and livestock products in the mining region. Moreover, unprotected access to active and inactive mining sites may cause safety problems for local people as well as livestock (Azapagic, 2004).

Although HIV/AIDS is a non-occupational illness, it is still a significant risk for both employees and local communities where the mining industry is located in some parts of the world. It is especially a high risk for South Africa (Azapagic, 2004). In fact, the reason why such a risk occurs is indirectly related to the mining sector. Prostitution is common in some resource-rich regions of Africa, where international mining companies and their camps are located. Therefore, this creates a suitable environment for the risk of HIV/AIDS for local people as well as the employees of the mining industry.

2.2.2.6. Culture and Customs

Mining industry is mostly managed by global companies. Besides, the income generated in the sector is clearly higher than many other sectors. Thus, the sector attracts professionals from all over the world. Additionally, due to the new technology and high-capacity equipment, the labor intensity of the sector declines while the individual skills of employees have become essential. As a result of these, the employment in the mining sector has become very competitive. This causes less local employment and a greater tendency towards ‘fly-in, fly-out’ practices to bring workforce from different parts of the world into rural and less developed regions. As a result of such significant change in these regions, considerable disruption in the social life, structure and local customs are observed (Azapagic, 2004, p.646).

2.2.3. The Major Economic Impacts of the Surface Coal Mining

The economic impacts of the mining sector are highly interacting with the negative and positive social impacts, which are discussed previously. Most of these impacts on environment and society are seen at the local level. For instance, mining operations may cause changes in traditional economic activities like agriculture due to land acquisitions, but on the other hand, it contributes to the development of other economic activities in the service sector, i.e. hotels, restaurants, and SMEs, e.g. workshops, catering, logistics, in a specific region that are mostly owned by employees and locals (Kotey and Rolfe, 2014).

In contrast to local economic impacts, national-level economic benefits of the mining sector are generally positive and easier to monitor. These benefits involve export income from international trading of natural resources (metals, coal, construction and industrial minerals etc.), tax payments, royalties and also employment opportunities with social security and thus high income taxes obtained from mining sector employees. However, all these benefits are also directly dependent on the existence of natural resources and the continuation of mining operations, so a heavy dependence on natural resources in the macro level economy of a country creates threats for all stakeholders at the national level in the long term.

As it is seen, the economic impacts discussed above are general for mining sector operations independently of what is extracted and how it is extracted. However, these parameters are very important in terms of local, social and economic impacts, because for instance surface coal mining operations create economic impacts on a wider local area, so its social and environmental negative impacts are also greater. Contrary to social and environmental impacts, most of the positive economic impacts are independent from the operational characteristics.

Additionally, besides the general impacts discussed above, the characteristics of the excavated mineral may cause extra negative and positive impacts. For instance, if the extracted mineral is coal with a low calorific value, it is used for electricity generation within thermal power plants and these facilities are built within a close distance of the mines due to economic reasons.

In such cases, indirect economic benefits of the mining sector at the regional and national level increase as well as its negative local, social and economic impacts. These negative local impacts involve mostly environmental pollution-related ones, such as the reduction of agricultural productivity and the increase of health problems due to air pollution. However, even if such impacts are really important to consider, these are not directly related to surface coal mining operations.

Understanding the impacts of the mining sector is important in order to highlight and focus the main sustainability concerns in the local level and general at the sectoral level. In this respect, the mining sector impacts with a special emphasize on the surface coal mining, are summarized in Table 1.

In Table 1, these impacts are grouped under environmental, social and economic pillars and their impact levels are considered as local, regional/national and also global. The sings, shown in brackets, are used to show if the impact is positive (+), negative (-) and neutral (o). Also, how these impacts possibly affect the focused group is given as direct or indirect with letters (d) and (i), respectively. As an example, if an impact has a direct positive impact at the local level, it is shown as (d) (+), or in case of an indirect negative impact, it is shown as (i) (-). Moreover, as it can be seen in Table 1, the impacts of mining operations are highly effective at the local level than the others.

As it can be seen in Table 1, all the environmental criteria are directly affected from the mining sector negatively at the local level. Besides this, almost all the environmental impacts of mining operations are negatively affected from mining operations directly or indirectly in a negative way.

Regarding the social pillar in Table 1, the direct positive and negative effects occur at the same time at the local level but the majority of these effects do not interact with the society at the regional, national and global levels. Thus, the economic impacts of the sector, most of the issues are observed as positive impacts at the local, regional and national levels.

Table 1. The impacts of the surface coal mining

Sustainability Pillar	Impact Group	Impact	Local	Regional/ National	Global
Environmental	Water	Surface water disturbance	(d) (-)	(i) (-)	(i) (-)
		Groundwater disturbance	(d) (-)	(i) (-)	(i) (-)
		Pollution	(d) (-)	(d) (-)	(i) (-)
	Earth	Land disturbance	(d) (-)	(i) (-)	(o)
		Erosion	(d) (-)	(i) (-)	(i) (-)
		Pollution	(d) (-)	(i) (-)	(i) (-)
	Air	Quality and pollution	(d) (-)	(i) (-)	(i) (-)
		Climate change	(d) (-)	(d) (-)	(d) (-)
	Ecosystem	Deforestation	(d) (-)	(i) (-)	(i) (-)
		Flora and Fauna	(d) (-)	(i) (-)	(i) (-)
	Miscellaneous	Noise and vibration	(d) (-)	(o)	(o)
		Traffic	(d) (-)	(o)	(o)
Social	Local economy	Employment	(d) (+)	(d) (+)	(o)
		Traditional economic activities	(d) (-)	(o)	(o)
		Local economic activities	(d) (-) (+)	(o)	(o)
	Ownership	Resettlement	(d) (-) (+)	(o)	(o)
		Acquisition of land	(d) (-) (+)	(o)	(o)
	Human rights and business ethics	Decent working conditions	(d) (+)	(o)	(o)
		Forced, child labor and unfair payment	(d) (-)	(d) (-)	(o)
		Bribery and corruption	(d) (-)	(d) (-)	(o)

Table 1. (continued)

Sustainability Pillar	Impact Group	Impact	Local	Regional/ National	Global
Social (cont.)	Infrastructure	Transportation and physical accessibility	(d) (-) (+)	(o)	(o)
		Energy accessibility	(d) (-) (+)	(o)	(o)
		Education, health and similar public services	(d) (+)	(o)	(o)
		Information accessibility	(d) (+)	(o)	(o)
	Health and safety	Labor health and safety	(d) (-) (+)	(o)	(o)
		Public health and safety	(d) (-) (+)	(o)	(o)
	Culture and customs	Local culture, traditions, customs	(d) (-) (+)	(o)	(o)
Economic		Employment	(d) (+)	(i) (+)	(o)
		Traditional economic activities	(d) (-)	(i) (-) /(o)	(o)
		Local economic activities	(d) (+)	(i) (+)	(o)
		Taxes	(i) (+)	(d) (+)	(o)
		Royalties	(o)	(d) (+)	(o)
		Incomes and taxes from exports	(o)	(d) (+)	(o)

2.3. Sustainability Concept for the Mining Sector

In order to operationalize the sustainability criteria at the strategic-level decision-making of the mining sector planning and decision-making, the sustainability concept is needed to be understood in terms of the mining sector. However, this is not a simple process because interaction of sustainability and the mining sector is argued by the different researchers. For instance, as Hilson and Basu (2003, p.320) stress, after a considerable amount of literature, a number of frameworks and indicator sets are conducted, defining sustainability within the context of mining is still challenging.

Negri (1999 in Kirsch 2009, p.90) criticizes such attempts saying that such approaches achieve nothing than to disburden the concept from its original reference to ecology. Parallel to this, Kirsch (2009) also stresses that the mining industry uses this transformation to refer primarily to economic variables under the phrase of sustainable development.

Besides these, Kirsch (2009) strongly disagrees and argues that the term ‘sustainable mining’ or the concept of “promoting mining as a form of sustainable development” through different reports, natural and community projects under social responsibility approaches “makes it more difficult for critics of the mining industry to increase recognition of its true social and environmental costs” (Kirsch, 2009, p.92).

However, among others, such as Laurence, 2011, Franks *et al.*, 2010, Hilson, 2000 given in Giurco and Cooper, 2012 and Worrall *et al.*, 2009, Gibson (2006a, p.334-335) highlights the counterintuitive conditions of the mining sector and sustainability while discussing how the mining sector is under pressure to reduce the local negative impacts and risks as well as how the sector is trying to guarantee the local benefits for long terms in order to gain social license to operate, re-build its reputation in regulatory and investment cycles globally (Gibson, 2006a, p.334-335).

Thus, like some other researchers, such as Hilson and Basu (2003), Azapagic (2004) and Laurence (2011), Gibson (2006a) also mentions how the leading actors of the global mining sector as well as regional and international organizations have been working ambitiously on this issue since the late 1990s.

Moreover, besides these studies and projects, key sustainability-related issues as well as the principles are determined by different stakeholders in order to operationalize sustainability in practice. Some of these are defined for a specific country, e.g. Canada (Ford, 2005) and India (the Ministry of Mines, India and ERM India, 2011) and others are discussed for a specific region, such as the European Union (EUROMINES, 2012).

There are also studies, such as Warhurst (2002), Azapagic (2004), and Global Reporting Initiative (GRI, 2011), to evaluate and monitor the sustainability of operations for contributing to operationalize the sustainability in practice that focus on the global companies and operators of the mining sector. Among these, one of the most widely known approaches is GRI (2011), which was initiated by the study of the International Council on Mining and Metals (ICMM).

The ICMM defines these principles globally for its members, the leading global mining companies operating in various regions of the world. In addition, as one of the earliest initiatives for integrating the concept of sustainability into mining sector operations, many other concepts and studies have been interacted with the sustainability principles of the ICMM.

In addition to these principles, the ICMM has initiated an evaluation and follow-up system to understand the operationalization success of the principles into practice. This system is named Global Reporting Initiative (for more information on how these studies interact, please see Appendix A).

In fact, after all these discussions and previous studies given above, no solid answer or definition has been obtained for sustainability in the mining sector yet. This may be due to the focuses of these studies and discussions mentioned above. As Giurco and Cooper (2012) also mention, available studies in the literature focus on different issues at different levels of decision-making. For instance, while some of them merely focus on the local social and environmental impacts, some others focus on pure ecological issues and others on national-level concerns of the decision-making authorities, such as supply security.

In other words, the possible definition for sustainability in the context of the mining sector changes based on the objective of the study and also based on the studying body. For example, ICMM defines the principles fit its members, which are global mining companies operating in several countries. However, as a governmental body, the Indian authorities focus more on the society and decision-making issues in their studies.

For this reason, the proposed framework under this study starts with scoping the sustainability principles in terms of national-level strategic priorities and local-level expectations. Without such a study-specific scope, indicator selection and alternative consideration and compression will not be able to obtain reasonable results in terms of sustainability.

While scoping the sustainability principles under the study, it must be considered that the mining sector is dealing with a limited non-renewable resource mostly in remote and/or environmentally sensitive locations. Hence, once the natural resource depletes, all the social and economic benefits will disappear after the mining sector leaves the region.

In this respect, it is claimed that the mining sector does not provide long-term benefits, especially for local communities, in a sustainable way (Lins and Horwitz, 2007, p.13). The main reason for facing such criticisms is that the bigger the benefits will be, such as the number of local employment created during the operations, the bigger the costs will be after the operation ends in practice. Accordingly, one of the main characteristics considered under sustainability and the mining sector discussions in this study is creating long-lasting social well-being.

However, even though the long-lasting social well-being involves both the obtained economic benefits and living in a healthy environment, such approach is found to be “human-centered” rather than “conservation-centered” as it is discussed clearly in Kirsch’s study (Kirsch 2009, p.89). Furthermore, Kirsch (2009) discusses that the assumptions on achieving sustainability by creating social welfare is not acceptable in terms of sustainability because these approaches shift the term from strong sustainability to weak sustainability.

The term of weak sustainability means very briefly that interchanging the natural capital into manufactured capital and so developed trade-offs during this interchange is named as weak sustainably by Kirsch (2009). Such trade-offs are also mentioned in the mining sector and sustainability discussions. As an example, Kirsch (2009) formulates his criticisms about weak sustainability as "a mining polluting river and causing extensive deforestation may be considered as sustainable if the profits from the project are successfully converted into manufactured capital with an economic value equal or exceeding the value of consumed and destroyed" (Kirsch, 2009, p.90-91). Contrary to this, strong sustainability is considered as "interdependence of human economies and the environment without trading them as interchangeable" (Kirsch, 2009, p.91).

However, it must also be considered that all of the human actions (economies) have consequences on the environment and therefore every time trade-offs appear. For instance, instead of a thermal power plant, obtaining energy from renewable resources, such as small scale hydro plants, may sounds more sustainable. However, if the number of hydro plants increases on a waterway in a specific ecosystem, trade-offs appear and the nature of the comparison of renewable and non-renewable energy investments changes.

Therefore, the main issue is not the occurrence of trade-offs but the lack of understanding and predicting the impacts of the significant negative consequences of these trade-offs based on clear, comparable and assessable information during the decision-making.

Regarding this, the second characteristic, which is considered under the sustainability and the mining sector discussions in this study, is obtaining comparable information on possible trade-offs and their consequences for optimizing the social and economic benefits and environmental costs while planning the action before any conflicting situation and irreversible mistakes and trade-offs appear. While doing this, trade-offs must be clearly defined and the criteria on how to deal with these should be identified. Gibson (2006b, p.175) suggests two approaches to do these;

- Defining the general rules to decide what types of trade-offs may be acceptable and what sorts may not be acceptable;
- Consulting with the stakeholders to discuss if the proposed trade-offs are reasonable.

Last but not the least, if the relation of mining and sustainability is discussed from a cycling/continuity perspective with minimum environmental impact and high economic feasibility, it is considered as an oxymoron by researchers like Horowitz (2006), Rajaram *et al.* (2005 in Laurence, 2011, p.278) and Kirsch (2009). However, this cannot be a fair discussion unless the demand of the minerals may be supplied feasibly and energy-efficiently through recycling and reuse practices. Therefore, the concept should not be considered as a problem of limited time frame and continuity but more like a problem of achieving natural resource efficiency in order to balance costs and benefits.

This may sound a conflicting argument with the first highlighted point, which is creating a long-lasting social well-being. In fact, better natural resource management will help to create permanent local and national social and economic benefits during and after mining operations.

In short, the mining sector may be or may not be sustainable, or it could contribute to sustainable development from the different perspectives of the discussing party. However, discussing and trying to evaluate and compare its plans, programs and projects and their alternatives in terms of sustainability criteria is completely reasonable. In order to do this, the sustainability criteria for comparing the actions of the mining sector can be summarized for this study as;

- creating a long-lasting social well-being,
- obtaining comparable information on possible trade-offs and their consequence, and
- achieving natural resource efficiency for balancing costs and benefits (including the protection of ecosystems and contribute to long-lasting well-being)

2.4. Evaluation of Sustainability in the Mining Sector

The mining sector has significant positive and negative impacts on the environment, society and economy during and after its operations (Giurco and Cooper, 2012; Düzgün and Demirel, 2011; Franks *et al.*, 2010; Zhengfu *et al.*, 2010; Sharma, 2010; Worrall *et al.*, 2009; Bell and Donnelly, 2006). As it is discussed in Section 2.1, some of these impacts affect specific groups, such as mining sector laborers, local communities, indigenous peoples or women in the region where operations are active. Some of the others have impacts at the national and regional levels, such as creating a high welfare for the communities or regional conflicts. Furthermore, some of the impacts even affect the sector itself deeply, for instance, mine incidents, which cause loss of social license for continuing of the operations.

Regarding these impacts, different evaluation systems are developed and practiced. Some these are used to evaluate the impacts of the company and the level of its sustainability, such as Azapagic (2004). The others, e.g. ODPM (2005a), WB (2010) and WB (2013), are used by the decision-making bodies of public and finance sectors in order to see if and how much the proposed action is fulfilling the set rules and regulations.

In order to mitigate, minimize or manage the impacts on the company-specific cases, the mining sector has initiated actions that are generally named as corporate sustainability. Also some of the global mining companies use sustainability assessment frameworks, e.g. Global Reporting Initiative (GRI, 2011), in order to evaluate and monitor the level of achievement after the corporate sustainability actions. Among these, one of the company-specific sustainability assessment frameworks applied in the mining sector is introduced by GRI (GRI, 2011).

Also the World Business Council for Sustainable Development (WBCSD) is another organization which has a similar approach for evaluating the level of sustainability of business in different sectors (Singh *et al.*, 2012). Both of these are the mining sector-specific frameworks in order to contribute to corporate sustainability within the sector.

In addition to these, decision-makers of the public authorities, finance institutions and other related stakeholders use tools for evaluating and analyzing the environmental, social and economic impacts of the proposed actions at different levels in order to mitigate or minimize the negative impacts. Moreover, some of these are used for operationalization and integration of sustainability during the strategic decision-making process. The tools and at which levels of the decision-making process these tools are used are shown in Figure 1.

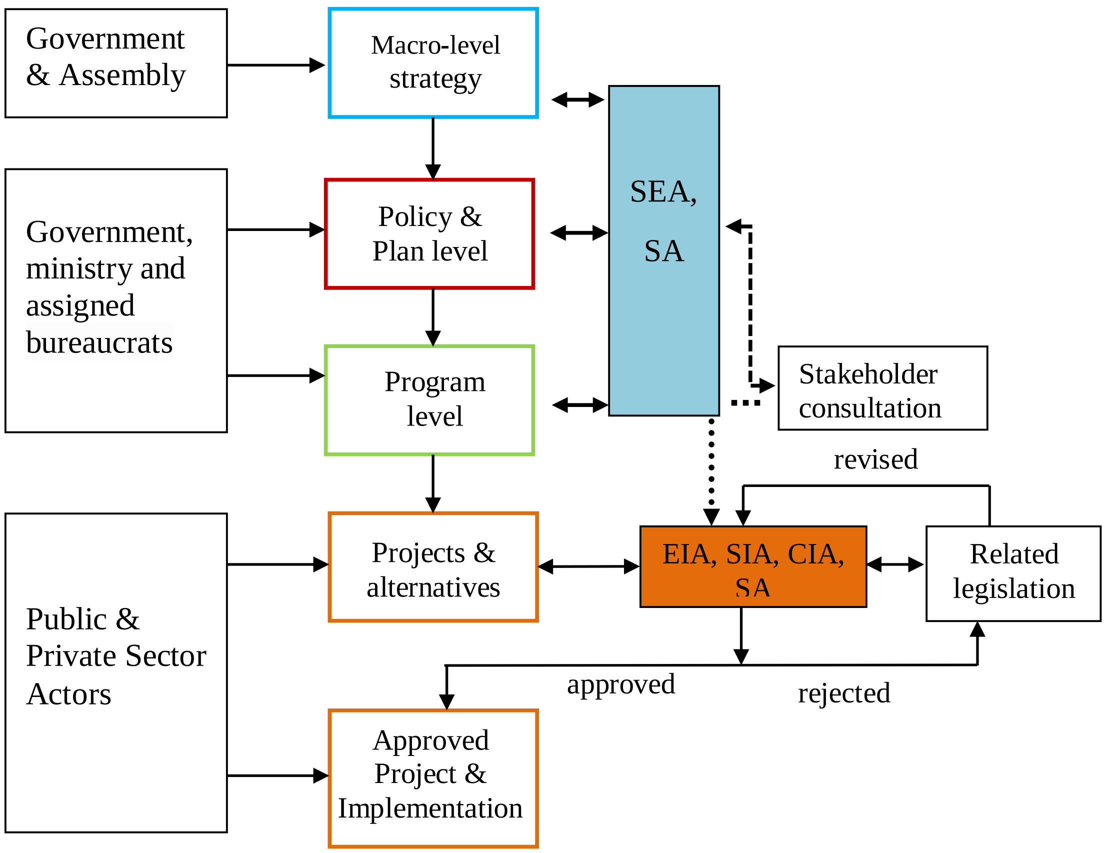

Figure 1. Assessment tools for the different levels of decision-making

Figure 1 shows the tools that are most widely known and used for strategic- and project-level decision-making processes, which are;

- Sustainability Assessment (SA): There is no regulation defining how and when SA should be applied. Even different authorities and stakeholders use different methodologies and frameworks to apply SA. Therefore, as it can be seen in

- Figure 1, SA is shown a tool applicable at both strategic and project levels. The main difference from SEA at the strategic level application is that SA is an integrated tool, where the environmental, social and economic impacts can be analyzed at different spatial levels. The details are discussed in Section 2.4.1.
- Strategic Environmental Assessment (SEA): As it is given in

- Figure 1, SEA is used at the policy-, plan- and program-level assessment. The regulation and targets of these decision levels are generally set by the government, with the approval of the assembly, in cooperation with the related ministries.
- Environmental Impact Assessment (EIA), Social Impact Assessment (SIA) and Cumulative Impact Assessment (CIA): As Morrison-Saunders et al. (2014) also highlight, these are very valuable tools to contribute positively to the specific dimensions of sustainability evaluation. These are used for the project-level evaluation of the impacts and discussing how to manage these for mitigating or minimizing the harm. Some of these are regulated, such as EIA, and others are applied voluntarily in most of the cases.

As it is mentioned above, in order to count a tool under sustainability assessment, it needs to focus at least three dimensions of sustainability, including environmental, social and economic pillars (Morrison-Saunders *et al.*, 2014). However, the level of consideration and integration of these dimensions into the decision-making process differ within SA and SEA. In this respect, as it is discussed in Section 2.3, the consideration of sustainability can be weak or strong within the process. Or the primary consideration can be environmental impacts while social and economic issues are considered to be less important at the decision-making due to the objective of the study. Regarding all these, SEA and SA tools are grouped into four (see Figure 2) as;

- EIA-based environmentally friendly assessment at the strategic level (European Union Directive on SEA, 2001)
- Integrated SEA with an environmental priority while considering the three pillars
- Assessment of sustainability with equal consideration of the three pillars (weak sustainability)
- Assessment of sustainability based on ecological priority (strong sustainability)

As it is shown in Figure 2, the strategic-level assessment tools are ordered from environmentally friendly to sustainable by the author based on their primary focuses. For instance, the ED-SEA is considered as an environmentally friendly approach because its main objective is environmental protection and the consideration of environmental issues during the development of the strategies (EC, 2001). Though the ED-SEA stresses the consideration of the social and economic factors during the assessment, it is expected that the main discussion should be conducted on the possible environmental impacts of the proposed strategic action.

In fact there are case-specific practices aiming to protect the environment and promote sustainability while applying SEA (Thérivel, 2004). In this study, this type of application is called as the integrated SEA. The main reason for this is that besides the environment, the consideration of social and economic issues are needed in order to promote sustainability.

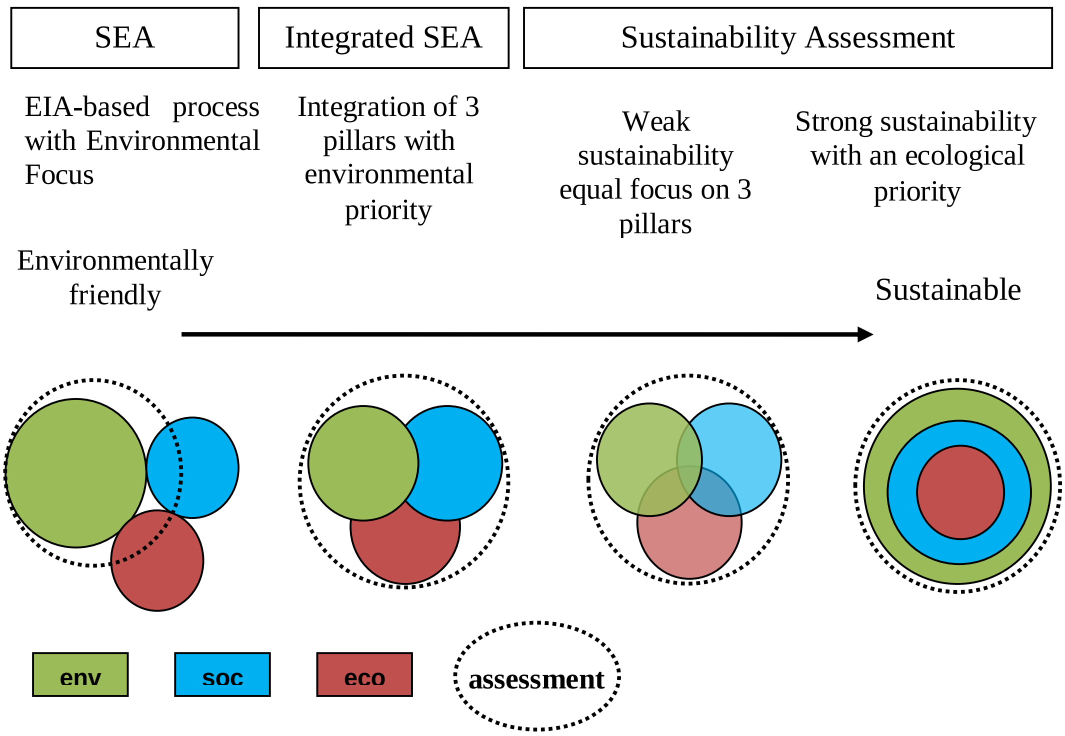

Figure 2. Assessment of sustainability with different scopes and priorities

As it can be seen in Figure 2, after two types of SEA practices, the assessment approach is classified as the sustainability assessment (SA). The main issue for the assessment approaches under SA is that sustainability-focused frameworks are either weak or strong. The differentiation of weak and strong sustainability is given based on the defined priorities of environmental, social and economic pillars during the scoping and assessment steps of SA applications. If the practitioner applies equal priority to three pillars while defining the objective and scope of SA process, it is grouped under weak sustainability. Moreover, if priority is significantly given to the environmental pillar rather than the other pillars, it is counted as a strong sustainability assessment.

2.4.1. Sustainability Assessment (SA)

The consideration and integration of sustainability at the strategic as well as company and product levels are becoming a common practice globally (Gibson, 2006b, Morrison-Saunders *et al.*, 2014). Kates *et al*. (2001 in Musango and Brent, 2011, p. 87) explain the main purpose of SA as providing information to decision-making bodies by evaluating the sustainable development alternatives based on the sustainability criteria at different time periods, decision- and spatial-scales. In this respect several frameworks are developed and used globally (Singh *et al.*, 2012).

These frameworks have different methodologies, including the use of indicators/indices, such as Global Reporting Initiative and Human Development Index and life-cycle processes and rankings, e.g. life cycle assessment and life cycle cost assessments. The detailed discussions about these are given by Ness *et al.* (2007) and Singh *et al.* (2012). Some of these are discussed in the thesis in greater detail than others. Before discussing the details of these methodologies; general information about sustainability assessment is given based on the literature review.

SA is defined in several different ways as it is not build on a regulation like some mandatory tools, such as SEA and EIA. Two definitions of SA are selected from the literature. The first one, given by Morrison-Saunders *et al.* (2014, p.38-39), states that any process directing the decision-making towards sustainability while considering minimum of environmental, social and economic dimensions is called SA. A more comprehensive definition for SA is given by Ness *et al.* (2007, p.499) as the evaluation of integrated nature-society systems, without distinguishing any decision and analysis levels and also time frames in the decision-making in order to determine the acceptable and unacceptable actions for making the society more sustainable.

Even though there have been frameworks and applications starting from the early 2000s, the use of sustainability assessment forms has become more common and the theory and practice of it has also been established considerably since then (Gibson, 2006b; Morrison-Saunders *et al.*, 2014). Some of these frameworks are applied for evaluating the sustainability levels of product and processes, i.e. life-cycle assessment; on the other hand, some others are applied at the regional and municipal planning, like sustainability appraisal in the UK (ODPM, 2005b).

International humanitarian and financial organizations are also initiating such frameworks to monitor country-specific changes of the sustainability level over time, such as the UN Human Development Index and Organization for Economic Cooperation and Development (OECD) indices (UN, 1990 and OECD, 1998 in Singh *et al.* 2012). In addition to these, there are sector-specific frameworks in order to monitor the sustainability achievement levels of companies in a specific sector, for instance mining sector-specific sustainability assessment and evaluation frameworks given by Azapagic (2004), GRI (2011), IIED (2002) and Gibson (2006a).

As a result of early SA practices and their outcomes, better distribution of benefits to reduce the gap between poor and rich and also a significant degradation of natural systems, which started to be visible even to individuals, the popularity of SA is promoted and also increased globally (Gibson 2006b). The details of impacts of the mining sector, how these are interlinked and their possible effects on sustainability issue are discussed in Section 2.2. In this respect, in order to consider these issues while SA is practiced and to succeed in the integration of sustainability criteria into decision-making process in practice, the consideration of the following four major components of sustainability assessment is recommended by Gibson (2006b, p.172).

- The decision-makers of the focused issue must have motivation and intention to launch potentially significant initiatives during the assessment process considering the outcomes. In other words, such a process should not be seen as an advisory contribution.

- The assessment should consider alternatives, options and strategies independently without jeopardizing any of them or shifting towards those seen as favor of decision-makers in order to consider the gains and losses on all fronts. This is also important while defining and considering trade-offs.
- Stakeholder consultation and informing them must be seen as an essential action while specifying the sustainability decision criteria and trade-off rules.
- Sustainability assessment framework must involve the process elements, which are clear definition of purpose, consideration and evaluation of alternatives, choosing (advising) the best available options in terms of different conditions and monitoring the practice in order to achieve continuous improvement.

As it is mentioned previously, SA is not a regulated tool and so the application framework is not defined step-by-step. However, there are principles and must-include components of SA available in the literature. Therefore, either a framework can be developed or selected among the available frameworks by the practitioner body by considering these principles and must-include components.

In order to make the selection/development within a reasonable concept, Morrison-Saunders et al. (2014, p.39) suggest three SA methodologies, which can be used for selecting the best possibly fitting one in terms of the aim of the study. These are;

- EIA-driven methodology for minimizing environmental, social and economic impacts within acceptable limits;
- Objective-led methodology for maximizing positive environmental, social and economic outcomes;
- Assessment of sustainability for determining whether or not a proposal is sustainable.

The first given one, the EIA-driven methodology, is built on traditional project-based environmental impact assessment. Therefore, it primarily aims to minimize the negative impacts or ensure that these impacts will remain within legal or acceptable limits (Morrison-Saunders *et al.*, 2014). This may be applied at project or strategic levels. Pope *et al.* (2004 in Morrison-Saunders *et al.*, 2014, p.39) states that this methodology is fundamentally base-line driven. This means that the comparison is done based on pre-development conditions and limits that can be acceptable. However, even if such an approach is reasonable for environmental and economic pillars, the comparison of social issues based on acceptable limits is not affective because the determination of 'acceptable limits' for social issues are easy and argumentative.

The objective-led methodology is highly associated with SEA methods (Morrison-Saunders *et al.*, 2014). The main reason is that it aims to guide the best strategy for achieving the targeted objective during the planning process (Therivel *et al.*, 2009 in Morrison-Saunders *et al.*, 2014, p.40).

As this model focuses on a specific objective, it has a considerable advantage when compared to the EIA-driven methodology, because a study-specific sustainability criterion should be defined for each time applying the model. Also if the definition of specific criteria is conducted with participation of the stakeholders, the priorities of them can be also considered for further analysis. Therefore, this is an important strength of the model over the previous one (Morrison-Saunders *et al.*, 2014).

The assessment of the sustainability methodology aims to derive the best choice with positive outcomes by testing the proposed alternatives in terms of sufficiency for obtaining the acceptable level of sustainability (Morrison-Saunders *et al.*, 2014). This methodology also aims to define sustainability uniquely based on the needs and expectations of the effected stakeholders. In this respect, it is similar to the objective-led methodology.

However, the difference between the objective-led and the assessment of sustainability methodologies is that the assessment of sustainability takes a holistic view of sustainability. Also it is relevant to the application of the methodology for a particular location and community just to observe how the sustainability changes by changing the conditions without any objective (Morrison-Saunders *et al.*, 2014).

In short, these methodologies can be applied for different purposes with different methods that range from single indicator methods, focusing on a specific part of the system, to holistic methods, focusing on the sustainability of the whole system with comprehensive data sets and analysis (Graymore *et al.*, 2008, p.363).

The methods, used within the three methodologies given above, may be selected based on the related external and objective parameters. The external parameters are those other than the objective- and scope-related criteria, such as the availability of data, available time, financial resources, as well as the availability of experts and human resources.

Contrary to the external parameters, the objective-related parameters are those directly related to the objective and scope of the study, for instance, regional or local analysis, sector-specific analysis, strategic- or project-level analysis, integrated or issue-specific analysis, focusing on three pillars or considering a part of the system, i.e. ecology, human well-being etc.

Regarding these, the method used in this thesis is selected based on the objective-related parameters due to two reasons. The first one is that the thesis specifically aims to integrate sustainability into strategic-level decision-making of a specific sector. Therefore, the objective of the study is more important than any other external parameters, such as the availability of data, available time, and financial resources.

Secondly, the scope is important criteria for selecting the method, based on the objective-related parameters. For instance, the scope of the sustainability concept, involving environmental, social and economic pillars within the thesis, is not determined based on the external criteria. Indeed, the scope of sustainability is determined at the beginning of the thesis in order to achieve the objective fully. For these two reasons, it is decided that the method will be selected based on the objective-related criteria instead of external criteria, which are given above.

In order to do this, first the previous studies on sustainability assessment are determined. Some of the studies, which are considered within this study, include regional sustainability assessment (Graymore *et al.*, 2008), urban residential development (Xu and Coors, 2012), hybrid energy systems (Afgan and Carvalho, 2008), energy technologies (Musango and Brent, 2011; Carrera and Mack, 2010, Maxim, 2014), sustainability assessment in agriculture (Binder *et al.*, 2010; Duarte *et al.*, 2013), waste water treatment systems (Balkema *et al.*, 2002), marine technologies (Basurko and Mesbahi, 2012), and new trade agreements (Lee and

Kirkpatrick, 2004). Other than these, Morrison-Saunders *et al.* (2014) discuss the details of the follow-up of different methods after sustainability assessment.

Besides these, there are also several studies on sustainability assessment applications using or suggesting different frameworks with a specific focus on the mining sector. Some of the application- and case study-based studies are given by Gibson, 2006a; Govindan *et al.*, 2014; Northey *et al.*, 2013; and Hilson, 2012. In addition, there are a few studies suggesting frameworks for implementing sustainability assessment in the mining sector. These studies are Azapagic, 2004; Hilson and Basu, 2003; Hilson and Murck, 2000; Worrall *et al.*, 2009; Si *et al.*, 2010; GRI, 2011; Shen *et al.*, 2013; Erzurumlu and Erzurumlu, 2014, and Marnika *et al.*, 2015.

Ness *et al.* (2007) discuss several frameworks and tools used for practicing the sustainability assessment in detail. Ness and co-authors (2007) group these into three, which are indicator-based frameworks, product-related frameworks and integrated tools. Among these frameworks, more commonly used and flexible ones for the application of different sustainability studies are selected and given in Table 2. The given frameworks are compared based on the characteristics, including coverage, sustainability scope, decision-making and spatial levels and finally data and expertize need levels.

The frameworks in Table 2 have strengths and weaknesses in terms of the objective, scope, decision-making and spatial characteristics and also data, time and expertise needs. Hence, some of these frameworks, e.g. sustainability reporting guidelines and cooperate social responsibility, are more flexible than others. This means that these frameworks can be applicable for different sectors and scopes as well as being less dependent on the availability of the data and expertise.

The third group, given by Ness *et al.* (2007), is integrated assessment tools. This group involves tools like system dynamics, multi-criteria analysis (MCA), risk analysis, cost-benefit analysis and also impact assessments, such as EIA and SEA. Among these, MCA is discussed in Section 2.4.1.1.

Table 2. Indicator-based and product-related sustainability assessment frameworks and characteristics

Criteria / Framework	System component	Whole system	Sustainability			Decision-making level			Spatial Level (national, regional, local)			Data and expertize need	
			Pillar specific	Integrated	Product related	Sectoral	Project-level	Strategic-level	N	R	L	High	Low
Ecological footprint [1-2, a]	✓			✓	✓		✓			✓	✓	✓	
Well-being assessment [1, 2, b]	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓
Quality of life[1,2]	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
Ecosystem health[1]	✓		✓				✓	✓		✓	✓	✓	✓
Natural resource availability[1]	✓		✓				✓	✓		✓	✓	✓	✓
Human Development Index [2, c]	✓		✓	✓				✓	✓			✓	
Sustainability Performance Index [2, d]		✓	✓			✓	✓			✓	✓	✓	
Life Cycle Index[2, e]	✓	✓	✓		✓	✓						✓	
Environmental Sustainability Index[2, f]			✓	✓				✓	✓			✓	
Environment Quality Index [2]	✓	✓	✓				✓	✓				✓	✓

Table 2. (continued)

Criteria / **Framework**	System component	Whole system	Sustainability			Decision-making level			Spatial Level (national, regional, local)			Data and expertize need	
			Pillar specific	Integrated	Product related	Sectoral	Project-level	Strategic-level	N	R	L	High	Low
Environmental Performance Index [2]	✓	✓	✓					✓	✓			✓	
Sustainability Reporting Guidelines [3]		✓		✓		✓	✓				✓	✓	✓
UNCSD's framework [2, g]		✓		✓				✓	✓			✓	
Social Life Cycle Assessment [5]		✓	✓		✓	✓						✓	
Corporate Social Responsibility [6]	✓	✓	✓	✓		✓	✓					✓	✓

Notes: Original works are developed or discussed by (these references are given in Singh *et al.*, 2012, p.287-295)
[a] Wackernagel and Rees, 1996; Chambers and Lewis, 2001
[b] Prescott-Allen, 2001
[c] UN, 1990
[d] Narodoslawsky and Krotscheck, 1994
[e] Khan *et al.*, 2004
[f] WEF, 2002
[g] Labuschagnea *et al.*, 2005

Sources: extended from
[1] Graymore *et al.*, 2008, p.363-367
[2] Singh et al., 2012, p.287-295 and Ness *et al.*, 2007
[3] Global Reporting Initiative, 2013
[4] Balkema *et al.*, 2002, p.155-156
[5] UNEP, 2009
[6] ISO 26000:2010

Ness *et al.* (2007) highlight that integrating the index-based frameworks, given in Table 2, with the integrated assessment methods, such as EIA, SEA and SA, contributes to the integration of sustainability into strategic-level decision-making systematically, because it is explained by Ness *et al.* (2007, p.505) that using the indicators and the integrated assessment methods in the same framework contributes to meeting the factors, such as the spatial coverage, flexibility and integration capability, successfully.

Spatial coverage indicates the capability of using the tools at different levels from project- to country-level applications. For instance, a specific impact can be calculated for a region or at the national level by aggregating the indicators while different integrated assessment tools are well-developed for different levels of decision-making (Ness *et al.*, 2007).

Flexibility is the capability of modification and re-design of the system components, like indicators and indices, based on the need of the decision-makers, such as specific sectoral studies or different scope and focused studies. Integration capability is another important factor used in order to integrate the environmental, social and economic pillars into the analysis and decision-making system successfully (Ness *et al.*, 2007).

For a comprehensive discussion and explanation of indicator and integrated assessment tools, which are used for sustainability assessment, the studies Ness *et al.* (2007) and Singh *et al.* (2012) should be seen. As it is discussed in detail in these two studies, several different methods are used for evaluating and comparing the projects, plans, products and companies in terms of sustainability. The multi-criteria analysis (MCA) is one of these methods and it is used in this thesis for the assessment of mining plan alternatives. Therefore, the reason for selecting it for the assessment of the alternatives and its characteristics are discussed in Section 2.4.1.1.

2.4.1.1. Multi-Criteria Analysis (MCA)

The multi-criteria analysis aims to identify the most preferred option through ranking them and so distinguishing the acceptable option from the unacceptable one (DCLG, 2009, p.19). The MCA is subject to growing interest in decision-making studies and practices. One of the main reasons for this is given by DCLG (2009, p.19) as the need for dealing with the large amounts of complex information in a consistent way during the decision-making process. The Framework Convention on Climate Change (UNFCCC, 2015) of the UN also stresses why the MCA is used often and also considered as a practical tool for decision-making assessments with different parameters. Regarding this, one of the primary reasons of its popularity is its handiness to deal with different subjects with different units through scoring, ranking and weighting approaches.

Another UN organization, Food and Agriculture Organization (FAO, 2015), stresses the benefit of using multiple qualitative and quantitative indicators simultaneously in order to support decision in the field of natural resource management. In this respect the MCA is regarded as a valuable tool at the natural resource management practices, because it generates priority ranking of the focused issues. So this ranking can be used effectively to compare relative performances of the management and decision alternatives based on different objectives and stakeholder preferences (FAO, 2015). Due to these, the MCA is selected for the thesis. A summary of the prominent features of MCA methods are given in Table 3.

Selecting the most suitable one among various MCA methods is an important issue for practicing the MCA. Among several methods, the Multi-criteria decision analysis (MCDA) is used for this study. The MCDA is one of the MCA methods, used by both private and public sector stakeholders.

The reason for selecting the MCDA is that it can be applied at different spatial levels, it is flexible and also it allows the practitioner to consider the pillars of sustainability. Additionally, the following features of the MCDA completely fit into the targeted assessment process in this study.

The main feature of the MCDA is that it orders the alternatives from the most preferred one to the least preferred based on the objectives defined by the practicing body. In fact, none of the alternatives may achieve all the objectives; however, the one fulfilling more objectives than others may be considered as the best option or the best beneficial one (DCLG, 2009).

Table 3. Characteristics of the MCA

Cons	Pros
o The selection of weighting criteria leads to subjectivity issues o The score and weights used may lead to subjectivity issues (if these are not defined in a clear and evidence-based manner) o Trade-offs and conflicts appear among the objectives and alternatives	✓ Good option for dealing with large and complex data ✓ Offering a number of ways of aggregating the data on individual criteria ✓ Objectives, scoring and weighting criteria are selected/defined by decision-makers ✓ Impacts/criteria in different units can be considered ✓ Both qualitative and quantitative information sources (data) can be used ✓ Considerations and comparison of different alternatives, conflicting objectives and stakeholder preferences
Limitations	**Strengths**
o While welfare loss is seen, improvement in welfare cannot be shown o Single MCA approach method cannot be applied for all circumstances o The assessment results should be considered as decision aid, not the 'best possible' option	✓ Use of scores and weights is useful for latter auditing ✓ Useful for internal and external communication and presenting results ✓ It is an open and explicit approach ✓ Numeric values, scoring or color coding can be used for performance assessment ✓ Useful for breaking the complex problems into manageable pieces in order to provide a coherent picture for decision-makers ✓ It is open to easier auditing and external evaluation ✓ Effectively supporting decisions, involving trade-offs among conflicting objectives

Sources: extended from Ness *et al.*, 2007; DCLG, 2009; UNFCCC, 2015; FAO, 2015; Maxim, 2014, Wang *et al.*, 2009

Moreover, the MCDA is applied to see possibly more beneficial alternative(s) among different possible decision alternatives; its outcome helps the decision-making authority to focus on these for detailed analysis cost- and time-effectively. Therefore, the outcome of the analysis should be used and considered as a decision-making aid, not the decision itself (DCLG, 2009). In this way, the obtained MCDA results at the strategic level prevent decision authorities to spent time and financial resources to analyze the 'worst' alternative(s) in detail.

For these reasons, for the mining sector, this means that after eliminating the 'worst' alternative(s) at the strategic level, the preferred projects that are dependent on alternative plans must be analyzed with tools like EIA and SIA to understand the impacts and minimize and mitigate the negative ones. Although this study does not aim to discuss neither the MCA nor the MCDA comprehensively, the steps for applying the MCDA and the details are given below (DCLG, 2009, p.50);

1. Defining the decision context
    1.1. Identifying the aims of the MCDA, decision makers and key players
    1.2. Designing the socio-technical system for conducting the MCDA
    1.3. Considering the context of the assessment
2. Determining the alternatives
3. Determining the objective and evaluation criteria (sustainability criteria in the case of this study)
    3.1. Identifying the criteria for assessment
    3.2. Identifying the priority of the criteria in a hierarchy
4. Assessing each alternative against the criteria (with indicators in this study).
    4.1. Score the options on the criteria (based on the indicators)
    4.2. Check the consistency of the scores on each criterion
5. Determining the weights for each criterion (indicator) to reflect their relative importance to the decision
6. Combining the weights and scores for each option to derive an overall value (Determining weights for each sustainability pillar in order to obtain the sustainability score of each indicator)
    6.1. Calculating overall weighted scores at each level in the hierarchy (calculating the weights of each pillar based on their priority)
    6.2. Calculating the overall weighted scores (of each alternatives)
7. Examining the results (evaluating and reporting the results in this study)

8. Sensitivity analysis

    8.1. Conduct a sensitivity analysis: do other preferences or weights affect the overall ordering of the options?

    8.2. Look at the advantages and disadvantages of the selected options, and compare pairs of options

    8.3. Create possible new options that might be better than those originally considered.

    8.4. Repeat the above steps until a 'requisite' model is obtained.

CHAPTER 3

THE SUSTAINABILITY INDICATORS FOR THE MINING SECTOR

The principal aim of this study is using indicators for evaluating the sustainability levels of plan alternatives in the mining sector. Therefore, among the available indicators, the determination of the best fitting indicators with the objective and scope of the thesis is needed. In fact, as sustainability assessment (SA) can be applicable at different decision-making levels and the thesis focuses on the strategic-level SA, the obtained indicators must be classified in terms of the characteristics of the corporate/project-level and strategic-level assessment.

Regarding these, the chapter involves two sections. The first section, Section 3.1, discusses what an indicator is and the main features of indicators. Section 3.2 presents the global environmental, social and economic indicator sets, which are developed based on the literature review and these are highly related to the mining sector. In addition to this, the section discusses the systematic inventory of the indicators as applicable at project- and strategic-level.

3.1. Definition of Indicator

Before discussing the mining sector, the specific indicators in Section 3.2 and the definition and basic functions of indicators are discussed in this section. An indicator is defined by Pagina (2000 cited in Moles *et al*., 2008, p.154) as;

> *"Indicators are pieces of information which simplify complex phenomena and highlight the trends of system functioning,*

through summarizing or typifying the characteristics of particular system"

Hence, indicators are a useful source of information for understanding, monitoring and evaluating the systems and their interactions with society and/or ecosystems, such as the mining operations and their impacts.

Indicators are practical tools for simplifying and compressing the data as well as obtaining scientifically credible information on measuring complex issues (Haberl *et al.*, 2004 cited in Moles *et al.*, 2008, p.154). Furthermore, three basic functions of indicators are given by OECD (1997 cited in Moles *et al.*, 2008, p.154) as simplification, quantification, and communication.

Simplification is important for analyzing the complex systems and phenomena as well as trends of a system within a time frame. This is also an important function for achieving effective communication among the stakeholders. As simplification is an important aspect of indicators, the indicator sets or indices should also accomplish this. Therefore, the number of indicators in a set or index is also important in order to simplify a complex system as it is aimed (Moles *et al.*, 2008, p.154).

However, the simplification feature should not cause the elimination of indicators more than necessary in order to avoid the exclusion of important information (Moles *et al.*, 2008). Contrary to this, if too many are used, this may cause management problems, including time- and cost-related problems (Graymore *et al.*, 2008). Also, such complicated large indicator sets conflict with the simplification aspect.

In order to obtain and monitor the sustainability level of a plan alternative, compression must be done in a standardized approach. Therefore, the quantification feature of indicators is also highly significant. This is especially important for social indicators since most of the available social indicators given in literature are qualitative. Once the quantification is achieved, the compression of indicators relative to a reference value, i.e. threshold, becomes possible. In this way, what an indicator says about sustainability can be better understood (Castellani and Sala, 2013).

Communication is the third function of indicators to be discussed here and it involves two targeted audiences, which are internal and external stakeholders. As there are many examples, different actors of the mining sector, including governmental bodies, international organizations and companies, investigate sustainability of their actions either for internal auditing and monitoring purposes or external stakeholder communication purpose. And indicators are used for some of these analyses, such as Global Reporting Initiative (GRI) of ICMM (GRI, 2011) and Azapagic (2004). By using such approaches, the sustainability performance of a company or a decision can be possibly communicated with the stakeholders (GRI, 2011).

In this respect, selecting indicators with easily internalized and understandable characteristics is of big importance. Additionally, "indicators must be able to translate both internally-relevant and externally-important sustainability issues into the representative measures of performance" (Azapagic, 2004, p.647). However, this is not an easy task because translating all the sector/company-related issues into sustainability assessment indicators may conflict with the simplification feature, as it was discussed previously.

Besides the above given definition of an indicator and three important features of indicators, indexing indicators under different dimensions are also considered for further discussions in this section. In fact, different terms, i.e. dimensions, principles, themes, domains, capitals, pillars and a number of groups, are used for indexing the indicators in different studies, based on the scopes of the studies. For instance, ecological instead of environmental and also technological and governance dimensions are used by Giurco and Cooper (2012) besides social and economic 'dimensions'.

Another example is taken from Moles *et al.* (2008), in which indicators are grouped under four 'domains', which are environment, quality of life, transport and socio-economic. Worrall *et al. (*2009) have grouped the indicators under three 'principles', which are environmental, socio-political and economic. The fourth and final example is from the study of the United Nations Commission for Sustainable Development that has four core indicator groups, which are economic, social, environmental and institutional (Singh *et al.*, 2012).

As a result of the previous studies, especially those about the mining sector and sustainability assessment, as well as by considering the objective and the scope of the study, three dimensions of sustainability are used in this study. These dimensions are environmental, social and economic. The inventory of the indicators is conducted under these dimensions in Section 3.2.

3.2. Classification of the Mining Sector Related Sustainability Indicators

Using the indicators is proposed for evaluating the strategic alternatives of the mining sector plans in terms of study-specific sustainability criteria and land degradation. Therefore, selection of appropriate indicators is necessary for conducting such an assessment.

In order to select the indicators that are applicable under a specific study, alternative indicators are needed. For this purpose a global indicator set is developed for practicing indicator-based sustainability assessment of the mining sector. The indicators are collected from the mining sector-related sustainability literature, published in scientific journal articles, international and sectoral organizations, such as, the United Nations (UN), the World Bank (WB), the Organization for Economic Cooperation and Development (OECD) and also sectoral organizations, i.e. the Mining Association of Canada, the International Institute for Environment and Development (IIED).

As a result of the literature review, 323 indicators, which are applicable for the mining sector-related sustainability studies, are determined. The collected indicators are grouped under themes and these are listed under environmental, social and economic indicator tables, given in Appendix B. These tables involve 146 environmental, 131 social and 46 economic indicators, respectively.

Even though all the collected indicators are directly related to the mining sector, their application scales and scopes are quite wide. Therefore, these indicators are considered as a global indicator set for the sustainability evaluation of project and strategy alternatives in the mining sector. The global indicator set is a useful directory for conducting indicator-based sustainability assessment studies with different objectives and scopes in the mining sector for different cases.

In this respect, before implementation of the indicator selection step in the developed framework for the strategic-level assessment of the mining sector plans, the indicators are needed to be classified in terms of the characteristics of strategic-level (SL) and project-level (PL) assessments. These characteristics are given in Table 4.

As it is given in Table 4, the PL assessment considers the impacts of specific projects or companies and mitigating the negative ones and enhancing the positive outcomes. Hence, a specific and concrete project with all the details lies at the center of the assessment. However, the SL assessment considers the sustainability criteria and it aims to integrate them into the decision-making process while preparing the strategy. Therefore, in such case, no concrete action has been taken yet. In this respect, very tangible information is available in the PL as all the details of the focused subject are known. For instance, specific health and safety risks or the ratio of employed women and men are assessable in detail at the PL and corporate level.

However, none of such tangible information is available at the SL level because the SL assessment does not aim to evaluate any specific project or organization in a specific area but it aims to understand the pros and cons of proposing a plan and program, which may affect several locations and also environment, society and economy cumulatively.

Moreover, as the scale and alternative consideration criteria are considered in Table 4, PL issues are at the micro level with a specific time frame. Moreover, possible design and location parameters can be comparable. Contrary to this, the SL scale and alternative criteria are uncertain in terms of spatial, technological and time frame characteristics.

As an example, if the SL focuses on energy policy and maximal use of domestic natural resources with the SL is aimed, there are several possible plans developed and these may lead to hundreds of projects. In such a case, the SL cannot evaluate the health and safety risks of all the possible alternatives specifically but it can discuss the limits that must be considered during further studies based on the previous experiences. As a result of considering these criteria, the classification of the indicators in terms of the SL and PL is conducted.

Table 4. Characteristics of project-level and strategic-level assessment

Criteria	Characteristics of	
	Project-Level (PL)	**Strategic-Level (SL)**
Objective	Decision-making with full knowledge of a project's likely significant environmental effects, and that any negative effects are prevented, reduced or offset, while positive effects are enhanced	Decision-making with the integration of environmental considerations into the preparations and adoption of plans and programs with a view of promoting sustainable development
Scope	• What are the main characteristics of the projects? • Where is it located? • What are project alternatives? • What are its main physical, social, economic effects? • What are its major impacts? • What are the mitigation measures?	• What are the objectives of decision-making body? • What are key drivers? • What are strategic options? • What are key restrictions? • What are major interests? • What are the most important policies to be met?
Scale	Considered impacts: Micro scale, mostly local Considered time: medium to short term	Considered impacts: Macro scale, global, national and regional Considered time: long to medium term
Alternative consideration	Specific alternative locations, design, construction, operation	Spatial balance of location, technologies, fiscal measures, economic, social or physical strategies
Tools and techniques	Depends on the specific case and mostly quantified. Examples of tool and techniques: field surveys for data collection, overlay-mapping, life-cycle assessment, cost-benefit analysis, multi-criteria analysis	Quantification of assessment is more difficult due to greater degree uncertainty but quantified approaches also possible. Examples of tool and techniques: forecasting, scenario analysis, multi-criteria analysis, mathematical modelling

Sources: Developed based on RSPB 2013, Thérivel 2004: 6-8; Thérivel and Wood 2005, Yaylacı 2005: 10-11, Partidário 2011, MoEUP 2012

Consequently, global SL indicator sets under the environmental, social and economic pillars are developed and these are given in Table 5, Table 6 and Table 7, respectively. The rest of the indicators in Appendix B, which are not given in the SL tables below, are classified as PL indicators under the environmental, social and economic indicator sets and these are also given in Appendix C. In this respect, the indicators given under the PL tables can be used for sustainability analysis of projects or companies with the developed sustainability assessment framework in this thesis for the future studies.

Table 5. Strategic-level global environmental indicator set

ID	Indicator	Unit	Indicator ID in Appendix B
E1	Percentage of each resource extracted relative to the total amount of the permitted reserves of that resource	%	3
E2	Percentage of the expected solid loss and habitat loss to the current conditions	%	4
E3	Percentage of the expected reduction of the landscape quality	%	5
E4	Total water withdrawal by source	Description	19
E5	Water sources significantly affected by withdrawal of water	Number	23
E6	Decrease in the groundwater level	m3	24
E7	Shortage of water that sustains biodiversity sectors	Description	25
E8	Total land area that needs to be rehabilitated	ha	42
E9	Percentage of the land area rehabilitated relative to the total land area occupied by the closed mines/quarries awaiting rehabilitation - need to be rehabilitated	%	43
E10	The net number of trees planted (after thinning and after subtracting any trees removed for the extraction activities)	Number	46
E11	The number of IUCN Red List species with habitats in areas affected by operations (Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.)	Number	50

Table 5. (continued)

ID	Indicator	Unit	Indicator ID in Appendix B
E12	Percentage of forest damaged by defoliation	%	52
E13	The number and percentage of total site areas identified as requiring biodiversity management	Number & %	58
E14	Habitats protected or restored	Description	59
E15	Loss of high mountain vegetation		60
E16	Loss of wildlife habitat		61
E17	Death and displacement of wildlife		62
E18	Effected area of selected key ecosystems	ha	63
E19	Size of land in/ on protected areas and areas of high biodiversity value outside protected areas	ha	64
E20	Amount of land disturbed or rehabilitated due to mining operations	ha	65
E21	Total area of permitted development (mines and all other facilities)	ha	92
E22	Total land area newly opened for extraction activities	ha	93
E23	Percentage of newly opened land area relative to total permitted development	%	94
E24	Total land area covered by ancient or rain forest that was cleared for extraction activities	ha	95
E25	The number of sites on environmentally protected or sensitive areas, including both current and planned developments	Number	96
E26	Loss of arable land	ha	97
E27	Loss of arable land (due to power station and other infrastructure)	ha	98
E28	Amount of land consumption	ha	99
E29	Area change from greenfield to brownfield	ha	100
E30	Land under erosion risk due to mining operations	ha	102
E31	Land under salinization risk due to mining operations	ha	103
E32	Land under contamination threat due to mining operations	ha	104
E33	Total waste extracted (non-saleable material, including overburden)	Tonnes	105
E34	Total amounts of overburden, rock, tailings, and sludge and their associated risks.	m3 & Description	109
E35	Reduction of landscape value due to infrastructure problems caused by operations	%	128
E36	Cutting the biological wildlife corridor due to mining sector operations	Number	129

Table 6. Strategic-level global social indicator set

ID	Indicator	Unit	# in Appendix B
S1	Percentage of indirect relative to direct jobs	%	3
S2	Net employment creation expressed as percentage contribution to employment in a region or country	%	4
S3	Total number of operations taking place in or adjacent to Indigenous Peoples' territories	Number	51
S4	The number and percentage of operations or sites where there are formal agreements with Indigenous Peoples' communities	Number & %	52
S5	The number of proposed developments that require resettlement of communities	Number	59
S6	Percentage of employees sourced from local communities relative to the total number of employees	%	61
S7	Reduction of basic services for the people (health, education, recreation, etc.)	%	69
S8	The number of households resettled due to proposed developments (Displaced population)	Number	70&78
S9	Population growth rate change before after	%	72
S10	Dependency of women and people aged 18 and older [before and after]	%	73
S11	Change in urban population	%	74
S12	Net migration rate (incomers/outgoing)	%	75
S13	Change in qualified population	%	76
S14	The number of archaeological sites affected from the strategy	Number	77
S15	Percentage of migrated population to different cities in displaced population	%	82
S16	Infrastructure expenditure per capita	monetary unit	83
S17	Change in the number of schools	Description or Number	84
S18	Change in the number of health service points open to public	Description or Nbr	85
S19	Change in the number of public buildings	Description or Number	86
S20	Vehicle accessibility-affected settlements/population	Number	87
S21	Accessibility of information/communication services	Description	88
S22	Recreational area per capita	m2	89
S23	House price to income ratio	%	90
S24	Net income change per capita	%	91
S25	Total new land acquisition	ha	**suggested**

Table 6. (continued)

ID	Indicator	Unit	# in Appendix B
S26	Change in recreational area after mining operations (due to mining operations)	ha	**suggested** [based on #21 and 22]
S27	Percentage of local population thinking of/observing a change in recreational area after mining operations (due to mining operations)	%	**suggested**
S28	Percentage of local population observing/expecting positive change, sourced from current/planned mining operations in their region in terms of social background	%	**suggested**
S29	Percentage of local population considering the mining sector investment as a potentially positive contributor to overcome local problems in terms of employment	%	**suggested**
S30	Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of infrastructure	%	**suggested**
S31	Percentage of local population thinking of/observing the mining sector as a potential source of conflicts at the local level in terms of corruption, social instability	%	**suggested**
S32	Percentage of local population thinking/observing the mining sector as a potential source of conflicts at the local level in terms of environmental issues, including land use and land acquisition	%	**suggested**
S33	Percentage of local population thinking of/observing improvement in information/communication among the mining sector actors and local public	%	**suggested**
S34	Percentage of local population thinking/observing accessibility to information about land management, new mining plans etc. is in place	%	**suggested**
S35	Percentage of local population thinking/observing ways of public consultation/participation are in place	%	**suggested**
S36	Percentage of local population thinking of/observing the mining sector as a potential source of problems at the local level in terms of environmental pollution	%	**suggested**
S37	Percentage of local population thinking/observing the mining sector as a potential source of problems at the local level in terms of health and safety issues	%	**suggested**

Table 7. Strategic-level global economic indicator set

ID	Indicator	Unit	# in Appendix B
Ec1	The amount of sellable product production	tonnes	2
Ec2	Earnings from all sellable products based on today's market price before interest and tax	monetary unit	4
Ec3	Added value to primary resources by further processing to semi-manufactured and manufactured products	monetary unit /tonnes	5
Ec4	Value-added per unit value of extracted reserve	monetary unit/tonnes	6
Ec5	Ratio of lowest wage to national legal minimum	%	13
Ec6	Percentage of revenues that are redistributed to local communities from the relevant areas of operation, relative to the net sales	%	20
Ec7	Investments into community projects (e.g. schools, hospitals, infrastructure) as percentage of net sales	%	21
Ec8	The total sum of all types of taxes and royalties paid/will be paid by extraction of the natural resource	monetary unit/yr	22
Ec9	Direct economic value generated and distributed	monetary unit/yr	27
Ec10	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind, or pro bono engagement.	monetary unit/yr	34
Ec11	Understanding and describing significant indirect economic impacts, including the extent of impacts.	Description	35
Ec12	Tax payment of the mining operations	monetary unit	37
Ec13	Percentage of royalty payments to expected revenues from selling the extractable reserve	%	39
Ec14	Produced goods or services per land input	%	44
Ec15	Total cost of land acquisition	monetary unit	**suggested**
Ec16	Ratio of economic growth in the region before and after the mining sector investment(s)	%	**suggested**
Ec17	Ratio of share of the region's contribution to national GDP before and after the mining sector investment	%	**suggested**
Ec18	Recovery of reserve (ratio of alternative's tonne / estimated tonne)	%	**suggested**
Ec19	Ratio of total tax payments in the region before and after the mining operations	%	**suggested**

Table 7. (continued)

ID	Indicator	Unit	# in Appendix B
Ec20	Ratio of tax payment of the mining operation to total local/traditional economic activities’ tax payment specifically in the mining license area	%	**suggested**
Ec21	The number of families (individuals) need to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations	Number	**suggested**
Ec22	Ratio of the number of local families benefiting from the mining sector directly by employment in the mining company to the number of families benefiting from the traditional economic activities on the mine operational area	%	**suggested**
Ec23	Ratio of the number of families benefiting from the mining sector indirectly by employment in the auxiliary sectors of the mining sector to the number of local families benefiting from the traditional economic activities on the mine operational area	%	**suggested**
Ec24	Ratio of unit land value in the region before and during (after) the mining operations	%	**suggested**
Ec25	Ratio of generated economic value on per unit land before and during (after) the mining operation	%	**suggested**

In addition to the collected indicators from the literature, several indicators are also suggested in this thesis. The suggested indicators are marked as **[suggested]** in Table 5, Table 6 and Table 7. As it can be seen in these, there are 13 indicators under the social pillar and 11 indicators under the economic pillar are suggested for the strategic-level global indicator sets in this thesis.

The first reason for suggesting indicators is considering and covering the missing significant issues in the classified SL sets. These missing significant issues are determined during the literature review on the sustainability and the mining sector and these are given in Chapter 2. By considering the interaction of sustainability and the mining sector during the classification of the indicators, the missing subjects are covered with these suggested indicators.

Moreover, especially the issues suggested with indicators given in the social pillar are highly related to the observed subjects, problems and needs mentioned by the local stakeholders during the face-to-face discussions and focus group meetings in the case study region. The suggested indicators due to the lack in the available indicator lists are given in Table 8.

Table 8. The suggested indicators based on lacking at the strategic-level

ID	Indicator
S25	Total new land acquisition
S27	Percentage of local population thinking/observing a change in recreational area after mining operations (due to mining operations)
S28	Percentage of local population observing/expecting a positive change, sourced from current/planned mining operations in their region in terms of social background
S29	Percentage of local population considering the mining sector investment as a potentially positive contributor to overcome local problems in terms of employment
S30	Percentage of local population considering the mining sector investment as a potentially positive contributor to overcome local problems in terms of infrastructure
S31	Percentage of local population thinking/observing the mining sector as a potential source of conflicts at the local level in terms of corruption, social instability
S32	Percentage of local population thinking/observing the mining sector as a potential source of conflicts at the local level in terms of environmental issues, including land use and land acquisition
S33	Percentage of local population thinking/observing improvement in information/communication among the mining sector actors and local public
S34	Percentage of local population thinking/observing accessibility to information about land management, new mining plans etc. is in place
S35	Percentage of local population think/observe ways of public consultation/participation are in place
Ec15	Total cost of land acquisition
Ec21	The number of families (individuals) needing to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations
Ec24	Ratio of unit land value in the region before and during (after) the mining operations

The second reason for suggesting an indicator is that after the inventory of the indicators as PL and SL, it is observed that the subjects of few indicators, which are classified as PL, are not covered by any of SL-classified indicators, for instance, health- and safety-related issues, added-value related issues and long-terms benefits of the mining sector at the regional and local levels. In order to prevent the lack of these important subjects in the assessment of the mining plan alternatives, the indicators given in Table 9 are suggested in this thesis.

Table 9. The suggested indicators based on the strategic-level assessment needs

ID	Indicator
S26	Change in recreational area after mining operations (due to mining operations)
S36	Percentage of local population thinking/observing the mining sector as a potential source of problems at the local level in terms of environmental pollution
S37	Percentage of local population thinking/observing the mining sector as a potential source of problems at the local level in terms of health and safety issues
Ec16	Ratio of economic growth in the region before and after the mining sector investment(s)
Ec17	Ratio of share of the region's contribution to national GDP before and after the mining sector investment
Ec18	Recovery of reserve (ratio of alternative's tonnes / estimated tonnes)
Ec19	Ratio of total tax payments in the region before and after the mining operations
Ec20	Ratio of tax payment of the mining operation to total local/traditional economic activities' tax payment specifically in the mining license area
Ec22	Ratio of the number of local families benefiting from the mining sector directly by employment in the mining company to the number of families benefiting from the traditional economic activities on the mine operational area
Ec23	Ratio of the number of families benefiting from the mining sector indirectly by employment in the auxiliary sectors of the mining sector to the number of local families benefiting from the traditional economic activities on the mine operational area
Ec25	Ratio of generated economic value on per unit land before and during (after) the mining operation

As a result of adding the suggested indicators, which are discussed above in Table 8 and Table 9, the total number of indicators, under the global indicator sets, increases to 349. The resulting new distribution of the indicators is as follows: 148 environmental indicators, 144 social indicators and 57 economic indicators, including both the strategic-level and also the project-level indicators.

As it is given in Figure 3, the environmental indicator set under the SL includes 36 indicators. The SL under the social indicator set involves 37 indicators, 13 of which is suggested. The third SL includes also 35 indicators under the economic indicator set and 11 of them are suggested in the thesis. The rest of the indicators are grouped under the PL tables, which are also given in Appendix C.

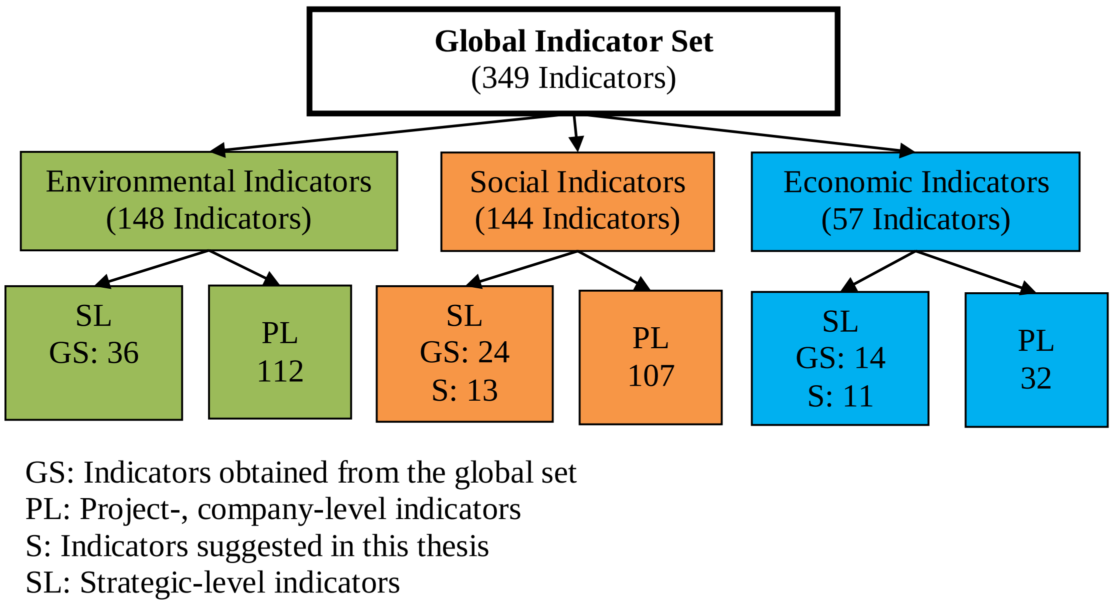

Figure 3. The number of indicators under three sustainability pillars

CHAPTER 4

THE DEVELOPED SUSTAINABILITY ASSESSMENT FRAMEWORK

The primary objective for developing the framework is to integrate the sustainability criteria into the strategic-level decision-making of the mining sector plans. The framework is discussed based on the details of the methodological steps, which are shown in Figure 4. The figure shows the steps of the framework in colors. The steps, given in the orange-colored boxes, are related to the strategy under investigation. The boxes with green color in Figure 4 indicate the sustainability-related steps of the framework. The blue boxes indicate the analysis steps of the developed framework.

The no-color boxes in Figure 4 indicate the screening criteria used in order to conduct the action shown in the colored boxes. These are independent parameters, which mean that they differ from county to country, region to region and company to company. In this respect, the actions, which are given in colored boxes, are directly affected from the independent parameters, shown next to each colored box.

Hence, the practitioner should be aware that she/he should start to apply the steps determined in the colored boxes after identifying the issues in the no-color boxes. Lastly, the lines between the boxes illustrate which action affects the other one. The direction of the arrow and the color indicates the affecting and affected actions. The dash line in Figure 4 means that the screening criteria also affect the action shown in the colored box.

4.1. Objective of the Strategy (Step 1)

The application of the strategic-level impact analysis is expected to be initiated while the development or revision of a policy, plan or any other regulative action at the strategic-level is raised by the decision-making bodies. This is enormously important because strategic-level analysis is considered as the most convenient level for understanding, mitigating and minimizing the negative impacts while increasing the positive ones, especially in the field of natural resource management (Coelho *et al.*, 2006; Forman, 1995; Brunckhorst, 2000 in Graymore *et al.*, 2009, p.454).

In this respect, once such development or revision is initiated, the first step of starting the strategic-level sustainability analysis is defining the objective of the strategy that is under consideration. In this way the direction of the possible developments and impacts of the issue can be identified. Without determining the objective clearly, the implementation of the sustainability assessment will not be effective. The reason for this is that the identification of a clear and sound objective will improve the efficiency of the whole process and will be the primary requirement for obtaining the reasonable SA result.

While determining the objective of the strategy, global and/or country-specific conditions should be considered in order to observe the reason for development or the need for revising the strategy. This is also shown in Figure 4 with a no-color box as an independent parameter in the framework. Regarding this independent parameter, the objective of the study should be determined based on the related legislation, official documents, i.e. white paper, international treaties or higher strategic documents, such as policy documents.

4.2. Scope and Targets of the Strategy (Step2)

The second step of the developed framework is defining the scope of the strategy and targets to be achieved within the scope of the strategy. Once the objective of the strategy is determined considering the global and/or country-specific conditions, the scope of the strategy can be also defined clearly. This is because the scope of the developed or revised strategy is highly shaped by the political stakeholders through policy documents, where the direction of the plans and programs are shaped.

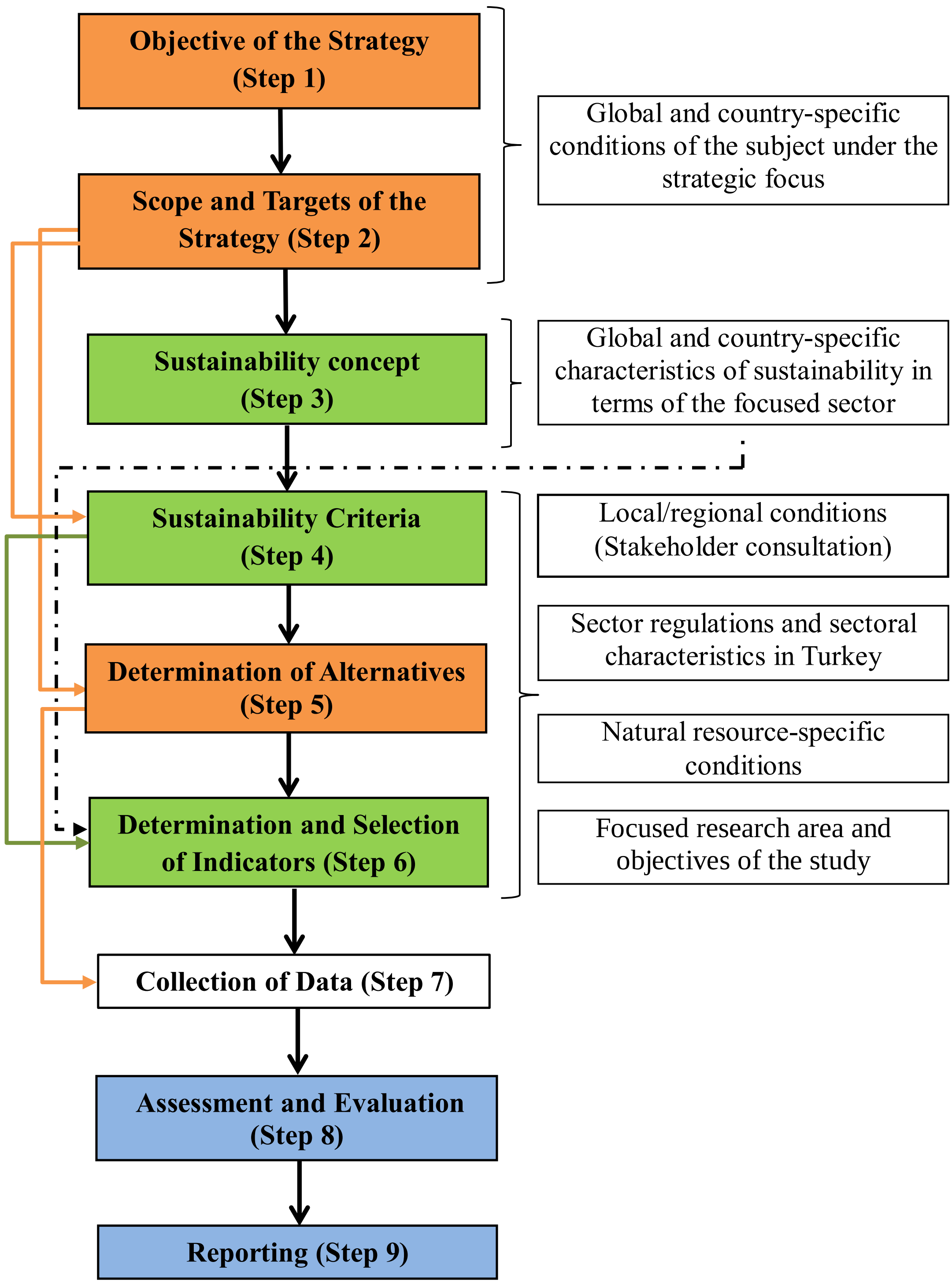

Figure 4. The indicator-based sustainability assessment framework

Once the scope is determined considering the objective of the strategy, the targets are determined or obtained from the strategic documents. The targets are the aimed final destination of the applied actions and the limits of them are generally defined by decision-makers. Increasing the share of energy generation from the domestic primary energy resources from 10% to 15% by 2020 is an example for such targets, which are defined by the decision-making authority. As it is seen, the target involves numbers and also a time frame.

In this respect, the scope and targets of the strategy are affected more from county-specific conditions than global issues. Therefore, it can be said that the determination of the scope and targets of the strategy is conducted by examining the policy while implementing the framework.

4.3. Sustainability Concept (Step 3)

Sustainability, especially the relation of sustainability and the mining sector, is a complicated issue. In case of practicing the developed framework in practice for the mining sector strategic planning, the outcome of the discussion in Chapter 2 can be used. However, if the framework is applied for a different sector, than the sustainability concept must be discussed in terms of the focused sector by following the discussion given in Chapter 2. These are also illustrated in Figure 5.

First of all, the literature-based understanding of the mining sector-related sustainability concept is important. As the sector has highly conflicting characteristics with the concept of sustainability, the literature will help the practitioners understand the main issues about the context of sustainability for a specific study. This study should be conducted in terms of international and country-specific studies and discussions. Based on these studies, global and national sustainability concepts in terms of the sector is determined, as it is shown in Figure 5.

Once the context of sustainability is obtained from the literature, this should be discussed in terms of the scope and the targets of the focused strategy. These steps act like a kind of a screening approach, which helps the practitioner localize and also focus the concept for the studied strategy. At the end of these, the sustainability concept of the SA is obtained.

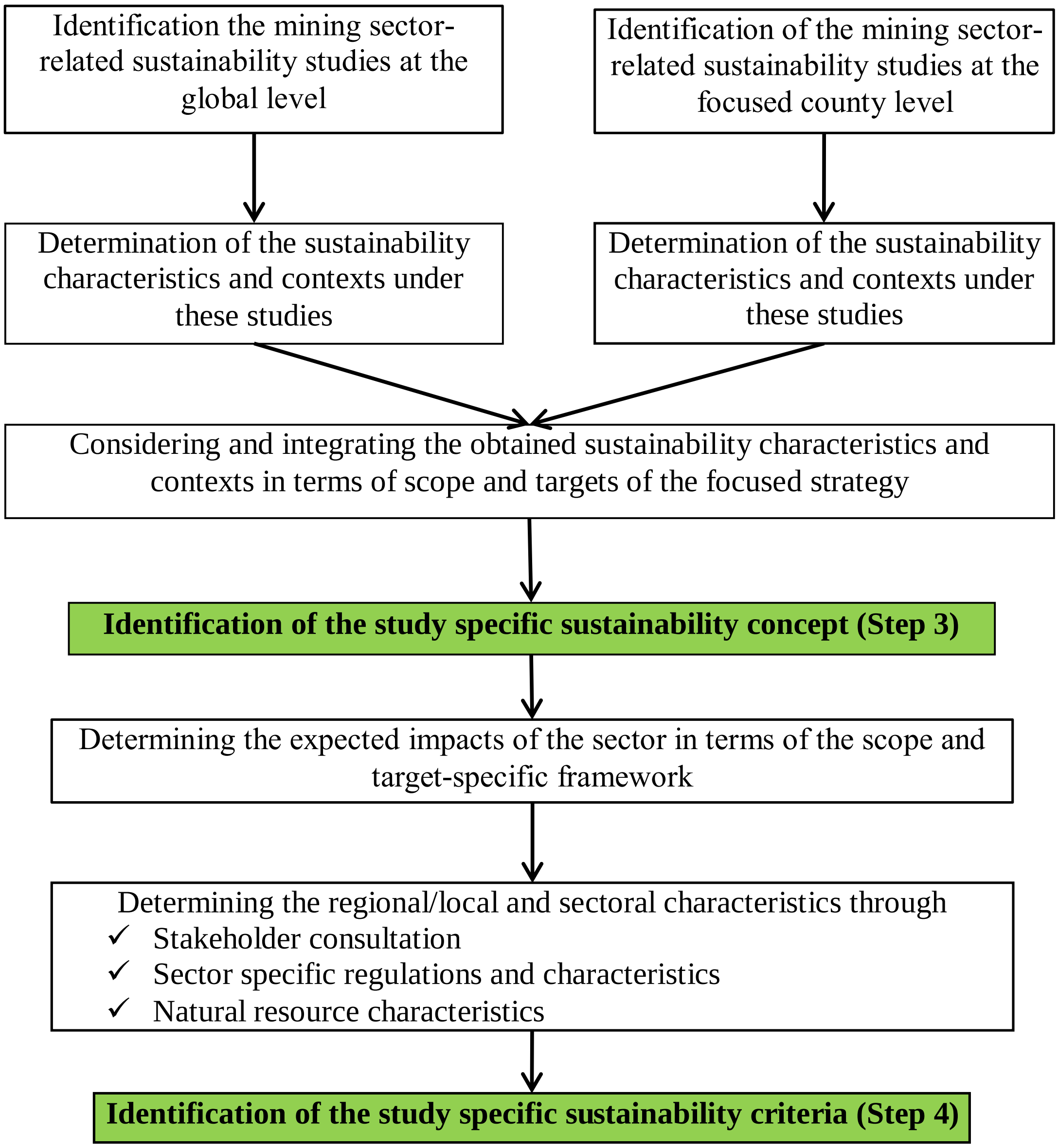

Figure 5. Identification of SA-specific sustainability concept and sustainability criteria

4.4. Sustainability Criteria (Step 4)

The fourth step of the framework is the identification of the sustainability criteria, which is determined specifically for the SA study. As it is shown in Figure 5, the outcome of the sustainability concept is used for identifying the study-specific sustainability criteria. In order to do this, first the expected impacts on the environment, society and economy of the scope and the targets of the strategy should be determined specifically in terms of the studied sector.

Secondly, the characteristics of the mining sector should be determined specifically for the country based on the literature review, previous experiences of the decision-makers and legislations (Wallis *et al*., 2007 in Graymore *et al*., 2009, p.454). Thirdly, region-specific and/or local characteristics, including the environmental, social and economic characteristics, needs and region-specific conditions, should be determined and understood through stakeholder consultations.

The consultation can be practiced via focus group meetings, face-to-face discussions and surveys with local stakeholders and experts. In addition to these, the characteristics of the focused natural resource should also be determined based on the literature review and expert consultations. As a result of these, the sustainability criteria, which should be used to determine the alternatives and select the indicators, are obtained.

4.5. Determination of Alternatives (Step 5)

The fifth step of the proposed framework is the determination of alternatives. The main considerations for identification of the alternatives are;

- The capacity for contributing to achieve targets of the strategy and also meeting the limitations of the scope of the study;
- Fitting into the stakeholder concerns and local and sectoral characteristics, which determine the sustainability criteria;
- Being realistic / reasonable in terms of applicability in practice and evaluation in assessment stages (with available finance, expertise and time).

In any case and condition, the first alternative for any strategy should be a 'no-action' alternative. Like all strategic-level assessment tools, i.e. the SEA, the developed framework also suggests a 'no-action' alternative as the first alternative to be considered. 'No-action' alternative means considering the current conditions as the first alternative and implementing the assessment step for these conditions.

The current situation expresses the environmental, social and economic conditions before the discussed strategy is practiced. Therefore, the 'no-action' alternative does not mean considering the situation before any human-driven action interacts with natural systems. Actually, it means accepting the conditions as they are now for analysis and compare other alternatives with it in order to obtain the sustainability scores of all the alternatives.

Besides the ‘no-action’ alternative, at least one alternative should be determined for comparison. Other than the above given three criteria, the alternatives should be also determined by considering the sectoral characteristic in the county, including the investment environment, regulations, the qualification and capacity of employers, accessibility to financial resources and technology. In addition to these, the characteristics of the natural resource as well as the study-specific objective and scope are significantly important parameters that must be considered while determining the alternatives, as it is shown in Figure 6.

4.6. Determination and Selection of Indicators (Step 6)

The sixth step of the framework is the determination and selection of indicators that are used for the assessment of the plan alternatives. Before discussing the details, it should be stressed that the indicator selection is highly interacting with the steps of alternative selection and sustainability criteria determination, which are shown with the green arrow in Figure 4.

The main reason for this interaction is that the selected indicators must be technically capable of evaluating the selected alternatives in terms of the sustainability criteria. Based on this, the determination of the sustainability indicators, applicable at the strategic-level sustainability assessment of a specific sector, and also the selection of the indicators, used for the evaluation of the alternatives, involves several sub-steps that are shown in Figure 6.

As it can be seen in Figure 6, the indicator selection process is conducted systematically. This is necessary to avoid from the possible problems, such as selecting irrelevant indicators or management difficulties of selecting more than the necessary number of indicators might be faced by the practitioners (Moles *et al.*, 2008; Graymore *et al.*, 2008).

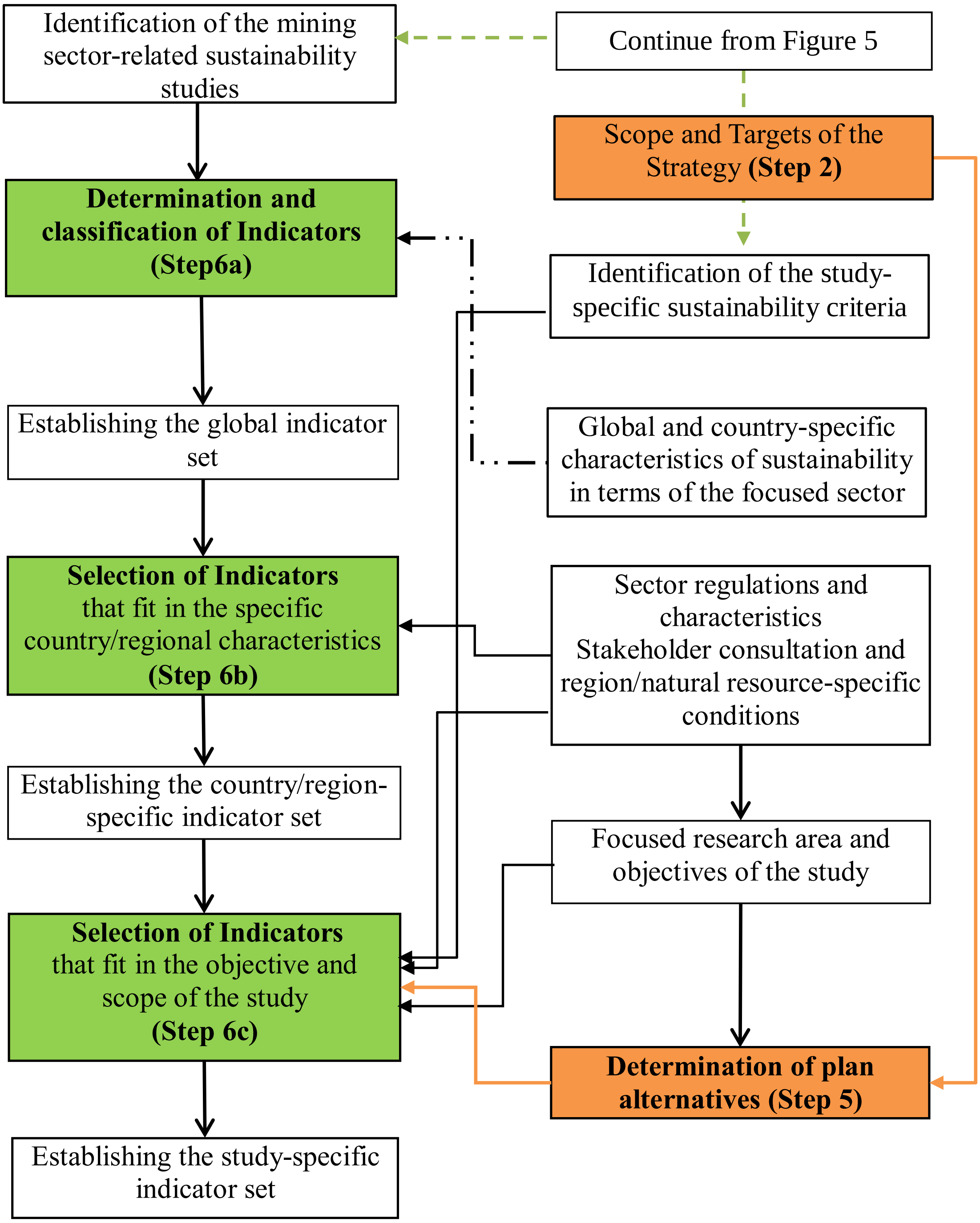

Figure 6. Determination of alternatives and indicators

Additionally, it should be also considered that managing a significant number of indicators at once within the assessment step is difficult, time-consuming and ineffective. This is because the field of use and the objectives of the indicators are different. Therefore, the indicator selection methodology, given in Figure 6, is helpful for the assessment practitioner to consider the selection criteria, which are the objective, the expected outcomes and the characteristics of the assessment, e.g. quantitative, qualitative, and project-level (Horsley *et al.*, 2015).

4.6.1. Determination and Classification of Indicators (Step 6a)

In order to select the indicators that are capable of evaluating the study-specific alternatives, a comprehensive set of indicators is needed. Therefore, the comprehensive indicator set, named as the global indicator set in this thesis, is developed by collecting the indicators from the previous studies, given in the literature. As it is shown with a dash line in Figure 6, global and country-specific sustainability characteristics of the focused sector is also considered while determining the indicators

The collected indicators are grouped under themes within each sustainability pillar, which are given in Appendix B. Once the determination of the focused sector and subject specific indicators are completed, the classification of these indicators is conducted. For the classification, like Wood and Garnett (2010) highlight, indicators are evaluated based on their capacities for covering the plan/program-level or project/company-level, local- or national-level issues.

As a result of such classification, the strategic-level global indicator set for the mining sector is obtained for further selection steps. The global indicator set is used as a pool for selecting the country-, region- and study-specific indicators in the following steps of the framework. These are shown with green boxes in Figure 6.

4.6.2. Selection of Indicators (Step 6b & 6c)

After completing the development of the global indicator set, the selection of the indicators is conducted in two steps. The first step (Step 6b in Figure 6) is the selection of the country- and/or region-specific indicators by considering the focused sectoral conditions, characteristics, regulations as well as the outcomes of the stakeholder consultation. As a result of this, the county/region-specific indicator set is obtained as it is shown in Figure 6.

The next action is the consideration of the study-specific sustainability criteria, the determined alternatives, natural resource-specific conditions and also the objective and scope of the study in order to develop the final study-specific indicator set (Step 6c in Figure 6). Regarding the introductory start about the indicator selection, the details of the indicator selection methodology is discussed below.

Indicator selection is important for obtaining accurate information on the focused aspects of the study (Oudenhoven *et al*., 2012), which are choosing the alternative to achieve efficient natural resource management and minimizing the land degradation-related negative impacts in this study. In addition to obtaining relevant indicators for the scope of the study, the indicator selection process itself is particularly important to prevent possible problems and difficulties arising from loss of information, obtaining a huge set of indicators and data availability problems (Moles, *et al*. 2008).

Indeed, several criteria are given in the literature for selecting the final set of indicators, which will be used for further analysis in this study. For instance, the selection of indicators is conducted based on five criteria for the regional sustainability assessment conducted by Wood and Garnett (2010, p.1878). These criteria are;

- Relevance: Obtaining most suitable indicators for the study subject;
- Coverage: Reflecting capacity of both local and global issues;
- Complementary: Complementing but not replication of the existing literature;
- Comprehensiveness: Focusing on environmental, social and economic pillars;
- Quantification: Having the ability of quantification and data availability.

Another simple approach is given by Castellani and Sala (2013, p.3430). The indicator selection is conducted based on the scope of the study in order to identify the most relevant themes with reference to sustainability concept of the strategic-level planning action. In addition to this, Castellani and Sala (2013, p.3430) also stress that there should be a reference value, i.e. a threshold, for the selected indicators in order to understand what the indicator says about sustainability.

Like Castellani and Sala (2013), Hiremath *et al*. (2013, p.556) also contributes to this discussion with a simple approach as associating the indicator selection with the characteristics of the study area (spatial area). According to Hiremath *et al.* (2013), selected indicators should have the capacity to evaluate spatial characteristics and so differences of actions can be seen.

A more systematic approach is discussed by Mascarenhas *et al.* (2015) based on the data reduction technique to obtain a smaller set of indicators from a global set. The Principle Components Analysis is mentioned as one of these techniques by Mascarenhas *et al.* (2015).

Additionally, scoring-based indicator selection criteria approach is also discussed in the study of Mascarenhas *et al.* (2015). This approach suggests a scoring matrix, where indicators are scored versus the selection criteria defined by the conducting body. In their study, these criteria are defined by Mascarenhas and co-authors (2015) and these are asked to be scored by key stakeholders in order to see the relevance of them for selecting the indicators.

The criteria are divided into two as core and side criteria and three core criteria have obtained high relevance scores from the stakeholders. These criteria are (Mascarenhas *et al.,* 2015, p.305);

- Link to planning goals,
- Relevance,
- Conceptual robustness.

Besides these, five of nine side criteria have also obtained high scores, which are;

- Availability of data and quality of data,
- Demonstration trends,
- Spatial variability,
- Interpretative capacity,
- Clarity.

Other four criteria with low scores are given as;

- Range of covered domains (obtained the lowest score with the following),
- Costs,

- Compatibility with other indicator systems,
- Flexibility.

Oudenhoven *et al.* (2012) also suggest a framework for indicator selection in order to assess the effects of land management and ecosystems services based on The Economics of Ecosystems and Biodiversity approach (TEEB, 2010 in Oudenhoven *et al.*, 2012, p.110). The framework of Oudenhoven *et al.* (2012, p.111-112) involves three selection criteria and related steps that are developed based on a comprehensive literature review. These criteria are;

- Flexible and consistent selection criteria: Indicators should be understandable by different end users and the selected ones must fit in the scope and objectives of the assessment.
- Appropriateness criteria: The selected indicators and also the set of indicators should be relevant to the study subject in terms of the studied subject, quantification and modelling.
- Data availability, credibility and portability criteria: Data is a significantly important issue for the assessment. In other words, higher data availability and appropriate selection of indicators means obtaining higher reliable information. Moreover, it is expected that the selected indicators should be applicable for other studies in different regions.

Juwana *et al.* (2012) discuss the indicator selection as an element of sustainability assessment and so it is mentioned that it is generally conducted based on the literature reviews of previous frameworks and indicator sets. Among these, Liverman *et al.*'s (1988 in Juwana *et al.*, 2012, p.360) approach for selecting the indicators is summarized through seven characteristics, which are;

- Time sensitivity,
- Space and focus group sensitivity,
- Being anticipatory,
- Availability of thresholds or reference values,
- Being unbiased,
- Suitable for data transformation, and
- Being integrative.

Based on these literature reviews, the scoring matrix approach of Mascarenhas *et al.* (2015, p.298) is selected for this study while establishing the sub-indicator sets in Step 6b and Step 6c in Figure 6. The reasons for deciding to use the scoring matrix approach can be summarized with the characteristics of the approach, which are given as;

- Being a systematic approach: As it is mentioned in Section 3.2 and Section 4.2.8, indicator selection is important for obtaining accurate information on the focused aspects of the study (Oudenhoven *et al.*, 2012) as well as for preventing the possible problems and difficulties arising from loss of information, obtaining a huge set of indicators and data availability problems (Moles *et al.*, 2008). Therefore, a systematic approach is considerably helpful and preferred to prevent the above given problems. Hence, the scoring matrix approach highly fulfils this in practice.
- Being easy to apply: Even if it is a systematic approach, the scoring matrix does not need specific expert human resources to apply compared to some other systematic approaches based on data reduction technique, such as the Principle Components Analysis (Mascarenhas *et al.*, 2015, p.296).
- Being free of the characteristics of the study area and the need for a threshold value: These two characteristics are given by Castellani and Sala (2013) and Hiremath *et al.* (2013) based on the approaches they used. In fact, as in most cases of strategic-level (SL) assessment with indicators, obtaining a threshold value for a specific subject, e.g. most of the social indicators, is difficult and even impossible for many of the qualitative indicators. Additionally, consideration of the spatial characteristics of the study area is not possible in some SL assessments as the study is not specifically applied for an area, for instance, SL assessment of a strategy related to energy efficiency. Therefore, using an approach free of these is preferred in the thesis.
- Flexibility in the determination of the selection criteria for scoring: The criteria, which are used as the baseline to understand the fulfilment level of the indicator to the focused issue, can be determined with different approaches, for example through expert judgement, survey with the

stakeholders or by practicing the preferences of the body. Therefore, the scoring matrix allows such practices effectively.

Concerning the reasons discussed above, the use of scoring matrix for indicator selection is decided for this thesis. Like using the scoring matrix for indicator selection, the first selection criteria need to be defined in order to score the indicators against these criteria. For this purpose, the studies Wood and Garnett (2010), Oudenhoven *et al*. (2012), Juwana *et al.* (2012), Castellani and Sala (2013), Hiremath *et al*. (2013), and Mascarenhas *et al.* (2015) are considered for the determination of the selection criteria.

Regarding these, the criteria, used at the scoring matrix for indicator selection, are derived by considering the objective, scope and study level of this thesis. Based on these, the selected criteria for this study are;

- **Scope:** The criterion is mainly used to select the indicators that fit into the scope and targets of the studied strategy and the focused sustainability issues. This is given as 'comprehensiveness' due to focusing on environmental, social and economic pillars by Wood and Garnett (2010, p.1878) and 'linking to planning goals' by Mascarenhas *et al.* (2015, p.305).
- **Relevance:** Wood and Garnett (2010, p.1878) explain relevance criterion as selecting the most suitable indicators for the specific study subject. Also this criterion is given as 'conceptual robustness' by Mascarenhas *et al.* (2015, p.305) and Oudenhoven *et al.* (2012, p.111-112) discuss this as 'appropriateness' in their study.
- **Data availability:** In order to implement the assessment, data need to be accessible. Additionally, data availability is important for obtaining reliable assessment outcomes. This criterion is highlighted by all the studies given above.
- **Quantification:** Almost all of the studies discuss the threshold number or reference values, except Wood and Garnett (2010, p.1878), yet none of them mention quantification capability as a criterion. However, in order to reduce subjectivity during analysis as well as to increase demonstration capability of trends, especially for social issues, higher quantification capacity of an

indicator is helpful. Therefore this is determined as the last indicator selection criterion used in the scoring matrix.

As these criteria are selected, the indicator selection process can be explained with the help of Figure 6. As it is given in the figure, the indicator selection is conducted under two levels, which are;

- Selection of indicators that fit in the characteristics of the specific country/region and are applicable at strategic-level decision-making (Step 6b)
- Selection of indicators that fit in the characteristics of the objective and scope of the study (Step 6c)

For starting the selection process, the indicators in the global set are used. The development of the global indicator set is shown under the determination of indicators step, which is Step 6a in Figure 6, and it is discussed in Section 3.2 in detail. As the indicators, which are specifically useable in the analysis of the mining sector, are obtained based on the literature research in Chapter 3, the further selection for the analysis can be performed using these indicators.

The selection of the country-specific indicators can be practiced as the next step for analysis of the mining sector plans at the strategic-level in Turkey (Step 6b in Figure 6). However, the selection of country-specific indicators, Step 6b, and the selection of objective and scope specific indicators, Step 6c, are conducted simultaneously in this thesis because the total global set involves manageable a number of indicators.

As it can be seen in Figure 6, the objective and targets of the strategic action as well as the characteristics of the country in terms of the focused sector should be considered under the scope criteria. Additionally, stakeholder expectations and localized sustainability criteria in terms of the focused sector is used as the evaluation under the scope criteria in the scoring matrix.

The third step, Step 6c, is applied by considering the study-specific objective and scope of the study (thesis in this case) as well as the characteristics of the plan alternatives and the natural resource. At this step, the relevance, data availability and quantification criteria of the indicators are scored by the expert(s) with the matrix given in Table 10. As a result of these, the final set of the indicators used for the assessment of the plan alternatives is obtained.

Table 10. Indicator selection matrix

Parameter / Indicator	Scope	Relevance	Data availability	Quantification	Score
I_1					
I_2					
I_3					
..					
..					
I_n					

For the scoring matrix, given in Table 10, a three-level scoring is used as low, medium, and high fulfilment of criteria that are scored as 1, 2 and 3, respectively. Score of 0 is given for ‘not applicable’ or ‘no idea’ cases. As a result of scoring each indicator against criteria, indicators obtain a final score which is calculated by adding all the given criteria scores.

Afterwards, the indicators are listed based on their final scores from the highest score to the lowest one. Based on this list, the final indicator set is selected, beginning from the top of the list to the lowest scored one. The total number of the indicators, selected for the sub-set, can be defined by the experts and/or stakeholders. Therefore, no threshold score is given. However, the number of indicators that are selected and used in the assessment is important to prevent loss of information and also eliminate the difficulties of management during the assessment (Moles *et al.*, 2008 and Graymore *et al.*, 2008).

Therefore, for this study the first ten highest scored indicators are recommended to use for the further analysis in each set of the sustainability pillars. The main reason for defining such a limit is obtaining an optimal number of indicators for the assessment. In other words, it is aimed to have an indicator set that can be manageable within a limited time and limited human-resources while preventing excluding important sustainability issues in the assessment step.

For defining this number limit, the suggestion of Bell and Morse (1999 in Moles *et al.*, 2008, p.154) is taken into consideration. They suggest that using 20 indicators in an assessment is reasonable in order to have a manageable number of indicators while preventing having too few, which causes exclusion of the important information, and having too many to face time and data obstacles. A similar suggestion is also given by Gustavson *et al.* (1999 in Graymore *et al.*, 2009, p.454).

In fact, as the assessment is conducted with the indicators under the three pillars in this thesis, the threshold of the selected number of indicators is determined as 10 indicators for each pillar. As a result, it is recommended in this study that maximum 10 indicators per the sustainability pillar indicator set or index can be used for the assessment of the alternatives.

Last but not the least, instead of single expert judgement for scoring the indicators, as it has to be applied in this thesis, in order to obtain the final indicator set, the importance and fulfillment of the indicators with the scoring matrix can be determined by the stakeholders and/or group of experts as it is practiced by Erzurumlu and Erzurumlu (2014) and Mascarenhas *et al.*, (2015) in their studies.

However, such a practice could not be conducted during this thesis due to time limitations. In fact, the local knowledge gained during face-to-face discussions, focus group meetings and the questionnaire survey that are applied in the case study region during this thesis, provides considerable information for practicing reasonable scoring of the indicators in the case study in this thesis. However, it is recommended that the scoring for selection of the indicators should be conducted with more than one expert and even with local stakeholders in the future applications.

4.7. Collection of Data (Step 7)

Data collection should be preceded by considering the scope, scale, selected indicators and alternatives as well as the planned assessment method. In some cases obtaining the needed quality data is problematic. For such cases, as Bell and Morse (2003 cited in Moles *et al.*, 2008, p.147) explain, data might be generated through surveys, filed works and other similar actions in order to avoid the selection of irrelevant indicators for assessment due to data limitations.

Therefore, as it is given as a criterion in the scoring matrix of indicator selection in Section 4.1.6, the accessibility of the data should be considered carefully. This is especially important at the strategic-level assessment because these actions are practiced in a limited time based on the determination of the policy by the political decision-making authority. Therefore, as it is mentioned in the characteristic of the SL assessment in Table 4 in Chapter 3, the alternatives cannot be defined in detail as it is at the project-level. Moreover, the consideration of the scale must be at the macro level as much as possible.

Additionally, depending on the planned assessment methods, the need for detailed data, covering longer periods of time, increases. For instance, if the assessment is planned to be conducted with a model, the needed data is significantly different from conducting the assessment with other methods, such as most of the indicator-based assessment methods, e.g. GRI (2011).

Moreover, the country of the applied assessment should also be considered in terms of accessibility to quality data in a timely manner. For instance, it is experienced during this thesis that the availability and also accessibility of comprehensive data with a reasonable time and scale coverage was significantly problematic. This causes a considerable amount of time loss and increases the need for financial and human resources in order to generate and collect the needed data for the analysis. Therefore, while selecting the indicators, considering the country- and region-specific conditions and also defining the scope of the study is of great importance.

4.8. Assessment and Evaluation (Step 8)

The eighth step of the framework is the assessment and evaluation step. Among different qualitative and quantitative assessment methods, the most suitable alternative should be selected to analyze the plan alternatives. The SA characteristics and components and also different methods and frameworks used for the SA are studied in order to determine the significant issues for the selection of the assessment method. Based on Gibson (2006b); Ness *et al. (*2007); Graymore *et al.* (2008) and Singh *et al.* (2012), the criteria for the selection of the assessment method are determined as;

- Scope of the strategy and sustainability principles;

- Determined plan alternatives;
- Selected indicators;
- Available data;
- Available time,
- Available expertize and human resources
- Available financial resources.

Regarding the above given criteria and also the discussion and compressions about the SA frameworks in Section 2.4.1, two studies, Ness *et al.* (2007) and Singh *et al.* (2012), discuss the different methods in detail. As it can be also seen in Section 2.4.1, some of the discussed methods are fitting better than the others to be applied in the indicator-based assessment frameworks, which are given in Table 2. Among several others, see Ness *et al.* (2007) and Singh *et al.* (2012) for details, the Multi-criteria decision analysis (MCDA) is used for this thesis.

The primary reason for selecting to use the MCDA is its capacity to deal with large amounts of complex information in a consistent way during the decision-making process and to identify the most preferred option by ranking them and distinguishing the acceptable option from the unacceptable (DCLG, 2009, p.19). Additionally, using multiple qualitative and quantitative indicators simultaneously in order to support decision in the field of natural resource management is possible with the MCDA (FAO, 2015). Also MCDA can be applied at different spatial levels, it is flexible and also it allows the practitioner to consider the pillars of sustainability.

Additionally, the MCDA helps the practitioners order the alternatives from the most preferred to the least preferred based on the objectives defined by the practicing body. In fact, none of the alternatives may achieve all the objectives but the one fulfilling the most objectives than others may be considered as the best option or the most beneficial one (DCLG, 2009). Furthermore, the MCDA can be used effectively to rank decision options at the strategic-level and also in the natural resource management field (Graymore *et al.*, 2009, p.455).

Moreover, the developed framework uses indicators and the selected assessment method allows using indicators effectively for evaluating and comparing the plan alternatives. Regarding this, as it is shown in Figure 7, the use of indicators for the assessment of the selected alternatives is possible with two ways. These are;

- Using indicators without developing indices – indicator set-based assessment
- Developing indices by aggregating the indicators – index-based assessment

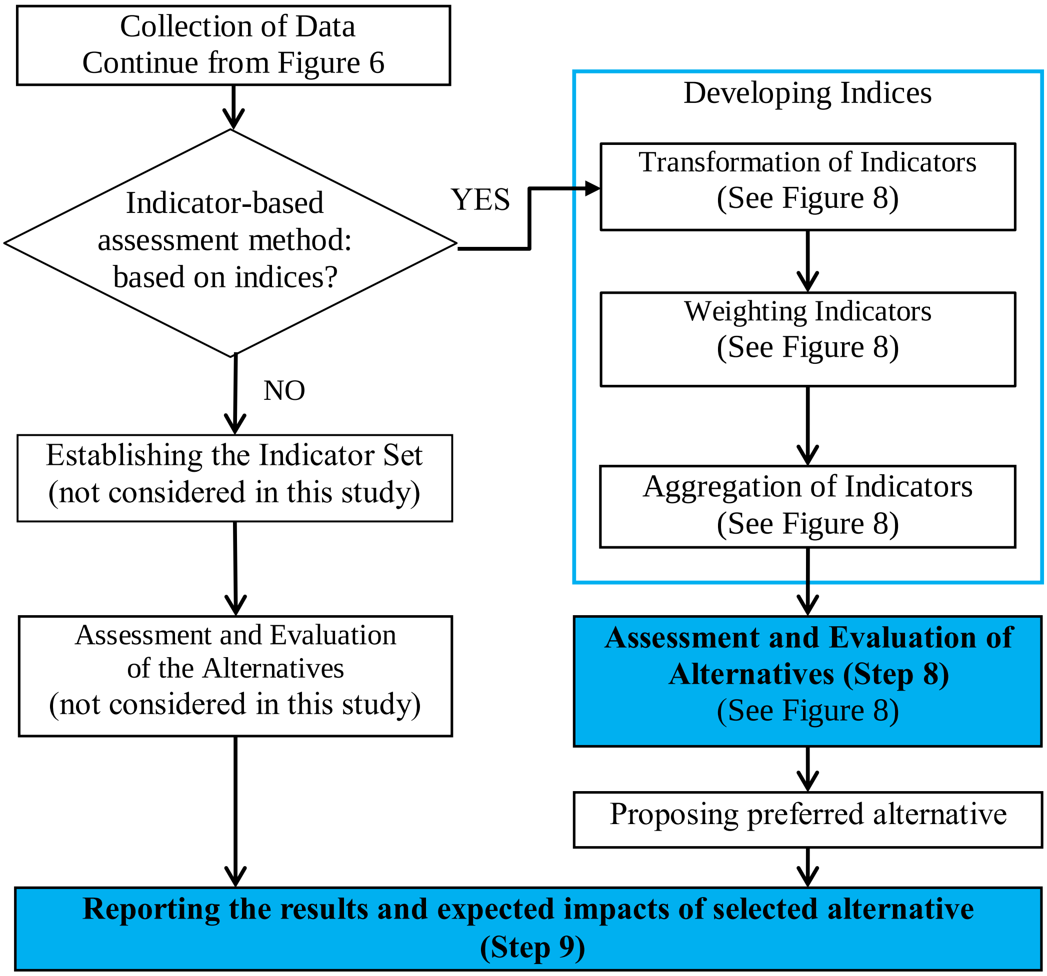

Figure 7. Steps of assessment, evaluation and reporting

The main reason for deciding to use an index instead of an indicator set is mainly due to the differences and characteristics of the indicators under environmental, social and economic pillars. In order to use an indicator set, the used indicators should be either quantitative or qualitative and they should have some unit and scales in the related pillar as well. Otherwise, an index must be developed by following the steps given in Figure 7. Based on the obtained results, the 'best' available alternative is selected and proposed for the implementation with a report (Step 9), where the details of the analysis and evaluation are given. These are shown with blue boxes in Figure 7.

Developing an index and evaluating the selected indicators for obtaining an index score are shown with the blue dash lined box in Figure 8. After obtaining the index scores, these are aggregated to obtain a final sustainability score of the analyzed alternative, which is shown with a pink dash-lined box in Figure 8. Finally, the sustainability scores of the alternatives are evaluated with a threshold value for valuation purpose, which is shown with the purple dash-lined box in Figure 8.

By following these steps, the selected sustainability indicators (SSIs) are evaluated within an index. The SSIs are selected in Step 6 as it can be seen in Figure 4. These SSIs are transformed, evaluated for determining the weights (relative importance) and weighted for obtaining an index score (IS) for each index, as these are shown in Figure 8. Also the relative impotence of each index is determined, and based on the weights of the indices, a Sustainability Index Score (SIS) of each alternative is calculated. After obtaining the SIS of all the alternatives, these are evaluated in terms of a threshold or with each other, as the last action in Figure 8. The details of these are given below.

4.8.1. Aggregation and Index Scoring

In order to obtain an index, which must involve more than one indicator, aggregation of indicators in some manner is necessary (Ness *et al.*, 2007). If aggregation is not applied, the assessment of the alternatives needs to be conducted in an indicator-based manner for each indicator in the set. So the comparison of the alternatives can only be performed separately in terms of the score of each indicator. (Sherbinin *et al.*, 2013, p.6). For instance, the resettlement indicator and the resource recovery indicator are used for scoring the alternatives. However, the obtained score can be compared separately for each of the indicators because the units and scales of the indicator are different. Therefore, obtaining a joint score based on these two indicators is not possible in the indicator set.

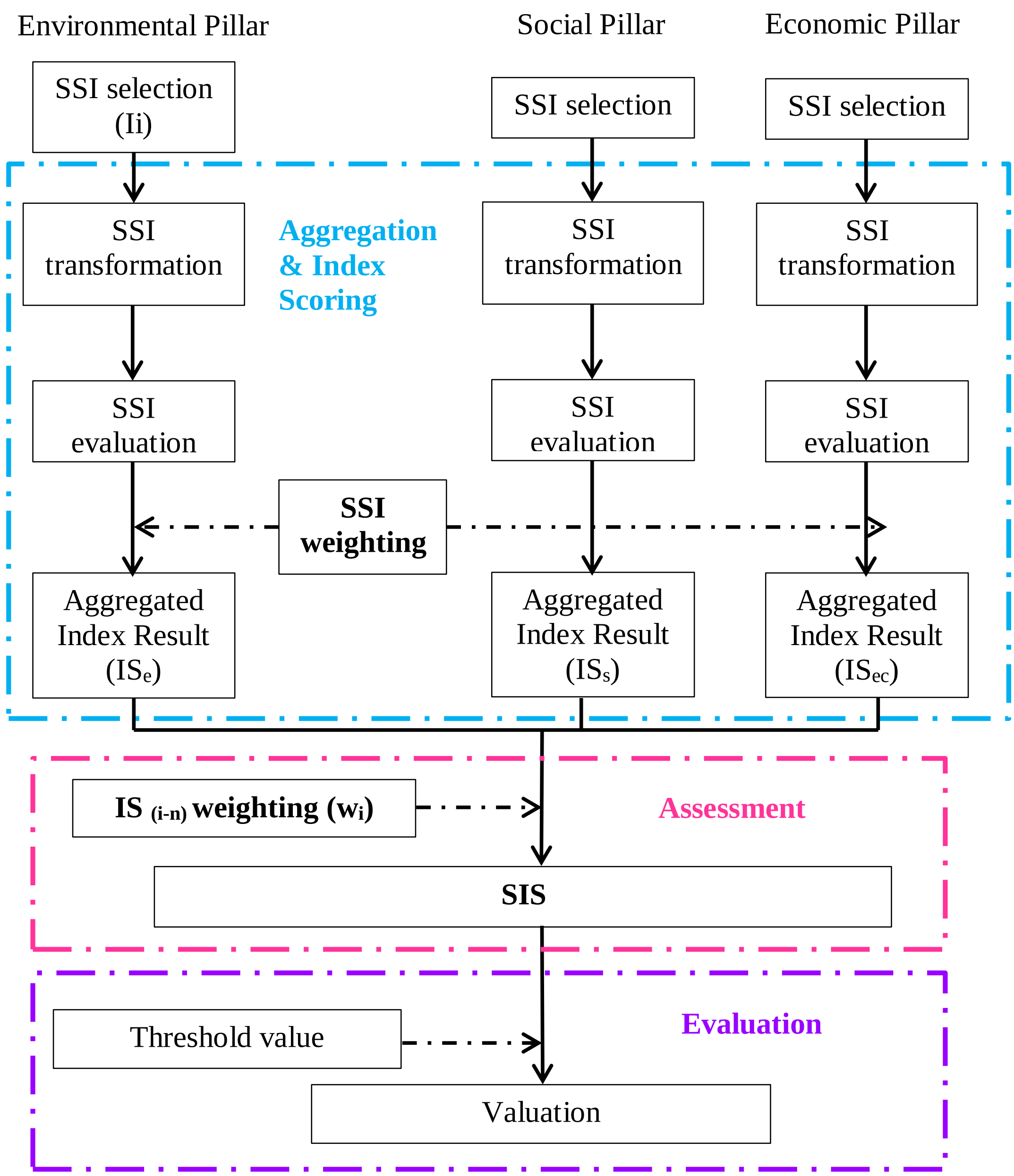

Figure 8. Aggregation, scoring and valuation steps

However, this is not always a negative feature. For example, some studies highlight that "using individual indicators for measuring the impacts is seen more objective and 'scientific' than indices, which try to add 'apples and oranges' based on subjective choices" (OECD, 2002, p.10). Therefore, depending on the target, objectives, scope and other factors, using indicator sets over indices may be preferable.

On the contrary, it should be kept in mind that using indices has also advantages over using indicator sets as working with the indicators, having different units and scales. However, even though the aggregation of the indicators allows the researcher to obtain a single score, it also causes loss of values and information as a result of the aggregation process.

The aggregation of indicators is converting different units of indicators to a common unit or a unitless scale (Sherbinin *et al.*, 2013) in order to obtain a final score for the index. The UN Department of Economic and Social Affairs (UNDESA, 2000 in OECD, 2002, p.15) describes aggregation as "the process adding variables or units with similar properties to come up with a single number that represents the approximate overall value of its individual components."

The comprehensive study by OECD on aggregation methods discusses mainly three aggregation methods (OECD, 2002), which are;

- Spatial aggregation, which is depending on the geographic scale of the indicators. For instance, national indices measuring specific parameters on a specific area is spatial aggregation;
- Temporal aggregation, which is monitoring of parameters over a time, such as hourly and daily measurements, annual averages;
- Thematic aggregation, which is establishing tools based on data for subcategories.

The framework uses thematic aggregation for establishing the environmental, social and economic indices. Several steps, such as selection of indicator, transformation, weighting, valuation, are implemented for aggregating two or more indicators into an index (OECD, 2002; Liu, 2014). For this study these are modified because the indicator selection is conducted under separate steps in this study. Transformation and weighting actions are applied under Step 8.

4.8.1.1. Transformation

This step aims to obtain a comparable dimension for the selected indicators. Indicators can be quantitative and qualitative. Besides, indicators may have different units and scales. Consequently, if such different indicators are selected to develop an index, these must be converted into unitless and same scaled indicators systematically. This may be conducted with two approaches. The first one is normalization and it is given in the equation below (Eq.1). Moreover, standardization is applicable for the transformation of indicators. The equation of the standardization is also given below (Eq. 2).

$$I_{i,\ nor} = \frac{Ii}{Iref} \qquad (1)$$

$$I_{i,\ std} = \frac{Ii - \sigma}{\sigma} \qquad (2)$$

In equation 1 and 2;

$I_{i,\ nor}$: normalized value of an indicator I,

$I_{i,\ std}$: standardized value of an indicator I,

I_i : original indicator value,

I_{ref} : simple average of all the indicators in the same pillar or the regulation threshold,

σ: standard deviation.

4.8.1.2. Weighting

It is deciding on the impact/importance level of an indicator within the index relatively to other indicators in the same index. There are different weighting methods and only two of them are applied in this study. These are equal weighting (EQW) method and analytical-hierarchy process (AHP) method.

Weighting of indicators is a decision given by the practitioner either to give more importance to some indicators than others and the level of this importance or to give equal importance to each indicator during the assessment. Indeed, there is no defined systematic approach or methodology for choosing one of these alternatives.

Maxim (2014, p.287) claims that "the equal weighting is the most popular approach in sustainable energy assessments due to the minimal additional input required to conduct the analysis." However, Liu (2014, p.614) claims that this method does not fit modern assessment methodologies because it cannot reflect different importance of various indicators. The alternative of the equal weighting is the rank-order weighting method and there are three categories, which are subjective, objective and combined (Maxim, 2014). For more details about these methods, study of Wang *et al.* (2009) can be seen.

Like Maxim (2014), Afgan and Carvalho (2008) also use the equal weighting method in their study for assessing the sustainability of energy systems. Additionally, they (Afgan and Carvalho, 2002) also implement the equal weighting method for multi-criteria assessment of power plants in another study.

One of the advantages of using the EQW method is minimizing the subjectivity while weighting the indicators. This is highlighted by Graymore *et al.* (2009, p.455) as weighting cannot be practiced without decision-makers' and stakeholders' value judgements. This causes a problem of subjectivity in weighting of indicators. In order to avoid this, besides the AHP method, the EQW method is also used for this study. The equation of the EQW method is given below (Eq. 3).

$$w_i = \frac{1}{n} \qquad i = 1,2,3, \ldots n \qquad (3)$$

w_i: weight of each SSI

n: total number of SSI

One of the alternative ways for weighting indicators while determining the index score is the AHP method. The AHP method is based on determining relative importance values of the indicators, where the relative preference of each pair-wise comparison is represented by these values (Liu, 2014). So the AHP is not about finding the 'correct' answer but finding the best fitted decision to overcome the defined problem or to achieve the objective in terms of decision-making body's understanding about the problem or criteria.

In order to apply the AHP, the first sub-problems of the studied problem need to be defined within a hierarchical system. These should be analyzed separately. The sub-problems may cover all or some of the specific aspects of the problem, which are highly related to the scope of the study. In fact, there is no limitation for determining the aspects of the sub-problems. The sub-problems may be tangible or intangible, carefully measured or roughly estimated, etc. (Saaty, 2008)

The problem-related criteria (indicators in this thesis) are also determined for evaluating the alternatives' achievement level of the goal or overcoming the problem. Once this hierarchical structure is created, the comparison of a criterion with other two at a time is conducted systematically. In this way, the impact of each criterion on the above problem is determined (Saaty, 2008).

As a result of this, the impact weight of the compared elements is converted into numerical values. Afterwards, the determined numerical impact value of each criterion is used for calculation of the overall value of the subject, one above in the hierarchy.

The compression of indicators is applied with a judgement matrix, which is shown below (Eq. 4).

$$= \begin{matrix} & I_1 \ldots\ldots\ldots\ldots I_n \\ I_1 \ldots\ldots\ldots I_n & \begin{bmatrix} \frac{w1}{w1} & \cdots & \frac{w1}{wn} \\ \vdots & \ddots & \vdots \\ \frac{wn}{w1} & \cdots & \frac{wn}{wn} \end{bmatrix} \end{matrix} \qquad (4)$$

I1,….,n shows each criterion (indicator) of the hierarchy that is compared with the other criterion based on the relative importance among them. The relative importance values (wn) in Eq.4 are used for the comparison of the criteria, and these values are given by Saaty (2008, p. 257) and shown in Table 11.

Once the matrix of the relative importance of the criteria is developed, the eigenvalues of the matrix should be estimated. By obtaining the eigenvalues of the matrix, the weight (or priority) of each criteria and index can be determined (Si *et al.*, 2010, p. 165).

For this, the following equations (Eq. 5 and Eq. 6) are used to solve the eigenvalue problem, which are given by Saaty (2008, p.261-262). In equation 6, "*n* is the principle eigenvalue of A, and one has a nonzero solution *w* and for normalizing its entries by dividing by their sums to make *w* unique" (Saaty, 2008, p.262).

Table 11. Scale for comparison of criterion pairs

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	(intermediate value)
3	Moderate importance	Experience and judgement slightly favor one activity over another
4	Moderate plus	(intermediate value)
5	Strong importance	Experience and judgement strongly favor one activity over another
6	Strong plus	(intermediate value)
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance is demonstrated in practice
8	Very, very strong	(intermediate value)
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
1.1 – 1.9	When activities are very close decimal is added to 1 to show their differences as appropriate	A better alternative way to assigning the small decimals is to compare two close activities with other widely contrasting ones, favoring the larger one a little over the small one when using the 1-9 values
Reciprocals of above	If one criteria (i.e. I_1) has one of the above nonzero numbers assigned to it when compared with the other criteria (i.e. I_n), then I_n has the reciprocal value when compared with I_1	A logical assumption
Measurements From ratio scales		When it is desired to use such numbers in physical applications. Alternatively, often one estimates the ratios of such magnitudes by using judgement

Source: The content of the table is given by Saaty (2008, p.257)
Explanation: All the content is copied from the original text of Saaty (2008) for keeping the clear and detailed explanations for the sake of the thesis.

$$\begin{bmatrix} \frac{w1}{w1} & \cdots & \frac{w1}{wn} \\ \vdots & \ddots & \vdots \\ \frac{wn}{w1} & \cdots & \frac{wn}{wn} \end{bmatrix} \begin{bmatrix} w1 \\ . \\ . \\ . \\ . \\ wn \end{bmatrix} = n \begin{bmatrix} w1 \\ . \\ . \\ . \\ . \\ wn \end{bmatrix} \tag{5}$$

$$\mathrm{A}w = nw \quad \text{or} \quad (\mathrm{A} - n\mathrm{I})\, w = 0 \tag{6}$$

(Eq. 7). As a rule of thumb of the AHP, the developed matrix should have a consistency ratio (CR) lower than 0.1. In order to calculate the CR, the consistency index (CI) and the random index (RI) are used. The calculations of the CI and the CR are given in equations 8 and 9 respectively, where n is the number of criteria.

$$\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)i}{nWi} \tag{7}$$

$$\mathrm{CI} = \frac{\lambda\mathrm{max} - \mathrm{n}}{n-1} \tag{8}$$

$$\mathrm{CR} = \frac{CI}{RI} \tag{9}$$

The RI values, which are used in (Eq.9), are taken from the table given by Saaty (2008), which is shown in Table 12. The calculation of RI values is discussed in detail by Saaty (2008) while discussing the positive reciprocal matrix consistency.

Table 12. Random index values for number of criteria in AHP

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.52	0.37	0.22	0.14	0.10	0.05	0.05	0.04	0.03	0.02	0.02	0.02	0.01

The values in Table 12 are calculated by selecting 17 pairwise comparison values (1/9, 1/8,….,1, 2, ……, 8, 9) randomly from Table 11 and putting these values in a n-by-n reciprocal matrix above and below the diagonal 1 values. After this, those put down the diagonal are used for calculating the consistency index. After repeating this 50,000 times and taking the average, this is called the random index by Saaty (2008, p.264). After practicing this once with simulation and obtaining their first order differences for the matrices of size from 1 to 15, the values in Table 12 are obtained. The details of the RI calculation can be seen in Saaty (2008, p. 263-266).

4.8.2. Assessment

The assessment section, the pink box in Figure 8, is implemented after obtaining the index scores (ISi) of each pillar. By conducting the aggregation steps, each pillar will have a sustainability score. This means that there will be n number of scores if there are n number of pillars. Therefore, the assessment step involves obtaining a single score out of n number of scores by using the equation below (Eq.10).

$$SIS = \sum_{i=1}^{n} ISi \; x \; wi \qquad (10)$$

In equation 10;

SIS: Sustainability index score of the assessed alternative

IS_i: Index score of i^{th} dimension

w_i: weight of i^{th} dimension (pillar) index in SIS

As a result of applying the equation 10 for all the index scores of all the alternatives, a single SIS can be obtained for each alternative. The weight of the pillars can be determined by using several approaches and methods. Like previously discussed, the EQW method and the AHP method are also used at this step in the developed framework.

4.8.3. Evaluation

Once the SIS of each studied alternative is obtained, the comparison and determination of the "best" alternative is conducted. For this, valuation is practiced, as shown in Figure 8. Valuation is comparing the index scores of the alternatives based on the predetermined classification of 'good' and 'bad' values. Therefore, in order to compare the SIS results of each alternative, thresholds or some sort of limit values are needed. However, as SISs are aggregated scores of each alternative based on *n* number of pillars, legislation based on formal limits for these indices are not available. Consequently, this comparison is conducted among the obtained SIS of the alternatives. So as the ultimate objective of all these steps is to select the 'best' option among several alternatives, the alternative with the highest score can be selected as the 'best' option.

In addition to this, for obtaining the sustainability ranking of the alternatives, the weighted sum approach is used for energy sector-related sustainability studies (Wang *et al.*, 2009; Maxim, 2014). Indeed, if the framework is applied for a specific index, for instance environmental index, and if the assessed subject has threshold values based on the legislation etc., these thresholds can be used for valuation purposes. If there is not any legislation about the comparing subject but the proceeding body is willing to do such valuation, Castellani and Sala (2013) suggest a simple methodology. Castellani and Sala's (2013, p.3430) methodology covers the following sources to define such thresholds;

- Using policy and similar official strategic documents and reports;
- Determining objective physical limits (availability of resources, permitted or geographical limits/borders, engineering limitations etc.);
- Determining values coming from literature.

4.9. Reporting (Step 9)

Reporting of the process and the findings is necessary for presenting them to the stakeholders. Additionally, reporting is necessary for monitoring and improvement actions in the future in order to follow-up the success and shortcomings of the process and given decision. Different reporting formats and documents are available for tools like EIA, SEA and also for SA, i.e. GRI. In this respect, there is no format defined for this study. The main reason of giving this step under the framework is discussing the importance of reporting within a strategic-level assessment tool and also making the framework complete so that the developed framework can be applicable for the assessment and evaluation of sustainability of strategies. As one of the most important parts of the report, assessment results and sustainability ranking of plan alternatives should be given. Based on these rankings, the analyses of each alternative and comparison among them should be clearly done in terms of environmental, social and economic pillars. Last but not the least, the sensitivity analysis and the outcomes of the analysis should be given in the report.

CHAPTER 5

IMPLEMENTATION OF THE SUSTAINABILITY ASSESSMENT FRAMEWORK FOR THE AFŞİN-ELBİSTAN COAL BASIN

The developed sustainability framework, discussed in detail in Chapter 4, is implemented with a case study in Chapter 5. In this respect, the chapter focuses on two main subsections. The first one is the introduction of the case study area, which is the Afşin-Elbistan Coal Basin (AECB), and the second one is the step by step implementation of the developed framework for the mining sector plans in AECB.

Before discussing the characteristics of the selected case study region and the implementation of the developed framework for the mining sector strategic planning in AECB, the reason for selecting AECB as the case study area is discussed. In this respect, the main factor for selecting AECB as the case study region is the energy policy of Turkey. From this point of view, the situation of the energy sector is also discussed in the country as the facts of the energy sector affect the energy policy in place.

According to the British Petroleum (BP) and the Statistical Office of the European Communities (EUROSTAT) studies in 2014, given in the Electricity Generation Sector Report of EÜAŞ (EÜAŞ, 2015a), the growing potential and speed of the energy sector is significantly high in Turkey compared to most of the European Union (EU) member countries. Specifically, Turkey is the leading country within the

EU member countries in terms of the increase in the demand for the electricity, coal and natural gas within the last 10 years.

In fact, Turkey is a net importer of fossil energy resources and 73.4% of the total energy demand of the country was supplied from the imported resources in 2013 (EÜAŞ, 2015a). More specifically, the energy from petroleum, natural gas and hard coal was supplied from the imported resources with the shares in the total supply of 93% in petroleum, 99% in natural gas and 94% in hard coal in 2013 (EÜAŞ, 2015a). Additionally, 51.7% of the total natural gas supply was used for electricity generation in Turkey in 2013 (EÜAŞ, 2015a).

On the consumption side of energy, more specifically electricity, the sectoral facts are discussed based on the electricity demand projection report of the Turkish Electricity Transmission Company, owned by the Republic of Turkey (TEİAŞ, 2013). According to this report, the electricity demand in Turkey increased by 9.4% in 2011 and 5.2% in 2012 (TEİAŞ, 2013). The projection for the average change in the annual electricity demand is given as 5.6% in reference (base) scenario, 6.5% in high demand scenario and 4.6% in low demand scenario for the next 10 years based on the studies of the Ministry of Energy and Natural Resources (MoENR) of Turkey (TEİAŞ, 2013). Therefore, because of the high import dependency on the primary energy resources in electricity generation as well as the expected increase in the energy demand for the next 10 years in Turkey, the energy policy of the country is shaped mainly towards securing the energy supply (EÜAŞ, 2015a).

The total installed electricity generation capacity in Turkey is 69,517.4 MW in 2014 and EÜAŞ owns and operates 21,879.1 MW of the total installed capacity in Turkey. Hence, EÜAŞ owns and operates 31.47% of the installed capacity in Turkey at the end of 2014 (EÜAŞ 2015b: 18). Moreover, 8,573.4 MW, that is 12.33% of the total installed capacity is lignite and hard coal burning power plants and 6,062.6 MW, or 8.7% of the total installed capacity is imported hard coal burning power plants in Turkey at the end of 2014 (EÜAŞ 2015b).

In fact, two lignite burning power plants, with the total installed capacity of 2795 MW, are located in AECB. Accordingly, the installed capacity in AECB equals to 4.02% of the total installed capacity of the country and it equals to 32.60% of the total installed capacity in terms of the lignite and domestic hard coal burning power plants in Turkey (EÜAŞ, 2015b). The two power plants, Afşin-Elbistan "A" and "B", have installed capacities of 1355 MW and 1440 MW, respectively (EÜAŞ 2015b).

In terms of the electricity generation by primary resources, 38,355.4 GWh of electricity was generated from lignite and domestic hard coal in 2014, in which the total electricity generation was 249,700.9 GWh. Hence, the share of the lignite and domestic hard coal in the total generated electricity in Turkey was 15.36 % in 2014. The shares of natural gas and Liquefied Natural Gas (LNG), hydraulic resources and imported coal in the generated electricity were 47.93%, 16.16% and 13.96% respectively in 2014. (EÜAŞ 2015b).

As it is mentioned above, the energy policy of Turkey is primarily aimed at securing the energy supply. Therefore, in order to achieve the policy target of the security of energy supply, the energy programs and plans, given in the 10th Five-Year Development Plan (MoD, 2013), target the use of all the available domestic primary energy resources for electricity generation. More specifically, this is stressed in the electricity sector report of EÜAŞ (EÜAŞ, 2015a, p.13) as "use of all the proven lignite and hard coal reserves in electricity generation by 2023".

Regarding the energy policy of Turkey as well as the strategic targets mentioned in EÜAŞ report (EÜAŞ, 2015a), AECB is becoming one of the points of interest as 38% of the total lignite reserve of Turkey is located there. Additionally, the basin hosts two thermal power plants with the total installed capacity of 2,795 MW, which equals to 4% of the total installed capacity of the country. As the total lignite reserve in the basin has not been benefitted completely, the basin is going to become an important alternative for further mining and electricity generation investments in the coming years.

In fact, the 10th Five-Year Development Plan (MoD, 2013: 104) also highlights that the domestic coal reserves should be extracted through private sector investment with clean and environmentally-friendly technologies. Therefore, the policy document also stresses the need for considering sustainability issues by indicating the expectation of environmentally-friendly actions. For this reason, the consideration of sustainability issues is also expected while exploiting domestic primary energy resources, including the lignite reserves. In this respect, the consideration of the sustainability principles while mining the lignite reserves in AECB becomes highly important as well as being a complicated issue due to the following reasons.

First of all, even though it is named as a coal basin, the Afşin-Elbistan basin is an important agricultural plane in Turkey. 53% of the vegetable production of the Kahramanmaraş Province is conducted in the basin (EMDA, 2014). The total populations of Afşin and Elbistan are 82,122 and 142,168 respectively in 2014 (TURKSTAT, 2015). Regarding these factors, the subject is becoming significantly complicated. Currently two active mining operations are located in the basin. The lignite mining in the basin is practiced with strip mining, a surface mining method, in very wide areas. Therefore, initiating new mining operations in the basin will cause the acquisition of land for the operations and the active mining area is extended towards agricultural lands. Therefore, these issues are conflicting significantly.

Secondly, the basin is densely populated. In order to practice new mining operations, obligatory resettlement is most probably necessary. Additionally, as the agricultural activities are still important for the local communities, the acquisition of agricultural land will cause loss of traditional economic activities of the locals. This may push them to resettle from their original settlements to other towns and maybe cities domestically.

In addition to these conflicting and possibly negative impacts of new operations, the establishment of new thermal power plant(s), changes in the surface structure, water resources etc. may also negatively affect the local communities in the future. Due to all such issues, strategic-level planning of possible new mining investments in the basin is needed to be conducted. Therefore, as the developed framework aims to integrate the sustainability consideration into strategic-level decision-making and planning of the mining sector, AECB has a potential to observe how the framework works in practice.

5.1. Overview of the Afşin-Elbistan Coal Basin

The Afşin-Elbistan Coal Basin (AECB) is located between Afşin and Elbistan districts of Kahramanmaraş Province in Turkey. Afşin and Elbistan districts are located at the north of Kahramanmaraş city center and these two are surrounded by the province of Sivas in the north, the province of Kayseri in the west, Malatya in the east and Göksun, Ekinözü and Nurhak districts of Kahramanmaraş in the southwest, south and southeast, respectively (see Figure 9).

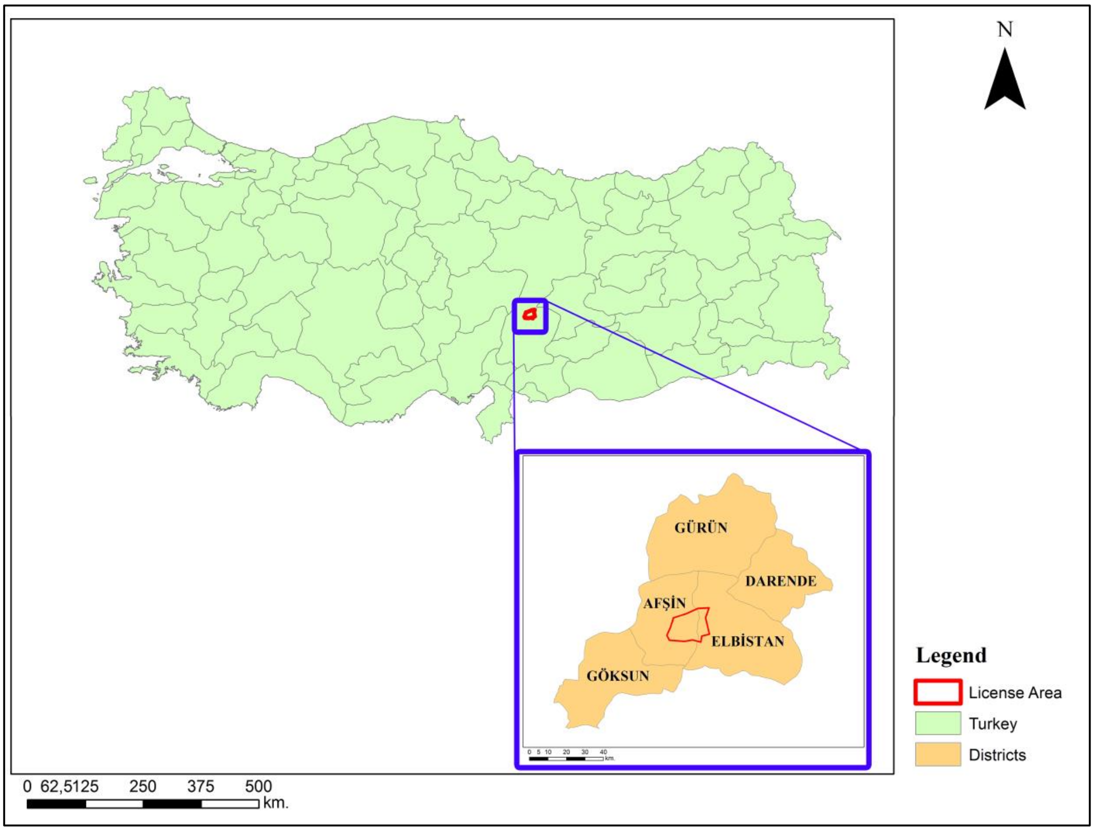

Figure 9. Locations of Afşin and Elbistan in Turkey

Kahramanmaraş Province is the 11th biggest province among 81 provinces in Turkey in terms of its surface area, which is 14.346 km². There are wide plains suitable for agricultural activities in the province, including Elbistan and Göksun in the north and Maraş, Andırın, Mizmilli, Narlı and İnekli plains in Pazarcık, Türkoğlu and Andırın districts in the south (see Figure 10). The most significant mountains of the province are Nurhak, Binboğa, Engizek, Uludaz and Ahırdağ.

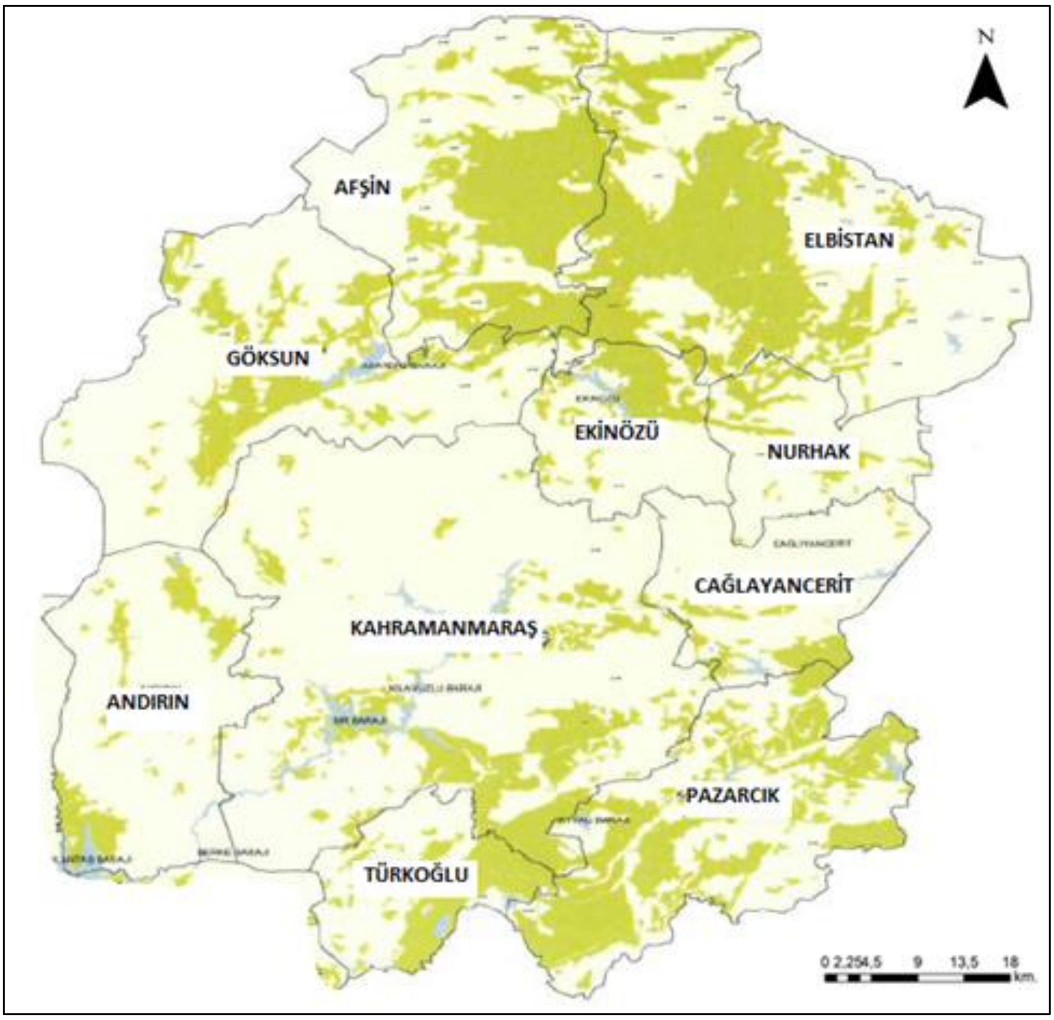

Figure 10. Agricultural plains of Kahramanmaraş Province
(source: EMDA, 2015)

The major streams of the province are the Ceyhan River, Hurman, Söğütlü, Göksun, Sarız, Erkenez and Andırın Creeks (see Figure 11). The source of Ceyhan River is in Pınarbaşı, which is located in 3 km southeast of Elbistan district (see Figure 11). The Ceyhan River, with a total length of 509 km., is one of the most important rivers for Çukurova Plain together with the Seyhan River (GoK, 2014).

59.7% of the surface area of the province consists of mountains, 24% of plateaus and 16.3% of plains (MoEUP 2011:4). The Elbistan Plain, with a length of 50-60 km in the east-west direction and a width of 20-25 km. in the north-south direction, has roughly a surface area of 1000-1300 km^2. Hence the plain is accepted as the fourth biggest plain in Turkey in terms of the surface area and agricultural potential, after the Çukurova, Konya and Harran Plains. The Elbistan Plain has an average altitude of 1100-1150 m (GoK, 2014).

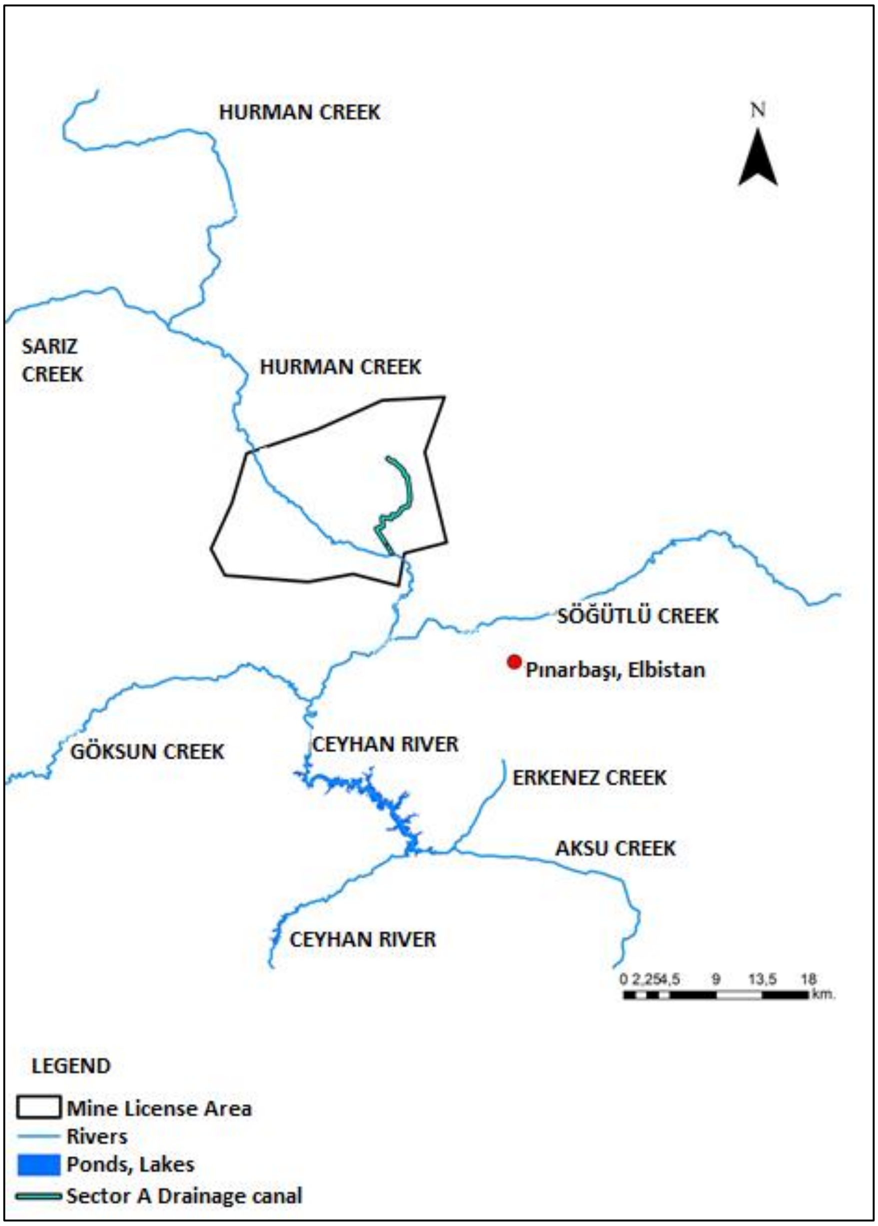

Figure 11. Major waterways in Kahramanmaraş Province (source: Düzgün *et al.*, 2014)

5.1.1. Electricity Generation and Mining Operations in the Afşin-Elbistan Coal Basin

The lignite reserve in Turkey is 14.5 billion tonnes and 52% of this is owned by EÜAŞ, 18.3% by the Turkish Coal Enterprise (TKİ), 18.1% by the General Directorate of Mineral Research and Exploration (MTA) and 7.5% is owned by private sector. Regarding this, the biggest proven reserve is located in the Afşin-Elbistan Coal Basin (AECB) (EÜAŞ, 2015b).

AECB covers a license area of 34,310 ha, 29,700 ha of which is owned by EÜAŞ and the license area of EÜAŞ is divided into five sub-sectors by EÜAŞ (EÜAŞ, 2013; EÜAŞ, 2015b). According to EÜAŞ (2015b) and the TKİ (2011), 4.4 billion tonnes of proven lignite reserve is located in the Elbistan Plain. The amount of the lignite reserve given by EÜAŞ and TKİ corresponds to almost 45% of proven and 38% of the total lignite reserves of Turkey (EÜAŞ, 2015b; TKİ, 2011).

The location of the lignite license area in the Elbistan Basin is shown with red borders in Figure 12 and the five sub-sectors and their locations within the license area are also shown in Figure 12. As it can be seen in Figure 12, the major section of the mine license area is located in the Afşin district and the total license area covers approximately 25-30% of the Elbistan Plain.

The first exploration activities were initiated with the German technical support by Otto Gold GmbH and the General Directorate of Mineral Research and Exploration of Turkish Republic, MTA, in 1966. As a result of the systematic exploration activities, the first lignite was explored in 1967. The feasibility studies on AECB were conducted between the years 1969 and 1970 and the basin were divided into five sub-sectors, as Kışlaköy (Sector A), Çöllolar (Sector B), Sectors C, Sector D and Sector E (see Figure 12).

The first surface mining operations were planned and started in Sector A (Kışlaköy) in 1973 for exploitation of 582 million tonnes of lignite. After starting the first excavation in 1973, the operations with the bucket-wheel excavators (BWE) were started in 1981 for stripping the overburden. In order to increase the lignite production in the basin, Sector B (Çöllolar) was subcontracted for operation based on the agreement signed between Park Teknik A.Ş. and EÜAŞ in 2009. The detailed timeline of the operations in AECB is given based on Ural (2014) in Appendix D.

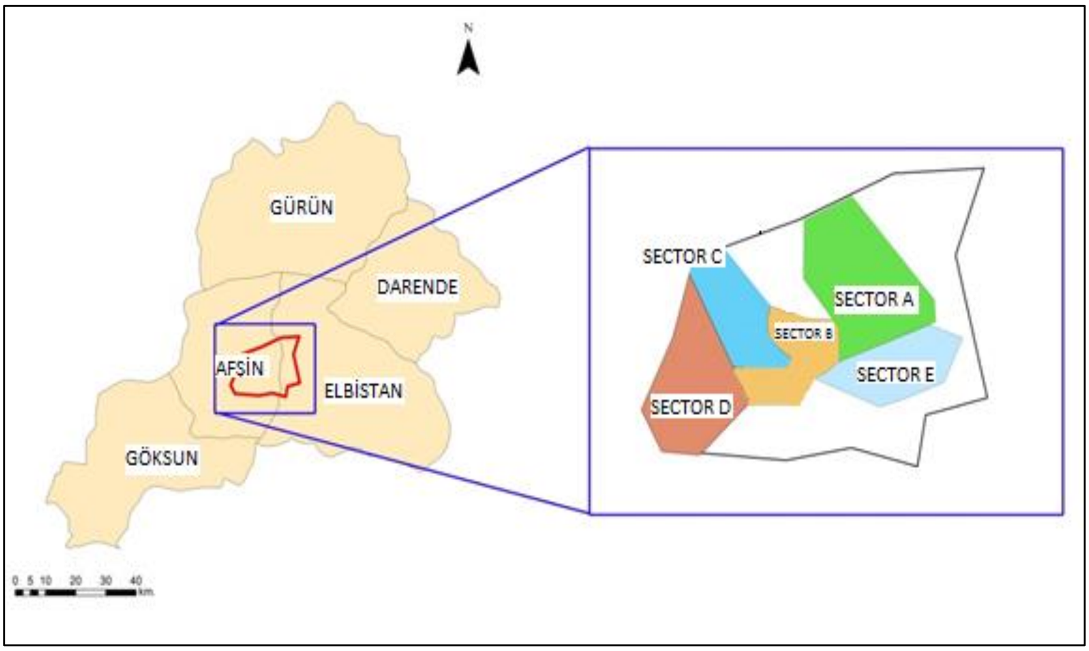

Figure 12. Location of the Afşin-Elbistan Coal Basin

Parallel to the mining operations, the construction work for the first thermal power plant (A Thermal Power Plant) was also started in 1973 and the first unit of the plant was commissioned in 1984 with the lignite provided from Sector A. The construction of the second power plant, B Thermal Power Plant, was started in 1999 to increase the installed electricity generation capacity in AECB. The first electricity generation was started in the B Power Plant in 2003. The Afşin-Elbistan "A" Thermal Power Plant has a 1,355 MW installed capacity and the Afşin-Elbistan "B" Thermal Power Plant has a 1,440 MW installed capacity (EÜAŞ, 2015b).

The lignite layer in the Sector A (Kışlaköy Sector) is almost horizontal in the central parts of the basin, where it dips 5^{o} to 20^{o} towards the southern end of the sector. Continuous mining operation is practiced with bucket-wheel excavator (BWE) and belt conveyor system in the sector (Mert, 2010). A BWE from the Sector A operations is shown in Figure 13.

Figure 13. Bucket-Wheel Excavator in the Sector A
(source: Düzgün *et al.*, 2014)

The operations are conducted in six benches in the Sector A (see Figure 14). A BWE works on each bench; hence there are six BWEs in the Sector A. The excavation capacities of the BWEs are 3000 bank m^3/hr for overburden and 3900 tonnes/hr for lignite excavation (Mert, 2010; Güneş, 2007). The BWEs can excavate up to 30 m. above the bench where it stands and 4 m. below the bench. The bench heights change between 18 m. and 20 m., which are mainly determined based on the radius of the wheel. The belt conveyors are 1800 mm in width and the working velocity of the conveyors is 5.2 m/sec. (Mert, 2010).

In addition to the BWEs, spreaders are used for spoiling both overburden material -waste- as well as waste ashes of the thermal power plants in the excavated mine area in the Kışlaköy Sector. For this purpose, 5 spreaders with capacities of 5600 loose m^3/hr and 5.2 m/sec. working velocities are used in the sector (Güneş, 2007). The spreaders and also the spoils in the Sector A waste dump area is shown in Figure 15.

Figure 14. Lignite excavation benches in the Sector A

Figure 15. Waste dump site and waste spoils in the Sector A

The Sector B (Çöllolar) is the second active mining operation in AECB. The license of the sector is owned by EÜAŞ. In fact the sector was privatized in 2007 in order to excavate the lignite reserve (Başaran, 2009). The primary aim of starting mining operations in the Sector B is to provide the lignite needed in the Afşin-Elbistan "B" Thermal Power Plant. The sector is located at the center of AECB and the Hurman creek passes from the southern border of the sector. The characteristic of lignite is highly similar in both A and B Sectors. The thickness of lignite in the sector changes between 40 and 60 m (TMMOB, 2012).

The agreement about the excavation of the Sector B lignite was signed between EÜAŞ and Park Teknik A.Ş for a period of 28 years in 2007 (Başaran, 2009). The first three years were planned to reach the lignite (Tutluoğlu *et al.*, 2011). The mining plans were completed for excavation of 1,260 million m^3 of waste material and 431.25 million tonnes of lignite with an annual lignite production of 17.25 million tonnes. (Başaran, 2007).

The excavations in the Sector B were started with hydraulic excavator and truck systems in order to open the box-cut. The excavated waste material was transported with trucks to outside dump. The outside dump is located on the southwest border of the sector, where the box-cut was also started to be opened. According to Tutluoğlu *et al.* (2011, p. 233), the box-cut extended about 260 ha at a depth of about 100 m at the end of the third year and the mining area was planned to extend 380 ha at a depth of about 142 m at the end of the fifth year. Additionally, similar to the Sector A in AECB, the mining operations were planned as continuous mining with the BWEs and belt conveyor systems after three years in the Sector B (Tutluoğlu *et al.*, 2011, p. 233).

However, two slope failures occurred in the Sector B in 6^{th} and 10^{th} February 2011. As a result of these failures, one worker died in the first failure and two engineers and eight workers died in the second failure (TMMOB, 2012). Approximately 20-25 million m^3 of material slid into the open cast mine due to the first slope failure. The failure is shown in Figure 16. The second failure caused sliding of 50 million m^3 of material into the open cast mine. The failed slope is shown in Figure 17. The dimensions of the slid slope is given as 1000 m long and 600 m wide by TMMOB (2012, p.5).

Figure 16. Slope failure at the southern slope of the Sector B

Figure 17. Slope failure at the north-west slope of the Sector B

5.1.2. State of Socio-Economy in the Afşin-Elbistan Coal Basin

The population of Kahramanmaraş Province is 1,063,174 in 2012. The district of Elbistan is the most populated district with a population of 142,168 in 2014 after the Kahramanmaraş city center (TURKSTAT, 2015). The population of Afşin is 82,122 in 2014 (TURKSTAT, 2015) and it is the third most populated district after Elbistan. The city of Kahramanmaraş is below the average of Turkey in terms of population density, which is 74 people/km^2 and 98 people/km^2 respectively. Also, according to the report by the Eastern Mediterranean Development Agency (EMDA), the average household size of Kahramanmaraş Province is 4.5 in 2011 (EMDA, 2014).

According to the data of 2012, the literacy rate in Turkey has been determined to be 93.3% and it is 91% in the same year in Kahramanmaraş. 95% of men and 87.05% of women are literate in Kahramanmaraş. When examined within the districts-scale, it can be seen that 90.4% of the total population in Afşin and 92.1% in Elbistan is literate (EMDA, 2014).

The city of Kahramanmaraş is one of the most important production centers of Turkey in terms of economic activities. Besides being one of the important trade centers on the historical Silk Road, it also serves as a crossroad connecting other important industrial and commercial centers such as Gaziantep, Malatya, Kayseri, Osmaniye and Adana today.

Production is performed in 35 different industrial branches with an annual turnover of approximately 2.5 billion USD in the province and 35,000 people are employed in these sectors. Among these, textile and food sectors are the primary sectors in the province. Besides these two, electricity generation, mining and production of industrial kitchen tools are other important sectors.

According to the Industrial Status Report of the province, prepared by the General Directorate of Industry of Ministry of Science, Industry and Technology (MoSIT, 2012), it is seen that 25% of the production and industrial activities are in food production sector, 24% is in textile, 13% is in manufacturing fabrication and metal products and 12% is in the mining sector except the lignite and coal in the province. Hence the mining sector is an important industrial activity in Kahramanmaraş.

Although vegetable oil, ice cream, pepper, flour, cheese, milk, yoghurt production are at the forefront in the food sector, the necessity of irrigation in the Elbistan Plain is expressed as an important need in order to use the full agricultural potential of the city (MoSIT, 2012). The city has 27.4% of the cotton production of Turkey (MoSIT, 2012).

Kahramanmaraş has an important economic potential in terms of the energy sector. Afşin-Elbistan A and B Thermal power plants correspond to 30% of the installed thermal power plant capacity of Turkey. In addition to the energy generation capacity from non-renewables, the province also has a significant renewable energy potential. Recently, 21 hydroelectric power plants are in operation by the end of 2012 and 12 hydroelectric power plant projects are under construction. (MoSIT, 2012).

In terms of agricultural production, 2.9% of the total agricultural land of Turkey is located in the TR63 Region, which includes Kahramanmaraş with Hatay and Osmaniye, and 5.4% share of the agricultural production of the country is produced in the region (EMDA, 2014). According to 2011 data, Kahramanmaraş is in the 20th rank in terms of plant production in Turkey (EMDA, 2014).

Regarding the agricultural production share within the Kahramanmaraş Province, Afşin, Elbistan, Pazarcık and central districts are prominent in terms of field crops production (EMDA, 2014, p.164). In addition to this, 30% of the vegetable production in the Kahramanmaraş Province is produced in Elbistan and 23% in Afşin (EMDA, 2014, p.169). Regarding this, 53% of the vegetable production in the Kahramanmaraş Province is produced in the basin, where lignite mining operations are planned.

Afşin and Elbistan are also two important districts of Kahramanmaraş in terms of stockbreeding. According to the Eastern Mediterranean Development Agency (EMDA, 2014), approximately 20% of the cattle in Kahramanmaraş is in Elbistan and 11.5% is in the district of Afşin in 2011. Elbistan is the third important district in the province with 10.6% and Afşin is the fourth with 9.2% in terms of the number of sheep. In terms of the number of poultry, though there is not any significant investment in Elbistan, Afşin hosts 16% of the poultry in the province.

5.2. Implementation of the Developed Framework for the Afşin-Elbistan Coal Basin Case

The indicator-based sustainability assessment framework, which is developed under this study, is applied in a case study in order to observe if it works as it is aimed and planned. For this purpose, the strategic-level planning of the Afşin-Elbistan Coal Basin (AECB) in terms of the mining sector is selected as the case study. As it is discussed at the beginning of this chapter, the main reason for selecting AECB is the energy strategy of Turkey, which aims to exploit the lignite reserve potential in the basin, where the agricultural sector is still highly important. As a result, these two sectors, agriculture and mining, which are important for Turkey, are seriously conflicting with each other.

Therefore, before taking any action, evaluating and understanding the potential impacts of the mining sector on the society, environment and economy is necessary at the strategic-level in order to mitigate any irreversible faulty planning practices. For this purpose, the potential local costs and benefits should be analyzed at the strategic-level in order to determine environmentally-friendly, socially responsible and economically feasible mining sector development alternatives.

The developed framework is applied step by step in this section with a specific focus on land degradation and efficient natural resource recovery properties of potential mine plan alternatives in AECB. The details of the developed framework are discussed in Chapter 4 and the flowchart of the steps is shown in Figure 4.

5.2.1. Identification of the Strategical Objective (Step1)

The first step of all types of assessment tools like the EIA, SEA and SA is determining the objective of the policy that potentially affects all the future development actions through plans, programs and projects. In the case of this study, the focused policy is the energy policy of Turkey. To study the policy, the 10th Five Year Development Plan of the Turkish Republic (MoD, 2013) is focused as it is the main policy document for long-term planning in Turkey.

Regarding the document, the objective of the energy policy of the country is to achieve the following items (MoD 2013);

- Security of the energy supply

- Increasing the use of alternative energy resources
- Achieving resource diversification
- Extending the use of the domestic natural resources in the energy production
- Achieving sustainability
- Creating free energy markets
- Improving energy efficiency

5.2.2. Identification of Scope and Targets of the Strategy (Step2)

The second step of the framework is the identification of the scope and also the strategic targets that will be used to monitor the achievement of the objective. As it is given in Step 1, the energy policy indicates comprehensive and diverse concepts to consider, such as renewable energy resources, energy efficiency and using the domestic energy resources, including the non-renewable resources. Therefore, like analyzing all these issues in a single assessment practice, scoping is necessary to focus on the strategic assessment subject.

As the study is conducted for the mining sector plans, the scoping of the policy should focus on "extending the use of the domestic natural resources in the energy production". Because, the policy aims to beneficiation of the domestic natural resources, this also involves using the domestic lignite and hard coal resources. And these resources are highlighted as an important alternative for securing energy supply in the development plan (MoD, 2013).

In addition to this, sustainability is another strategic objective, because the exploitation of these resources should be conducted taking sustainability issues into consideration. As a result of these, the scope of the strategic plan involves the beneficiation of domestic lignite and coal resources for energy generation purposes by considering the sustainability issues. The scope is given in the development plan (MoD, 2013, p. 104) as;

> *Domestic coal reserves should be exploited for generation of electricity by the private sector through using highly efficient and environmentally friendly technologies. Lignite reserves in the Afşin-Elbistan Basin are used for electricity generation.*

The above given policy issues are determined and defined by the policy making authorities, which are government, specifically the ministry, and the assembly as the approving authority of the policy. The next step is practicing the policy. In order to implement the policy and succeed in the above given objective by focusing on the scope given above, the targets of the strategic action are mostly determined by the practicing public actors. As the Electricity Generation Authority of the Ministry of Energy and Natural Resources (EÜAŞ), the strategic documents of EÜAŞ are considered for this case.

As the license owner of the Afşin-Elbistan Coal Basin, the strategic planning documents of EÜAŞ are considered to understand the targets. In this respect, the target for achieving the objective is exploiting the lignite resources with the possible highest recovery in AECB as "… [exploitation of lignite reserves in C, D and E Sectors under public-private partnership approach]..." (EÜAŞ, 2014, p.44)

5.2.3. Identification of the Sustainability Context (Step 3)

As it is given in detail in Section 4.1.3, the identification the sustainability context in terms of the focused sector is performed based on a detailed literature review. For this purpose, this study is applied in Chapter 2 in this study. As the details of the discussion can be seen in Chapter 2, the sustainability context in the mining sector is determined as;

- Creating long-lasting social well-being;
- Obtaining comparable information on possible trade-offs and their consequence, and
- Achieving natural resource efficiency for balancing costs and benefits (including protection of ecosystems and contribution to long-lasting well-being).

Regarding these, the primary scope and the targets of the sustainability in the mining sector are determined specifically in the case of this study in terms of the strategic planning alternative in AECB in Step 4 by considering the local understanding of sustainability in the basin.

5.2.4. Defining the Sustainability Criteria (Step 4)

In addition to the general understanding of the sustainability context for the mining sector in Step 2, the sustainability criteria is also needed to be determined at the local level in order to obtain applicable and reasonable outcomes at the end of the analysis. The main idea behind this is that the serious and direct negative impacts of the sector are observed at the local level. These impacts are discussed in detail in Section 2.2. Additionally, it can be seen in Table 1 that the majority of these impacts are direct and negative at the local level. In this respect, considering the local stakeholders' perception of sustainability and integrating these into decision-making process is essential.

For this purpose, public consultation is practiced in the study. As one of the methods for public consultation, a survey is applied with the participation of the targeted stakeholders. This is also valuable for integrating the local stakeholders into the decision-making process as early as possible to avoid any possible conflicts that may occur in the future. Besides the survey, such involvement may be also practiced through meetings with community representatives and stakeholder organizations, as it is discussed in a case in the Central America by Erzurumlu and Erzurumlu (2014).

Before the development and application of the survey, the process shown in Figure 18 is recommended to be applied as a part of the developed framework. Firstly, the stakeholders with legal personality, who are directly affected or represent those directly affected or who have a potential to affect the decision, should be defined (Step 4.1 in Figure 18).

Secondly, organizing focus group meetings with these stakeholders is recommended to understand their expectations and needs (Step 4.2 in Figure 18). Thirdly, the outcomes of these focus group meetings should be used for developing the questionnaires (Step 4.4 in Figure 18). The pilot scale questionnaires should be applied in the focused region as the fourth step in order to see whether the highlighted points fully cover the local individuals' expectations and needs (Step 4.4 in Figure 18). If so, the questionnaire is applied in the focused area (Step 4.5); if not, the questionnaire should be modified based on the obtained input from the pilot study. The results of the survey and the focus group meetings are analyzed as the sixth step and the local sustainability criteria are determined by following these steps.

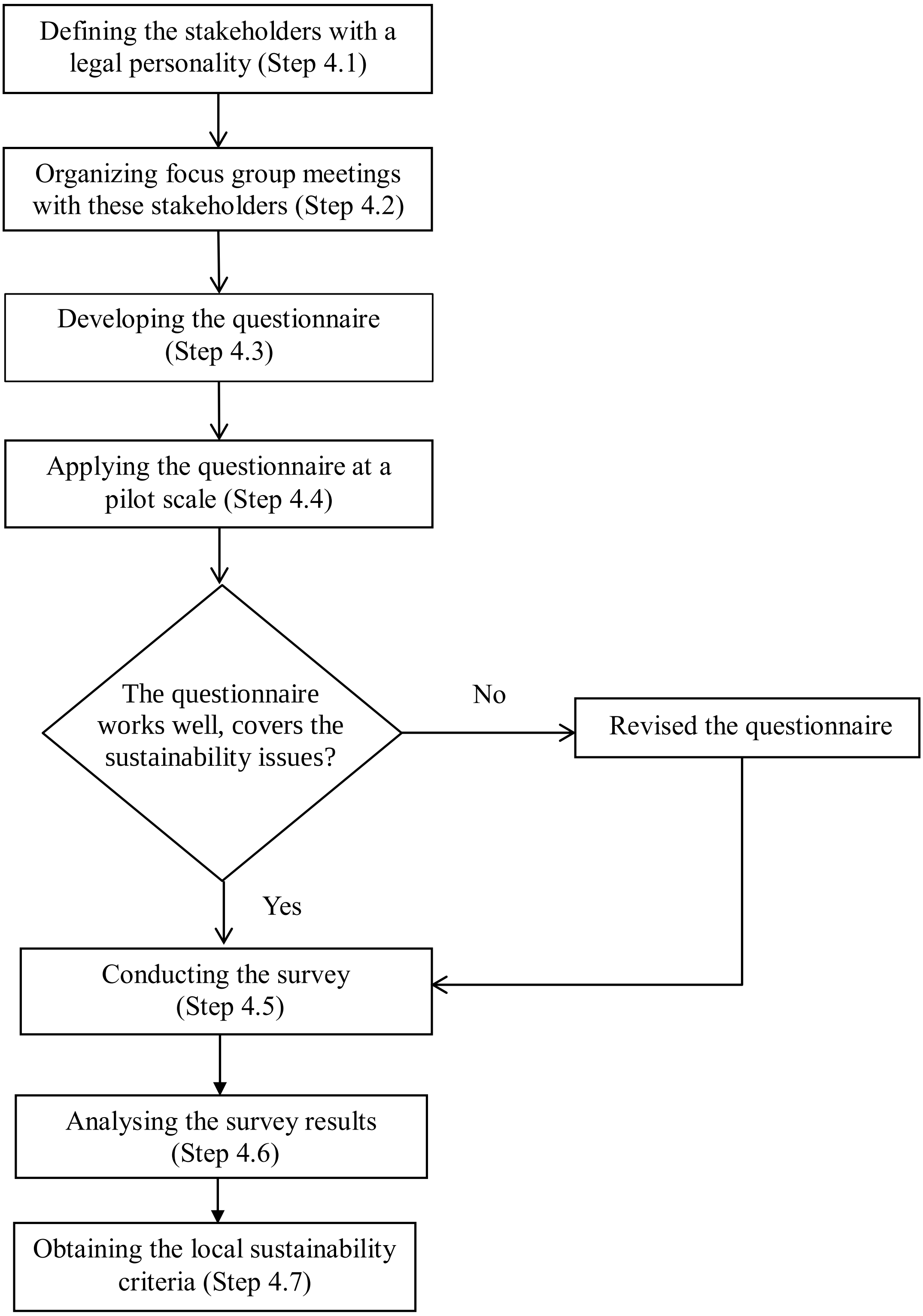

Figure 18. The approach for local sustainability criteria determination

By following the approach in Figure 18, the local sustainability criteria are determined. First of all, the stakeholders with legal personality are determined. These stakeholders are given in Appendix E. In order to reach an understanding about sustainability, specific needs and problems at the local level, meetings were organized in Ankara and Kahramanmaraş as well as in Elbistan and Afşin districts between October 2013 and December 2013.

In fact, among these meetings, the focus group meetings were conducted with the stakeholders that are directly connected with or affected from the mining sector operations in AECB. Other stakeholders, given in Appendix E, were visited to inform, to discuss the subject and obtain their vision and comments about the subject. In this way, the achievement of higher and extensive stakeholder participation is aimed.

As a result of these meetings, sustainability-related issues are used for the development of the questionnaire. The questionnaire that is developed and applied is given in Appendix F. The questionnaire was first applied at a pilot scale to the representatives of local organizations and also the locals in 10 settlements in AECB in December 2013. The outcomes of the focus group meetings and face-to-face interviews with locals, the key issues, highlighted by local communities, are considered as the sustainability principle framework priorities for this study.

These are grouped under three pillars of sustainability and given in Table 13 below. The given sustainability issues and priorities are compared with the global sustainability context obtained from the literature in Step 3. The comparison matrix is given in Table 14.

According to the comparison in Table 14, the local sustainability concerns are clearly collected under creation of a long-lasting social well-being in AECB. The second highly stressed issue is obtained as the effective natural resource management in AECB in terms of the mining and agriculture-related land use and land degradation subjects.

The land acquisition is a financially, socially and environmentally overlapping subject, stressed by the local stakeholders and it is highly related to mine planning and also loss of agricultural land in the region. Therefore, the land acquisition-related local sustainability issues are counted under the effective natural resource management.

Table 13. Sustainability-related priorities in AECB

Pillar	Key Issues and Priorities
Environmental	• Mitigating air pollution emerging from the thermal power plants • Water management • Land use planning and protecting the agricultural land
Social	• Positive discrimination for the locals during new employment practices • Timely accessing information on land acquisition plans • Considering negative impacts of land acquisition and loss of traditional economic activities • Improvement in the infrastructure • Investing in the community for development of the qualified local work force
Economic	• Promoting development of auxiliary industry of the mining and energy sectors in the region • Practicing the land acquisition lump sum • Sharing the benefits and contribution to the socio-economic development

To sum up, the sustainability criteria within this study are determined as;

- Creating long-lasting social well-being through;
  - **Employment:** Prioritizing local employment and capacity building in local communities;
  - **Land acquisition management:** Minimizing the land acquisition and lump sum land acquisition;
  - **Infrastructure:** Improvement in the infrastructure.

Table 14. Global and local sustainability priority comparison matrix

Global Sustainability Issues / Local Sustainability Issues	Creating long-lasting social well-being,	Obtaining comparable information on possible trade-offs and their consequence	Achieving natural resource efficiency for balancing costs and benefits
Mitigating air pollution emerging from thermal power plants		Very important issue on the local level but the mining sector planning approach can not directly interfere with the subject – out of scope	
Water management	**x**		**x**
Land use planning and protecting agricultural lands			**x**
Positive discrimination for the locals during new employment practices	**x**		
Timely accessing information on land acquisition plans		**x**	
Considering negative impacts of land acquisition and loss of traditional economic activities	**x**		**x**
Improvement in the infrastructure	**x**		
Investing in the community for development of qualified local work force	**x**		
Promoting development of auxiliary industry of the mining and energy sectors in the region	**x**		
Practicing the land acquisition lump sum	**x**	**x**	**x**
Sharing the benefits and contribution to the socio-economic development	**x**		
Total Overlapping Issues	**8**	**2**	**4**

- Obtaining comparable information on possible trade-offs and their consequences;
    - **Change in the local economic activities:** Impact of land acquisition and land use change due to mining operations versus created local employment in the mining sector and auxiliary sectors;
    - **Change in the practice of the local economic activities:** Impact of land acquisition and land use change on the agriculture due to mining operations versus positive impact on the practice of the agriculture due to accessing groundwater, used for irrigation.
- Balancing costs and benefits by effective natural resource management through;
    - **Land use management:** Minimizing the land use for the mining operations;
    - **Land acquisition management:** Minimizing the land acquisition;
    - **Water management:** Minimizing groundwater drainage and using the drained water for agricultural purposes.

However, the use of groundwater for agricultural purposes and the expectations of the locals about this is conflicting with the sustainable use of natural resources. The groundwater management is a complicated subject and it should be considered and studied in detail in order to understand its impact and to evaluate the level of sustainability of using the groundwater as irrigation water. However, the irrigation issue is a subject of infrastructure. Regarding this, the irrigation issue is considered under the infrastructure parameter as improving the irrigation infrastructure in AECB.

5.2.5. Determination of the Plan Alternatives (Step 5)

The fifth step is the determination of the alternatives that will possibly be implemented in order to achieve the strategic objective by considering the sustainability criteria. Even though the strategic-level environmental and sustainability analysis are discussed in many different researches, case study-based publications are limited. The practice in most of these studies is the definition of alternatives and analysis of them, and finally the outcomes are shared with the stakeholders. Apart from these, Gibson (2006a) explains how the early alternative consideration based on public consultation is conducted in Canada in a nickel mine project at the project-level.

Regarding the approach given by Gibson (2006a), in the proposed framework, the public participation and stakeholder consultation is conducted before the alternative development phase. In this way, early consideration of the local needs and expectations will be practiced at the strategy level and also at the project-level in the future and also the achievement level of the sustainable development concept in practice will be higher.

As it is discussed in previous steps, the scope of the strategy and sustainability criteria are determined based on the local stakeholder's participation. Regarding these factors, the alternatives are determined for achieving the strategy and sustainability criteria by considering the economic and also engineering limitations.

While working on the alternatives, first the decision-making authority's planning approaches and also the mine planning practices are considered. This means that as the reserve has been divided into sectors by the decision-making authority previously, any alternatives about re-dividing these sectors are not considered for this study.

However, the consideration of the alternatives, including re-dividing of the reserve, is definitely suggested for further studies about the basin. In fact, such a study is not practiced during this research study because of two reasons;

- As the reserve is owned by a governmental authority, the political motivation and willingness must lead such a study. Otherwise, the obtained outcomes will not be accepted and taken in consideration in practice if the objective of the study does not overlap with the decision-making authority's previous planning actions and;
- Such a study needs more time and expert contribution as well as extra field survey to analyze the engineering limitations for exploiting the reserve under different reserve sections.

As a rule of thumb of the strategic-level analysis, the first alternative should be a no-action alternative. In addition to SA practices at the strategic-level, this is also important and must be a fulfilled condition for the SEA practices. Therefore, as the proposed methodology is compatible with the SEA, no-action should be considered as the first alternative. Other alternatives are developed based on the strategy and sustainability scoping outcomes of the applied framework. These are given in Table 15.

Table 15. The Mining Sector Plan Alternatives for AECB

Condition - A	**Condition – B**
No change in the Hurman Creek bed and highly staying within the current license area	Change of the Hurman Creek bed and extending the current license area in order to maximize the reserve recovery
Alternative 1: No-action – continue operations in the Sector A (Kışlaköy) and the Sector B (Çöllolar)	**Alternative 4:** Extracting the Sector C - Intervention with the Hurman Creek but no intervention with the Sector B and B Power Plant
Alternative 2: Extracting the Sector D Reserve – No intervention with the Hurman Creek, B Power Plant and Sector B	**Alternative 5:** Extracting Sectors C and D together - Intervention with the Hurman Creek but no intervention with Sector B and B Power Plant
Alternative 3: Extracting the Sector E Reserve	

The pre-defined sectors are named as the Sector A, the Sector B, the Sector C, the Sector D and the Sector E, which are shown in Figure 19. In the Sector A (Kışlaköy) and the Sector B (Çöllolar), the mining operations are currently in practice. Therefore, a safe distance is needed between these operations and the suggested alternatives. The possible alternatives are exploiting the Sector C, D and E separately and the joint combinations of these sectors. In this respect, as the Sector B (Çöllolar) is recently active, the only possible combination can be the combination of the Sector C and D. As a result of these, these alternatives arise as ‘no-action’; ‘exploitation of the Sector C’, ‘exploitation of the Sector D’, ‘exploitation of the Sector E’ and ‘jointly exploitation of the Sector C and D’.

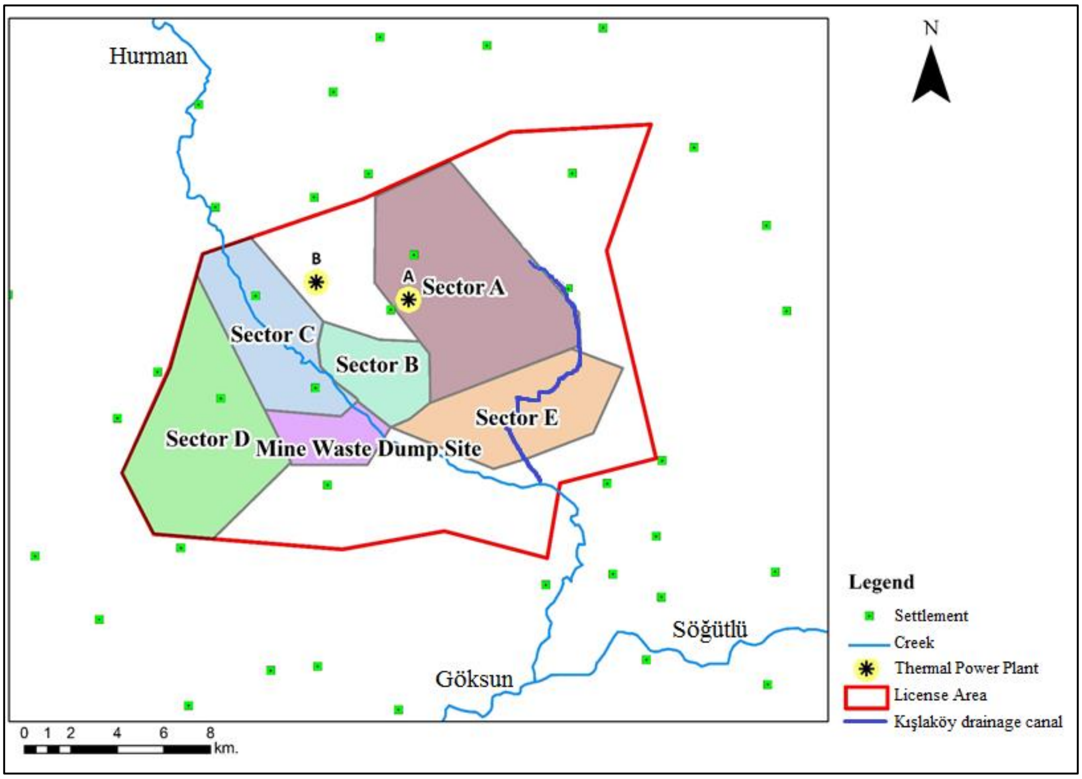

Figure 19. Mining license area in AECB and mining sectors determined by EÜAŞ

In fact, as the location of the Sector C is considered (see Figure 19), potential interaction with the B Thermal Power Plant and also with the Sector B operations must be taken into account. Indeed more importantly, the Hurman Creek passes from the north-west to the south-east through the Sector C. As a result, if the sector is going to be mined, the bed of the Hurman Creek must be changed at the north-west end of the sector. Therefore, changing the bed of the Hurman Creek is a preliminary condition for all the alternatives, including the excavation in the Sector C. Consequently, the alternatives, including the operations in the Sector C, demand changing the bed of the Hurman Creek but others may be mined without such a change; the alternatives are grouped under two conditions, as Condition A and Condition B, in Table 15.

Among the above listed alternatives, those highly accomplishing the strategy objectives and targets, obtained in Step 2, and local sustainability scoping outcomes given in Step 4, are tried to be used for further discussions. As the sustainability criteria are minimizing the land use for mining operations and also considering the water-related concerns of the local communities; the alternatives including the change of the Hurman Creek's bed and extending the license area should not be considered.

Therefore as these two criteria are given under Condition-B in Table 15, alternatives under Condition B are not considered for further discussions. This is because even if these alternatives may have a higher potential to achieve the strategic targets (Step 2), these are definitely unsustainable in terms of the local stakeholders' point of view. As a result, only three alternatives are left to analyze as Case 1 in this study. The details of these alternatives are given below.

5.2.5.1. Alternative 1: No-action

As it is mentioned previously, the first alternative must be the no-action alternative. The no-action alternative means that the conditions should be accepted as they are before any suggested alternative is applied in the basin. Therefore, all the existing conditions and operations are considered under the no-action alternative without any modifications or changes. In this respect, no-action means continuing mining operations in the Sector A and the Sector B, as it is shown in Figure 20. The other suggested or developed alternatives are compared against the no-action alternative. In this way, possible change in the sustainability level might be evaluated according to the existing situation (existing sustainability level).

In other words, the sustainability index score (SIS) of the no-action alternative is accepted as the threshold. Thus if the compared alternative will have positively higher SIS than no-action's SIS, it should be selected. But if the compared alternative will have a lower SIS in a negative way than the no-action, the compared alternative should not be selected for implementation.

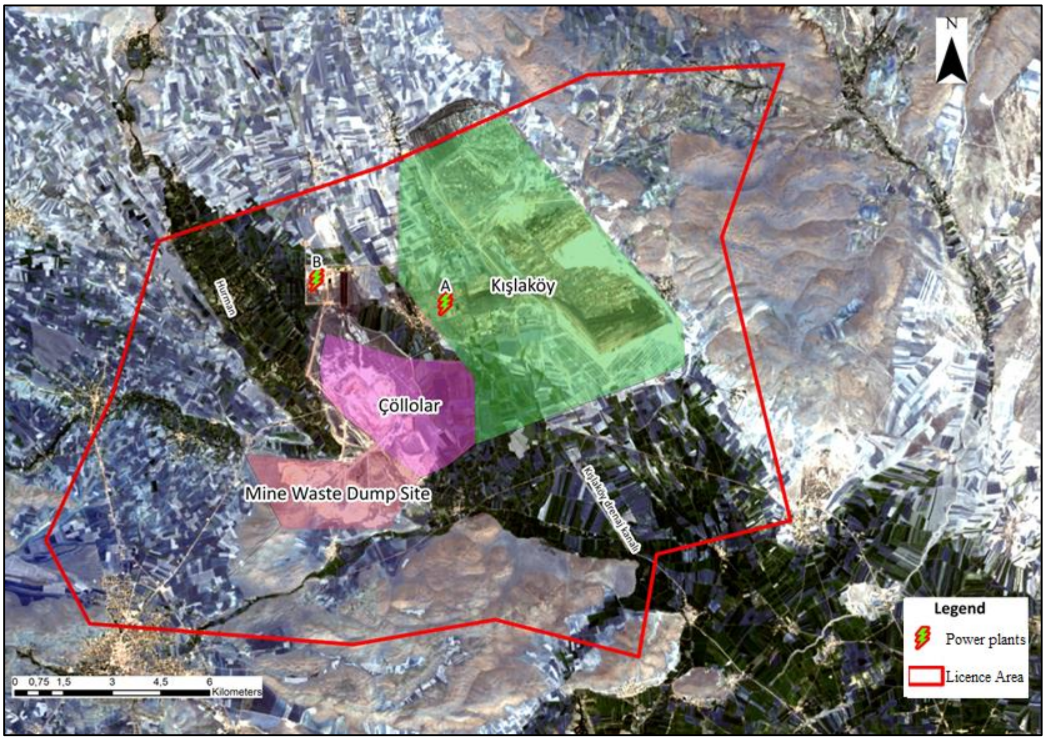

Figure 20. The mine operation area for No-action alternative in AECB (Source: Landsat 8, August 2013, source: http://earthexplorer.usgs.gov/)

5.2.5.2. Alternative 2: Extracting Sector D

The second alternative is extracting the lignite reserve in the Sector D (See Figure 21). For this alternative, the following conditions must be considered. The possible mining operations in the Sector D should not interact with the Hurman Creek, B Power Plant and the Sector B. For this purpose, a pillar distance is set based on the expert opinion (Ural, 2015). The pillar is determined as 300 m on the surface that approximately equals to a distance of 1300 m at the bottom of the reserve due to the overall slope angle. In addition to these, the operations should stay within the current license area as the local stakeholders clearly stress that the land use for mining operations should be minimum. Therefore, the pit should be designed within the current license area as it is shown in Figure 21. The details of the alternative are given in the data collection step (Step 7).

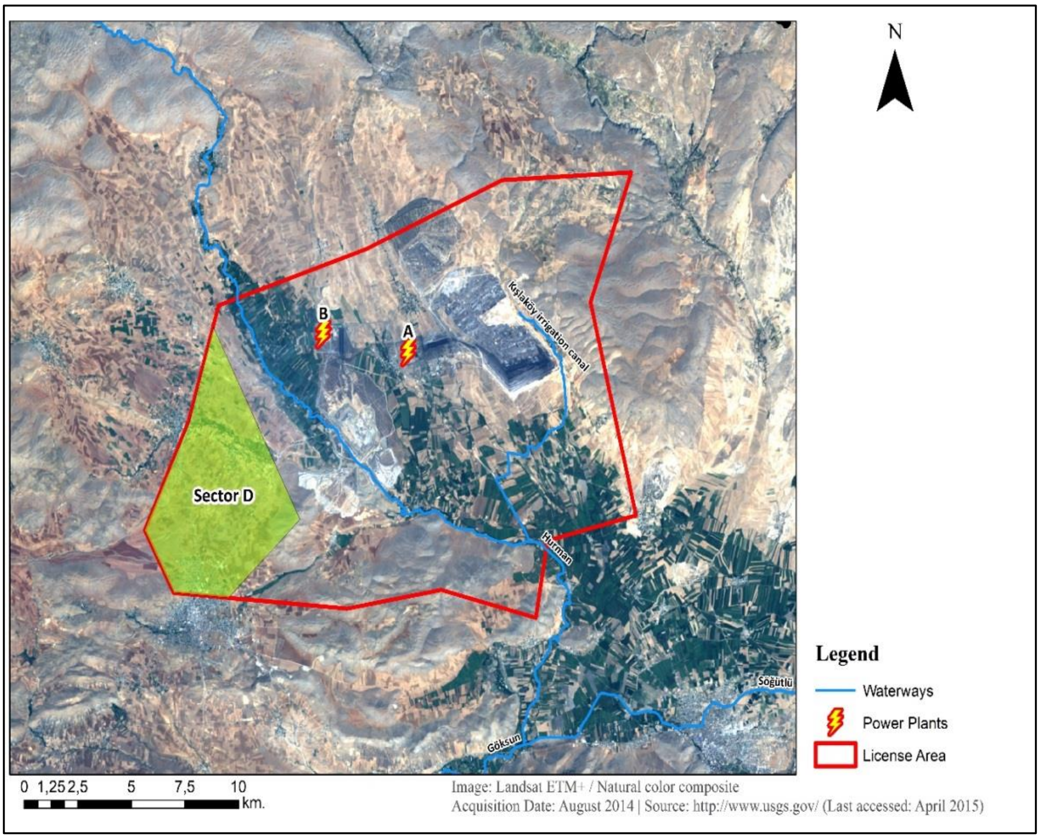

Figure 21. The mine operation area for Alternative 2 in AECB

5.2.5.3. Alternative 3: Extracting Sector E

The last alternative, which meets the conditions given in Condition A, is mining Sector E (Figure 22). As minimal land use and staying within the current license area are important criteria, the mining operations should be planned by using the opening of Sector A. In this way, as no pillar will be left between the Sector A and the Sector E, the recovery amount and the land use for the mining operations will be optimal. These conditions are determined before the data collection and assessment phase based on expert opinion while considering the general engineering factors.

However, a pillar must be left between the Sector E and the Sector B (Çöllolar). The pillar between the Sector E and the Sector B has the same parameters, which are applied in the Alternative 2. These are leaving a 300-meter pillar on the surface between these operations and an approximately 1300-meter pillar is also needed to be left at the bottom of the lignite reserve to keep the overall pit slope within the acceptable limits. As the alternatives are finalized, the next step, indicator selection, should be completed based on the identified sustainability criteria as well as the alternatives within the scope of the strategy.

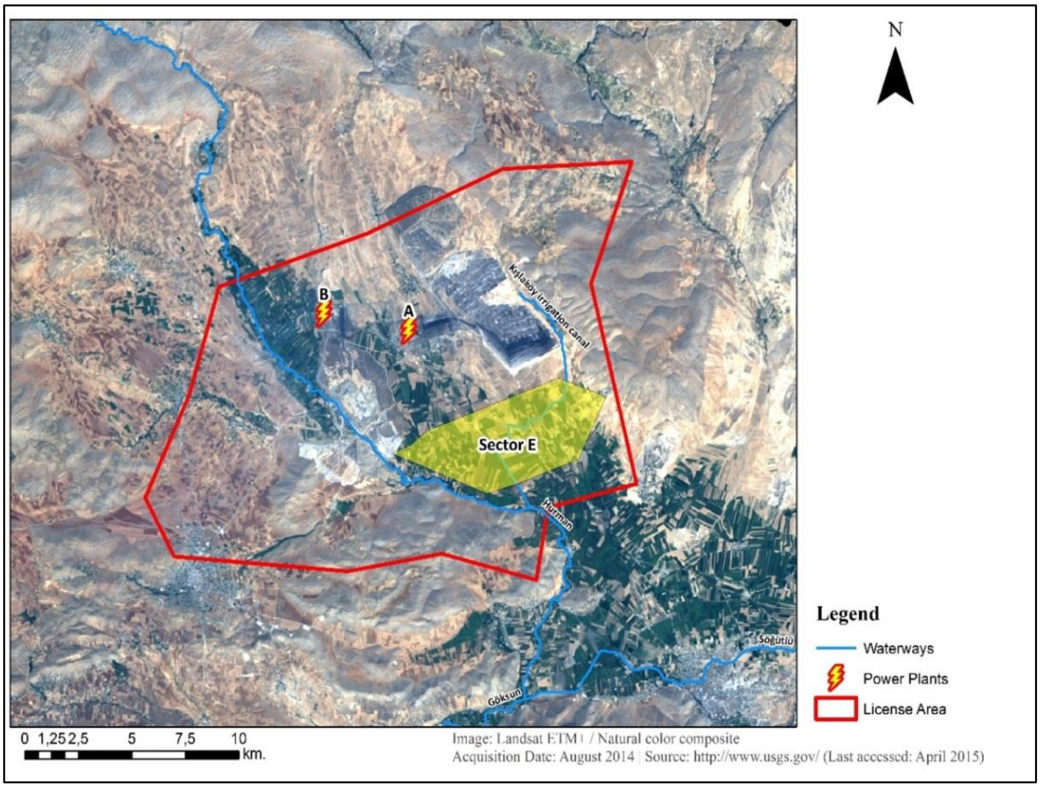

Figure 22. The mine operation area for Alternative 3 in AECB

5.2.6. Determination and Selection of Indicators (Step 6)

The indicators, classified in Chapter 3, are evaluated in the indicator selection matrix in Appendix G. The used scores are modified from the analytical-hierarchy process (AHP) method of Saaty (2008). The scoring is not conducted based on the relative importance of the indicators; in fact only the scoring scale of the AHP method is simplified to classify and select the indicators in this study. The details of these parameters, criteria and the scoring scales are given in Appendix G. After scoring all the indicators based on the parameters in Appendix G, the final set of indicators are obtained for the environmental, social and economic indicator sets and these are given in Table 16, Table 17, and Table 18 respectively.

The environmental indicators are scored in Appendix G and the number of the highest scored indicators, obtaining 15 and 14 points, is only eight. As the number is lower than the determined indicator number threshold and there are four indicators with a score of 13, these are also selected and given in the environmental set in Table 16. The indicators in Table 16, Table 17, and Table 18 are not listed based on their scores. Therefore, the order does not show any importance among the selected indicators. Also, some of the given indicators are marked with **[m]** and **[s]**. The **[m]** means that the indicator is modified from the original indicator in Appendix B and the **[s]** indicates that the indicator is suggested in this thesis, respectively.

As it is discussed in Section 4.6, maximum 10 indicators are planned to be considered for each set in order to keep the total number of indicators within a manageable amount, based on the literature review (Bell and Morse, 1999 in Moles *et al.*, 2008, p.154; Gustavson *et al.*, 1999 in Graymore *et al.*, 2009, p.454).

Contrary to this, as there are seven indicators given in the in the social set and six in the economic indicator set, the following highest scored indicators are not selected in order to get 10 indicators. This is because other than the selected indicators, the relevance parameter scores of other indicators are '0' in the social set. This means that if these indicators were selected for the purpose of obtaining 10 indicators in the social set as it is applied in environmental set, the added indicators would be out of the scope of the thesis. This is not true for only one indicator that is given 3 points for relevance but 0 point for data availability. As data availability is a limitation for assessing the indicator within this study, it could not be selected. A similar situation is also seen in the economic indicator selection in Appendix G. Besides the indicators with '0' scored relevance parameter, two indicators with higher relevance scores but '0' data availability score are not also selected for further analysis.

Table 16. Final environmental indicator set for Case 1

ID	Indicator	Unit
E1	% of resource is left relative to the total amount of the permitted reserves of that resource* **[m]**	%
E2	Total land area that needs to be rehabilitated [**m**]	ha
E3	Percentage of forest damaged by defoliation	%
E4	Amount of land (will be) disturbed due to mining operations [**m**]	ha
E5	Total area of permitted development (mines and all other facilities)	ha
E6	Total land area newly opened for extraction activities (including area for overburden storage and tailings)	ha
E7	Percentage of newly opened land area relative to total permitted development	%
E8	The number of sites on environmentally protected or sensitive areas, including both current and planned developments	Nbr
E9	Loss of arable land	ha
E10	Amount of land consumption	ha
E11	Area change from greenfield to brownfield	ha
E12	Total waste extracted (non-saleable material, including overburden) **[m]**	m^3

*The original indicator is needed to be transformed to negative impact as all the other selected indicators in the set indicate negative impact conditions (the original version is given in Chapter 3 and Appendix G).

Table 17. Final social indicator set for Case 1

ID	Indicator	Unit
S1	The number of proposed developments that require resettlement of communities	Nbr
S2	The number of households resettled due to proposed developments (Displaced population)	Nbr
S3	The number of archaeological sites affected from the strategy	Nbr

Table 17. (continued)

ID	Indicator	Unit
S4	Vehicle accessibility negatively affected by settlements/population* **[m]**	Nbr
S5	Total new land acquisition** [**s**]	ha
S6	Percentage of local population thinking/observing the mining sector as a potential source of conflicts at the local level in terms of environmental issues, including land use and land acquisition **[s]**	%

*The original indicator is needed to be transformed to negative impact as all the other selected indicators indicate negative impact conditions (the original version is given in Chapter 3 and Appendix G).

**Contrary to economic indicator set, land acquisition is seen as a negative impact in the social set in this study because most of the purchased land is agricultural land and it is an important local economic activity of the locals. The applied questionnaire shows that local communities see land acquisition as a negative impact on their society.

Table 18. Final economic indicator set for Case 1

ID	Indicator	Unit
Ec1	Production amount of sellable products **[m]**	tonnes
Ec2	Produced goods or services per land input	%
Ec3	Total cost of land acquisition* [**s]**	monetary unit
Ec4	Recovery of reserve (ratio of alternative's tonnes / estimated tonnes) [**s**]	%
Ec5	The number of families (individuals) that need to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations** [**s**]	Nbr

Table 18. (continued)

ID	Indicator	Unit
Ec6	Ratio of the number of local families benefiting from the mining sector directly by employment in the mining company to the number of families benefiting from the traditional economic activities on the mine operational area*** [**s**]	%

* The cost of the land acquisition is a negative indicator for the investor but it has a positive impact on land owners from the economic point of view. In this study's case, the cost of land acquisition can be accepted as a positive impact because the public will benefit from the payment and the cost of the acquisition will be covered by the investor(s).
**In case of changing the source of income from traditional economic activities to employment in the industry and in the service sector, the vocational qualifications of the locals need to be improved as well as resettlement etc. is necessary. Hence the indicator is indicating a negative economic impact. For the sake of the economic index, the indicator needs to indicate positive outcome in order to obtain a cumulative positive result from the economic index. Therefore, the indicator value will be standardized as a dominator of 1.
***As a rule of thumb, an industrialized and regulated mining sector creates well-paid jobs for its employees compared to small scale and traditionally practiced economic activities, such as agriculture, livestock. This is also seen from the applied questionnaire, as 16.2% of the individuals from the households who participated in the survey are working as unpaid family laborer in the agriculture sector. Therefore, the high employment number of the locals in the mining sector improves the economic well-being of locals during the mining operations.

5.2.7. Data Collection and Baseline Conditions (Step 7)

The data collection is conducted based on the finalized alternatives and also considering the selected indicators. First, the needed data and the sources of obtaining the data are determined by studying the alternatives and indicators. Regarding the alternatives, 'no-action', the Sector D and the Sector E mine planning-related information is needed to be focused. These are discussed in the reserve model sub-section below.

The selected indicators under the three sustainability indicator sets are given in Table 19. The indicators are tagged with IDs as those in the environmental set E1 to E12; social set, S1 to S12 and economic set, Ec1 to Ec8 in Table 19. These IDs are used in the assessment step. In addition to the IDs and units of the indicators, also the source of the needed data for analyzing these indicators is also given in the fourth column of the table.

Table 19. The needed data and data sources for the selected indicators

ID	Indicator	Unit	Data Source/Need
E1	% of resource is left relative to the total amount of the permitted reserves of that resource **[m]**	%	Reserve model and mine layout of the alternatives
E2	Total land area need to be rehabilitated [**m**]	ha	Mine layout
E3	Percentage of forest damaged by defoliation	%	Mine layout and land cover maps
E4	Amount of land (will be) disturbed due to mining operations [**m**]	ha	Mine license area
E5	Total area of permitted development (mines and all other facilities)	ha	Mine layout of the alternatives
E6	Total land area newly opened for extraction activities (including area for overburden storage and tailings)	ha	Mine layout of the alternatives
E7	Percentage of newly opened land area relative to total permitted development	%	Mine layout and mine license area
E8	The number of sites on environmentally protected or sensitive areas, including both current and planned developments	Nbr	Mine layout and land use/land cover maps
E9	Loss of arable land	ha	Mine layout of the alternatives
E10	Amount of land consumption	ha	Mine layout and land use/land cover maps
E11	Area change from greenfield to brownfield	ha	Mine layout and land use/land cover maps
E12	Total waste extracted (non-saleable material, including overburden) **[m]**	m^3	Reserve model and mine layout of the alternatives
S1	The number of proposed developments that require resettlement of communities	Nbr	Mine layout and land use/land cover maps

Table 19. (continued)

ID	Indicator	Unit	Data Source/Need
S2	The number of households resettled due to proposed developments (Displaced population)	Nbr	Mine layout and land use/land cover maps and latest consensus
S3	The number of archaeological sites affected from the strategy	Nbr	Mine layout and land use/land cover maps
S4	Vehicle accessibility negatively affecting settlements/population* **[m]**	Nbr	Mine layout and land use/land cover maps and questionnaire results
S5	Total new land acquisition [**s**]	ha	Mine layout
S6	Percentage of local population thinking/ observing the mining sector as a potential source of conflicts at the local level in terms of environmental issues, including land use and land acquisition **[s]**	%	Questionnaire results
Ec1	Production amount of sellable products **[m]**	tonnes	Reserve model and mine layout of the alternatives
Ec2	Produced goods or services per land input	%	Reserve model and mine layout of the alternatives
Ec3	Total cost of land acquisition [**s]**	monetary unit	Reserve model and mine layout of the alternatives
Ec4	Recovery of reserve (ratio of alternative's tonnes / estimated tonnes) [**s**]	%	Mine layout of the alternatives and unit land prices
Ec5	The number of families (individuals) needing to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations [**s**]	Nbr	Reserve model and mine layout of the alternatives
Ec6	Ratio of the number of local families benefiting from the mining sector directly by employment in the mining company to the number of families benefiting from the traditional economic activities on the mine operational area [**s**]	%	Mine layout of alternatives, land ownership of land and employment information

5.2.7.1. Reserve Model and Mine Layout of the Alternatives

As it is given in Table 19, the data for 22 of the selected indicators out of 24 indicators can be generated from the lignite reserve and mine layout of the alternatives. In addition to these, data for two of the indicators can be obtained from the license area and from the results of the conducted survey in AECB. For this purpose, the model of the lignite reserve in AECB is developed within this research study.

The reserve model data is obtained from the Department of Mining Fields, EÜAŞ in 2014. The drilling studies were conducted by MTA in different time periods in AECB. All the data is given as Logs of the drill holes in pdf format. The distribution of the number of logs along with the sectors is given in Table 20.

Table 20. Sector-based distribution of the used log data in AECB

Sector	Number of drill holes
Sector C and Sector D	775
Sector E	562
Sector B (Çöllolar)	186
Total Drill Hole Data	1523

For a better presentation, the drill holes used for the reserve model are shown on the sector map of AECB in Figure 23. Three different colors are used in this figure. The green colored drill holes are located on the Sector E and part of the Sector A (Kışlaköy), which is named as the Corridor Section of the Sector A. The corridor part of the Sector A is located at the north-west of Sector E.

The red colored drill holes are shown in the Sector B (Çöllolar). The purple colored drill holes are those in the Sectors C and D as it can be seen in Figure 23. In fact, the drill holes at the north-east end of the Sector C are located within the area of B Power Plant. The power plants are shown with yellow signs in Figure 23.

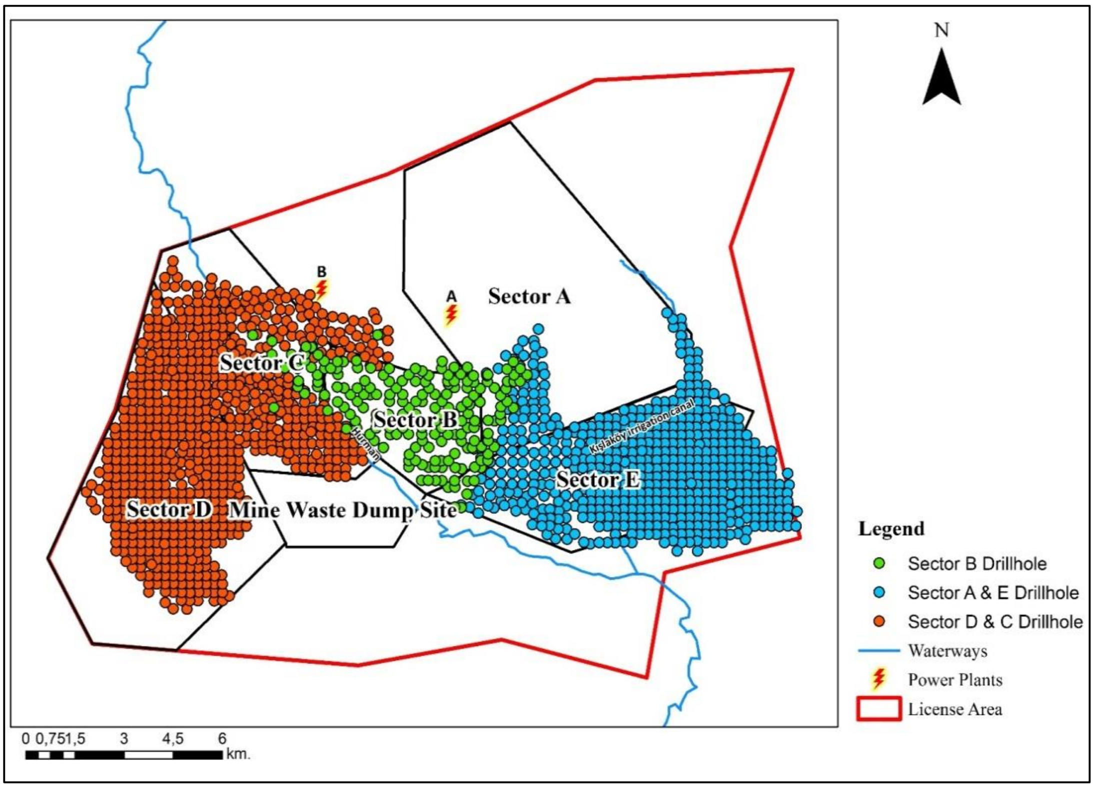

Figure 23. Distribution of drill holes in AECB mine license area

Regarding the drill hole Logs in pdf format, firstly, the calorific data for 1523 drill holes are transformed from pdf format to Excel tables. During this transformation, only the calorific values of the drill holes are taken into consideration. The reason for considering only the calorific value is that the study does not aim to develop a detailed mine plan to be used in the production at the project-level. Additionally, due to the time and human-resource limitations, other parameters, such as Sulphur, ash and moisture contents, could not be transferred into Excel tables.

After completing entering the calorific values of each drill hole from pdf to Excel, this is used for modelling the reserve in the basin. The reserve model is developed on Micromine 2014 Version 15.0.3.8 software, licensed for the Mining Engineering Department of Middle East Technical University. The histogram of the lignite reserve based on calorific value is given in Figure 24. The statistics of the reserve is given in Table 21. The cut of grade of calorific value for lignite is considered as 750 kcal/kg, which is the minimum usable calorific value in the A and B Thermal Power Plants in AECB (Ural, 2015; Besbelli *et al.*, 2009; Yörükoğlu, 1991).

Table 21. Summary statistics of lignite reserve in AECB

	Minimum Value	Maximum Value	Mean	Median	Standard Deviation
Calorific Value (kcal/kg)	751.00	2,915.00	1,166.21	1,162.00	224.48

In order to see the distribution of the lignite reserve, QQ Plots are drawn for the normal or log-normal distributions of the calorific value in Micromine and these are given in Figure 25 and Figure 26, respectively. Although there are some slight deviations from normal QQ line in the data (Figure 25), the data is considered to be normal as the deviation is attributed for high calorific values, which are less frequent in the data (Figure 24). As it is seen from Figure 26, lognormal QQ plat is not appropriate for the data.

As it is mentioned previously, the reserve model is only used to obtain the needed data for the assessment of the indicators, which is given in Table 19. Therefore, a detailed mine plan and a model usable for production is not created. However, the general mine operation parameters of the current operating mining sites are considered.

For this purpose, the parameters of the Sector A (Kışlaköy) mining operation are obtained as (Ural, 2015);

- Overall slope angle : 10-12^{o}
- Bench slope angle: 35-45^{o}
- Bench height: 20-25 m
- Bench width: 100 m

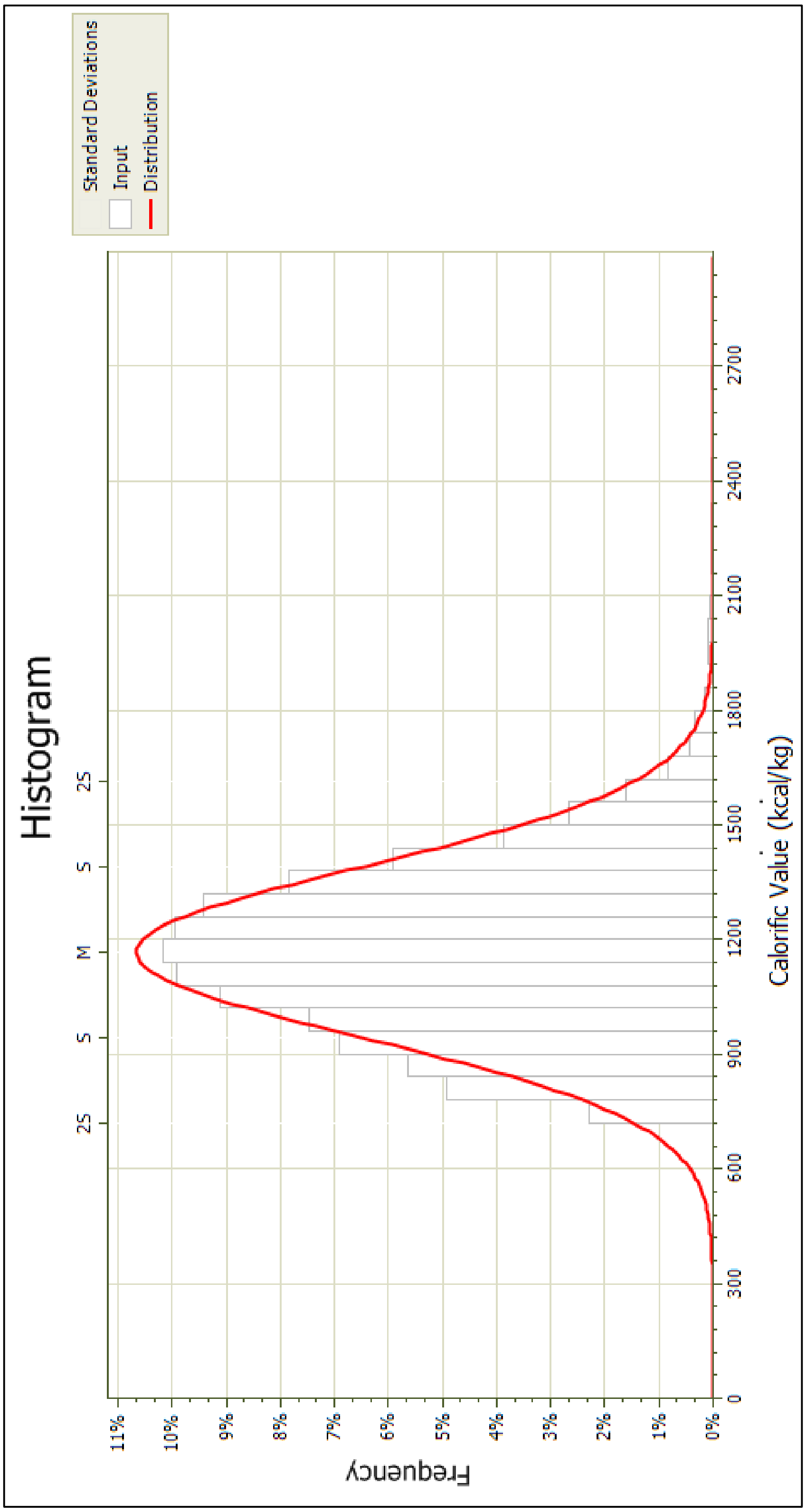

Figure 24. Histogram of the calorific value for the reserve

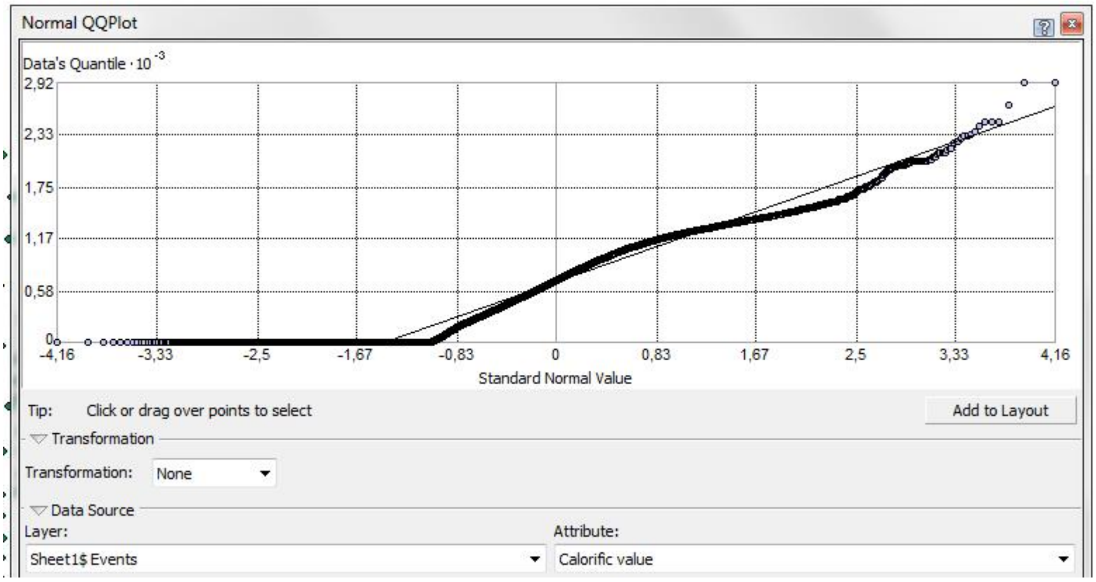

Figure 25. QQPlot for normal distribution

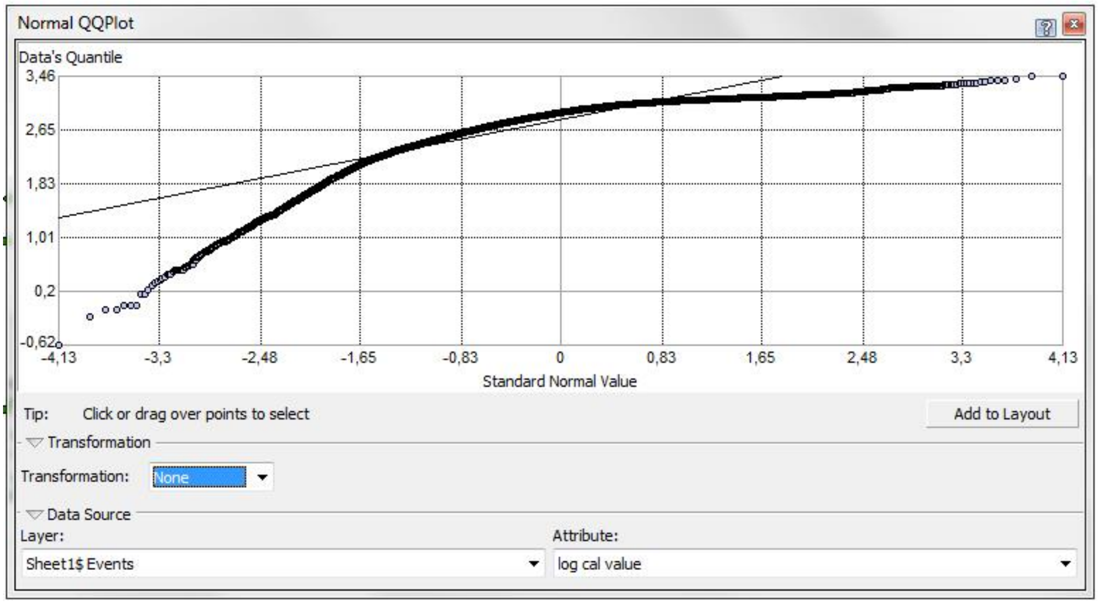

Figure 26. QQPlot for Log-normal distribution

According to the mining operational parameters in the Sector A in AECB, the mine plans of the alternatives are created based on the following parameters;

- Overall slope angle: 12^o
- Bench slope angle: 40^o
- Bench height: 15 m
- Bench width: 100 m

The Inverse Distance Weighted (IDW) grade interpolation is applied to complete the 3D block model in Micromine. In order to calculate the total reserve, the approximate reserve recovery and the land use need of the each alternative in the assessment step, an optimal block size is tried to be used.

Regarding this, as the bench height is accepted as 15 m., the block size for this study is determined as 7.5 m, which equals to the height of 2 blocks in a bench. Top-view reserve model figure is given in Appendix I. The results of the reserve model for each sector and the average calorific values of these are given in Table 22. In addition to these, the details of the reserve calculation are given in Appendix H.

Table 22. Reserve estimation results of the sectors in AECB

Sector	Volume (m^3)	Lignite Reserve (tonnes)*	Average Calorific Value (kcal /kg)
A (Kışlaköy)	284,599,828.10	398,439,759.40	1,057.34
B (Çöllolar)	516,899,390.60	723,659,146.90	1,035.86
C	459,931,921.90	643,904,690.60	1,034.18
D	539,386,171.90	755,140,640.60	1,096.87
E	590,157,984.40	826,221,178.10	946.51
B Power Plant overlain	135,064,125.00	189,089,775.00	1,055.72
Total	2,526,039,421.90	3,536,455,190.60	1,031.19

*Density = 1.4 t/m^3 (Ural *et al*., 2005)

ALTERNATIVE 1: NO-ACTION

The first alternative is the no-action alternative. It involves two currently active mining operations in the Sector A and the Sector B. Figure 27 shows the mining operations in the Sectors A and the Sector B in AECB. Based on the developed reserve model, the calculated parameters of the no-action alternative are given in Table 23.

Sector A (Kışlaköy)

The Sector A, also known as Kışlaköy, is an active mine with 398,439,759.40 tonnes of lignite reserve left in the southern part of the mining area. The Sector A is shown with the green area in Figure 27. The total licensed sector area is 5,334.60 ha in Kışlaköy and the actual open cast mining area is 4,480.26 ha, including the reserve the future mining area is located in (corridor area) with an area of 1,259.0 ha. 920.23 ha of total mining area is outside the dumping site, which is being reclaimed. As there is no mining operation in the remaining part, which is called the corridor, this area will need to be expropriated.

The stripping ratio in the Sector A is 2.26:1 (Ural *et al.*, 2005) and it is assumed that the recovery ratio of the remaining lignite reserve in the corridor region will be 85.30% based on the overall recovery ratio in the sector, which is calculated based on stripping ratio. The future mining area, the corridor area, is located on the agricultural land; there are no villages or other settlements in this area. However, the main road connecting the villages of Alemdar, Bakraç and Çoğulhan to the Elbistan District passes through this area.

Sector B (Çöllolar)

The no-action alternative also involves the active mining operation in Sector B, also named as Çöllolar. The reserve is estimated in the Sector B as 723,659,146.90 tonnes. The current planned operational area involves both the lignite excavated mining area and also the outside waste dump site. The surface areas of these are

1,352.19 ha and 604.30 ha respectively. The total mine license area is 2,354.44 ha. The stripping ratio in the Sector B is 2.21:1 (Çankaya, 2005).

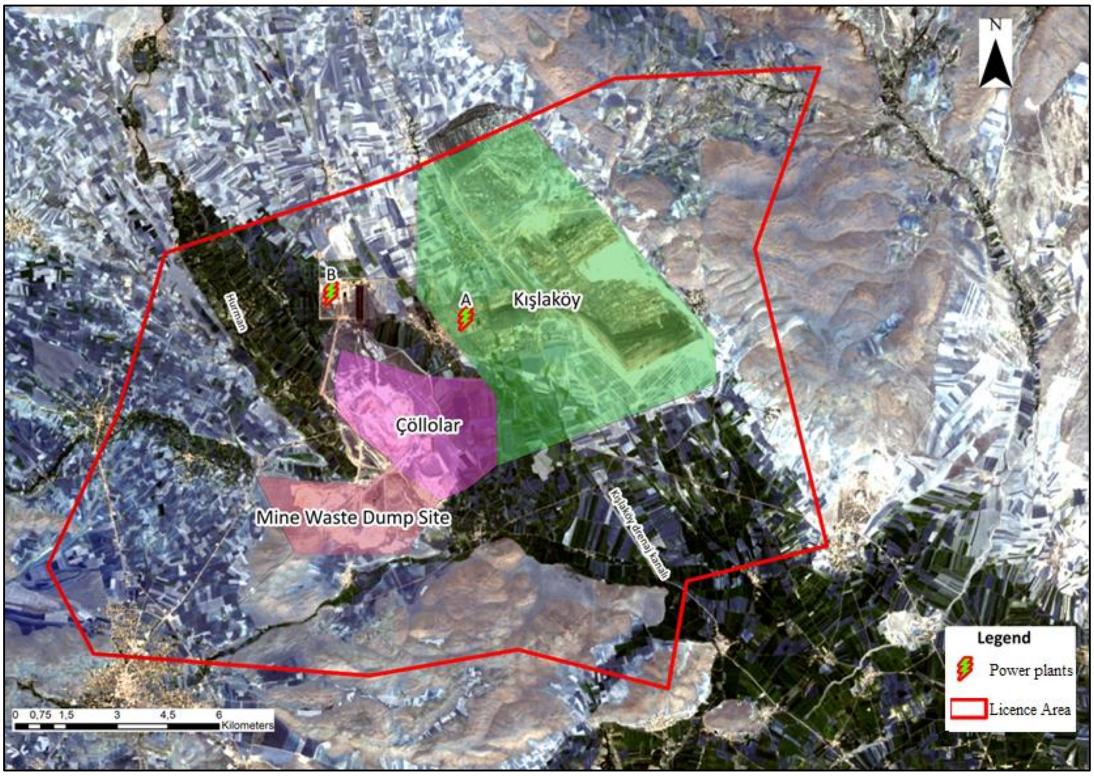

Figure 27. The mine operational area for the No-action alternative
(Source: Landsat 8, August 2013, source: http://earthexplorer.usgs.gov/)

Table 23. Summary of the parameters for no-action alternative

Parameters	**Sector A (Kışlaköy)**	**Sector B (Çöllolar)**
Lignite reserve (tonnes)	398,439,759.40	723,659,146.90
Overburden (m^3)	768,061,000.00	1,266,473,208.00
Stripping ratio (m^3/ton)	2.26:1**	2.21:1***
Recovered reserve (tonnes)*	339,850,000.00	573,064,800.00
Recovery of the reserve (%)*	85.30	79.20
Mine operation area (ha)	2301.03	1352.19
Outside dump area (ha)	920.23	604.30
New opened mine operation area (ha)	1259.0	459.98
Total planed mining area (ha)	4480.26	2416.47
Total Defined Sector Area (ha)	5334.60	2354.44

*calculated based on stripping ratio; **Ural *et al.*, 2005; ***Çankaya, 2005

ALTERNATIVE 2: EXTRACTING THE SECTOR D

The second alternative covers the mining operation in the Sector D, which is shown in Figure 28. In order to calculate the parameters for this alternative, the mine outline is developed with Micromine. It should be considered that the developed mine plan is a very rough plan that cannot be used for production planning or other assessment purposes at the project-level in practice.

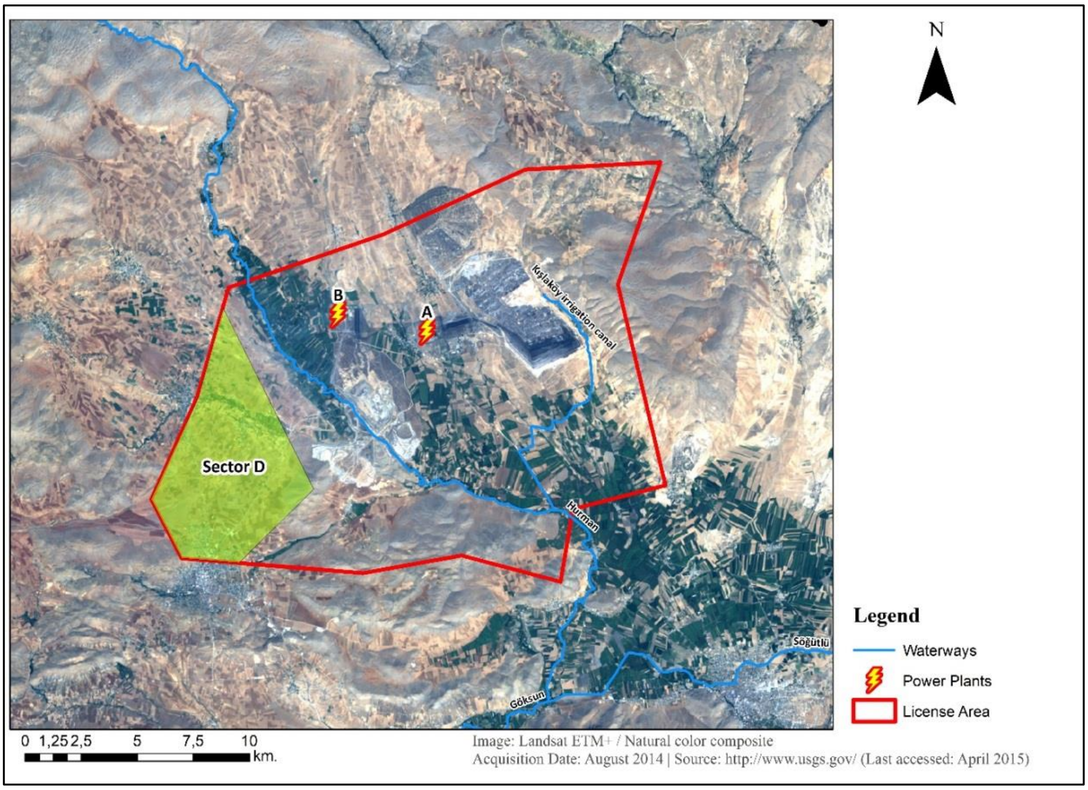

Figure 28. The mine operation area for Alternative 2

Based on the developed mine outline, the parameters, which will be used at the assessment step, are calculated and these are given in Table 24. The total surface area of the open cast mine is calculated as 3,425.32 ha. The sector area, defined by EÜAŞ, is calculated as 4,225.93 ha. As there is not an active mining operation in the sector, the mining operations should be started by opening a box-cut. The waste material of the box-cut opening will be dumped outside the open cast mine area.

Table 24. Summary of the parameters for Alternative 2

Parameters	**Sector D**
Lignite reserve (tonnes)	755,140,640.62
Overburden (m^3)	2,428,525,648.98
Intercalation (m^3)	113,098,782.00
Stripping ratio (m^3/ton)	3.79:1
Recovery of the reserve (%)	88.84
Recovered reserve (tonnes)	670,841,325.00
Outside waste dump (m^3)	617,821,160.57
Internal waste dump (m^3)	1,923,803,269.67
Total waste dumped (m^3)	2,541,624,430.98
Mine operation area (ha)	3425.32
Outside dump area (ha)	973.70
Total planed mining area (ha)	4399.02
Total Defined Sector Area (ha)	4225.93

After opening of the box-cut, the lignite excavation starts and the rest of the overburden will be dumped in the excavated mining area. The box-cut opening is shown in Figure 29 and the total mining operation area is shown in Figure 30 below. More detailed figures for the alternative are given in Appendix I.

ALTERNATIVE 3: EXTRACTING THE SECTOR E

The third alternative covers the mining operation in the Sector E, which can be seen in Figure 31. In order to calculate the parameters for this alternative, the mine plan is developed with Micromine. As it is set during the development of the alternatives, planning the mining operations within the license area is expected. Therefore, the Sector E open cast mine plan is developed within the license area but it covers a bigger surface area than the sector area of EÜAŞ, which is given as 2,728.84 ha. The total surface area of the Sector E is calculated as 4,927.73 ha according to the prepared mine layout under this study. Although there is not an active mining operation in the sector, it is planned that the mining operations can be started without a box-cut if the excavation is continued from the opening of the Sector A. In this way, the recovery in the sector can be increased and also the waste of the Sector E can be dumped in the mined-out part of the Sector A.

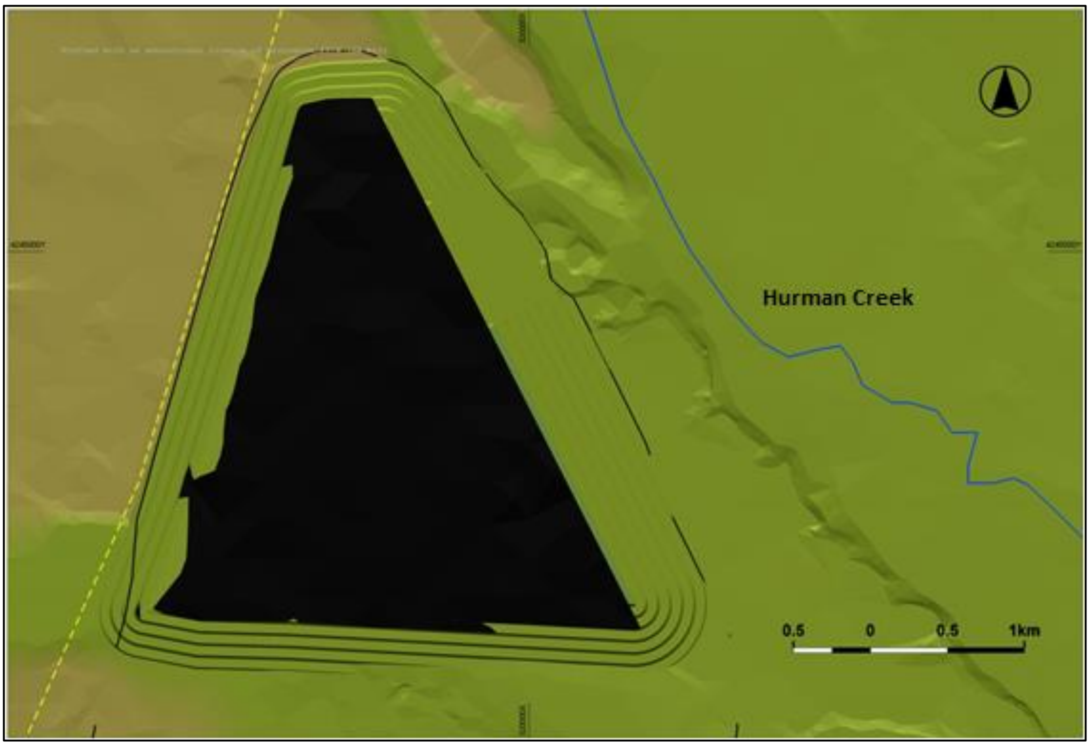

Figure 29. Top-view of the box-cut opening in the Sector D

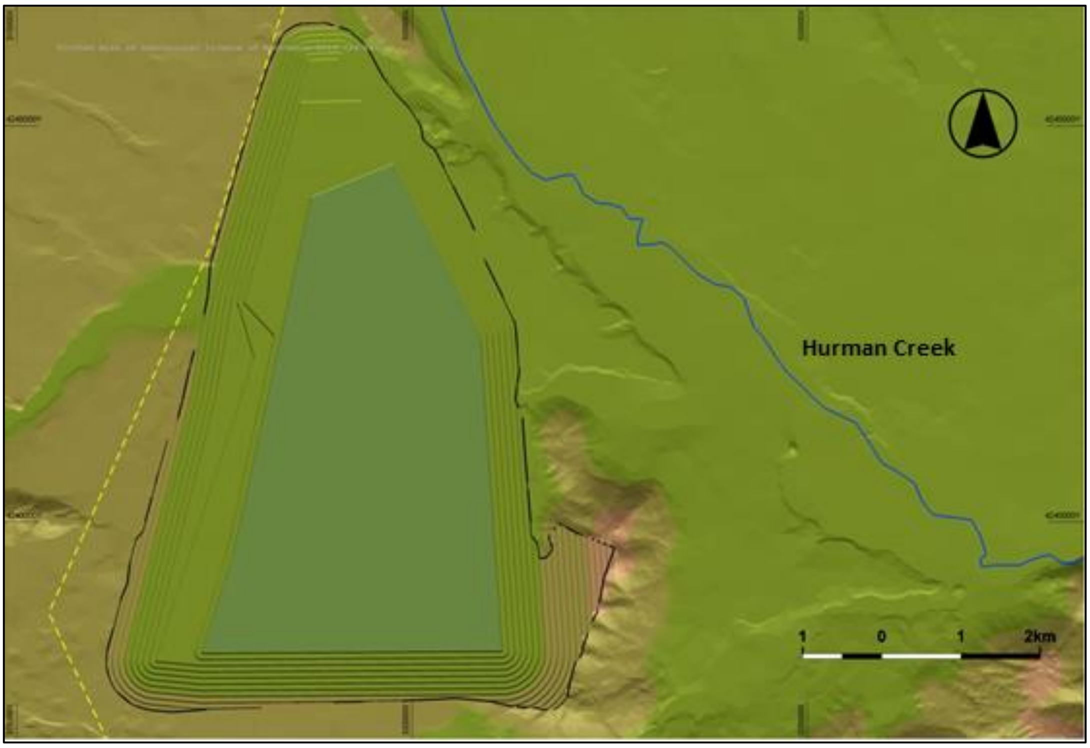

Figure 30. Top-view of the mine layout of the Sector D

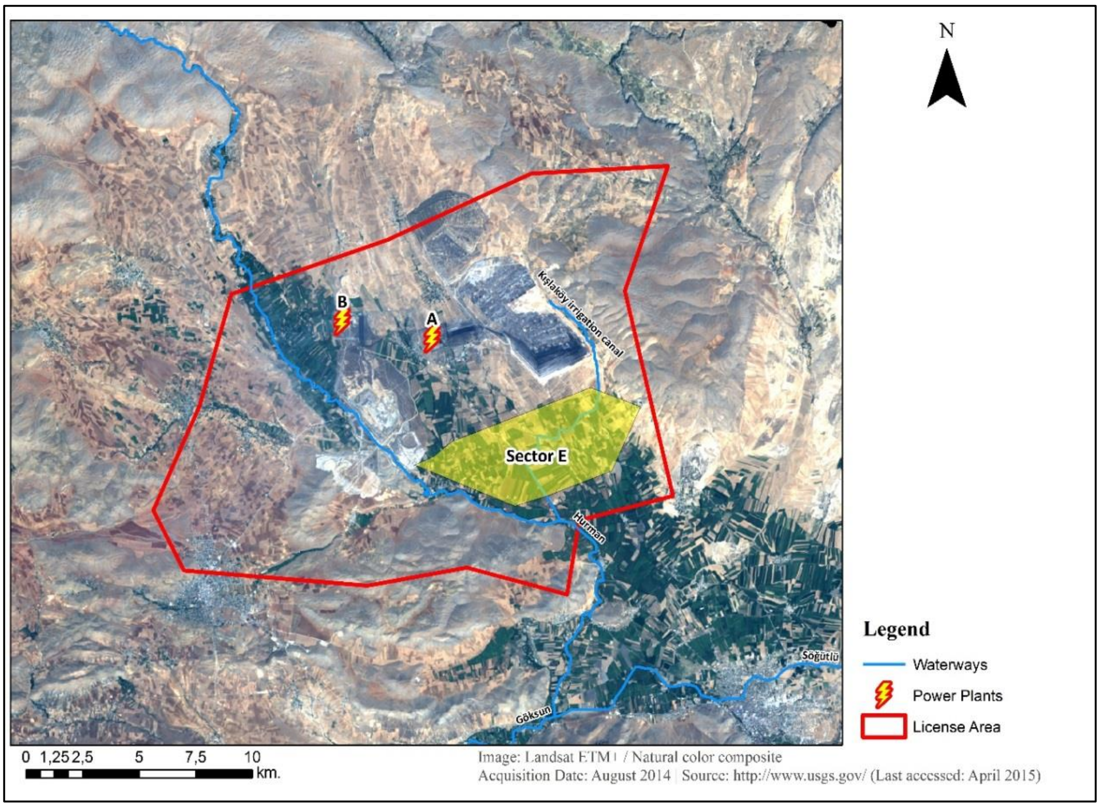

Figure 31. The mine operation area for Alternative 3

In fact this is determined after developing a plan with a box-cut and a pillar between the Sector A during the planning of the alternatives of this study. It is seen that if the operation is planned with a box-cut opening, the waste material from the box cut will be dumped outside the mining operational area. This will cause extra land acquisition. In addition to the need of extra land just for the waste dump, it is also realized that such a plan causes a significant decrease in the lignite recovery.

In order to avoid these, the plan for the Sector E is developed as it will be practiced as an extended excavation from the corridor section of the Sector A. The total mining operation area based on the mine layout developed under this study is shown in Figure 32 below. A more detailed figure of the mine plan is given in Appendix I. As it is seen in Figure 32, the south-west of the Sector E mine overlaps with the Hurman Creek. However, according to the primarily defined conditions, no interaction with the Hurman Creek is aimed. It is assumed in practice that the original basin of the Hurman Creek will be kept and so the interaction seen in the above figure will not occur. Based on the above given mine layout, the parameters, which will be used at the assessment step, are calculated and these are given in Table 25.

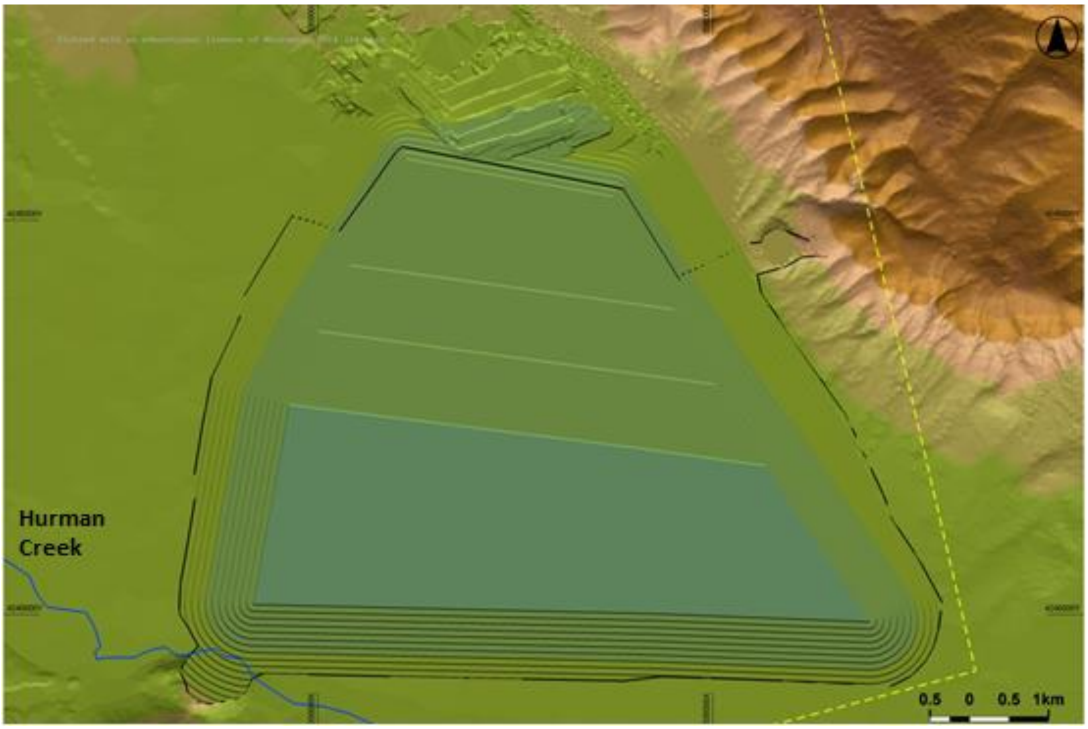

Figure 32. Top-view of the mine layout of the Sector E

Table 25. Summary of the parameters for the Alternative 3

Parameters	Sector E
Lignite reserve (tonnes)	826,221,178.13
Overburden (m^3)	4,292,318,278.54
Intercalation (m^3)	451,214,718.75
Stripping ratio (m^3/ton)	11.08
Recovery of the reserve (%)	51.80
Recovered reserve (tonnes)	428,011,762.50
Outside waste dump (m^3)	-
Internal waste dump (m^3)	4,743,532,997.29
Total waste dumped (m3)	4,743,532,997.29
Total planed mining area (ha)	4,927.73
Total Defined Sector Area (ha)	2,728.84

5.2.7.2. Land Use and Land Cover Maps of the Afşin-Elbistan Coal Basin

In addition to the lignite reserve model and the mine layouts for the plan alternative, the maps for land use and land cover are also needed to obtain the data to analyze the indicators given in Table 26. In order to obtain data for analyzing these indicators, two maps are prepared. The first one is given in Figure 33. The figure is developed by Düzgün *et al.* (2014). The figure indicates the classification of the land in terms of its purpose of use, which includes agricultural, settlement, forestry, water ways, green and brown lands. The map is studied at the ArcGIS ArcMap 10 software in order to calculate the data that is used for analyzing the indicators with IDs, E3, E8 and E9, given in Table 26.

Table 26. Data, used for indicator evaluation, generated from the land use and land cover maps

ID	Indicator
E3	Percentage of forest damaged by defoliation
E8	The number of sites on environmentally protected or sensitive areas, including both current and planned developments
E9	Loss of arable land
S1	The number of proposed developments that require resettlement of communities
S2	The number of households resettled due to proposed developments (Displaced population)
S3	The number of archaeological sites affected from the strategy
S4	Vehicle accessibility negatively affecting settlements/population

The land use map is used to obtain the data indicating the possible impacts and interaction about the infrastructural changes, resettlement needs and possible interaction with the archeological sites due to the application of the alternatives. The satellite image with the roads, settlements, mine license area, the Sector D and the Sector E mine layouts as well as the water ways, is given in Figure 34. The locations of the archeological sites are obtained from EÜAŞ. The figure is mainly used for to determine the data for the indicators with IDs of S1, S2, S3 and S4, given in Table 26.

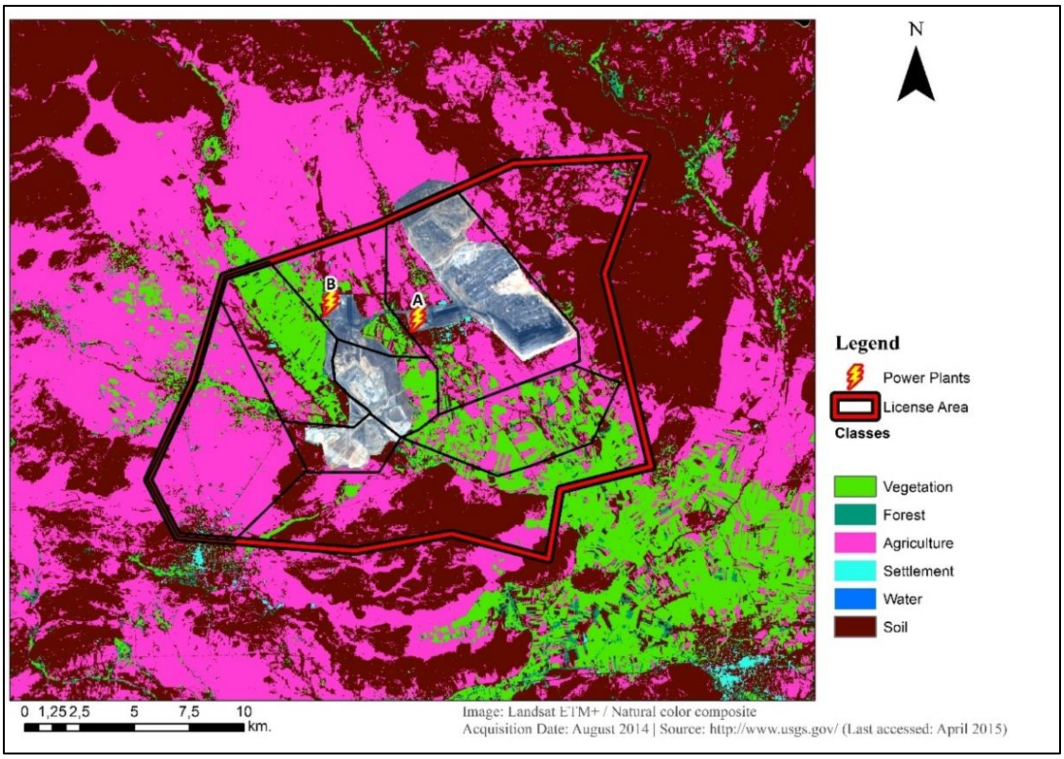

Figure 33. Land use land cover map of AECB
Source: Düzgün *et al.*, 2014

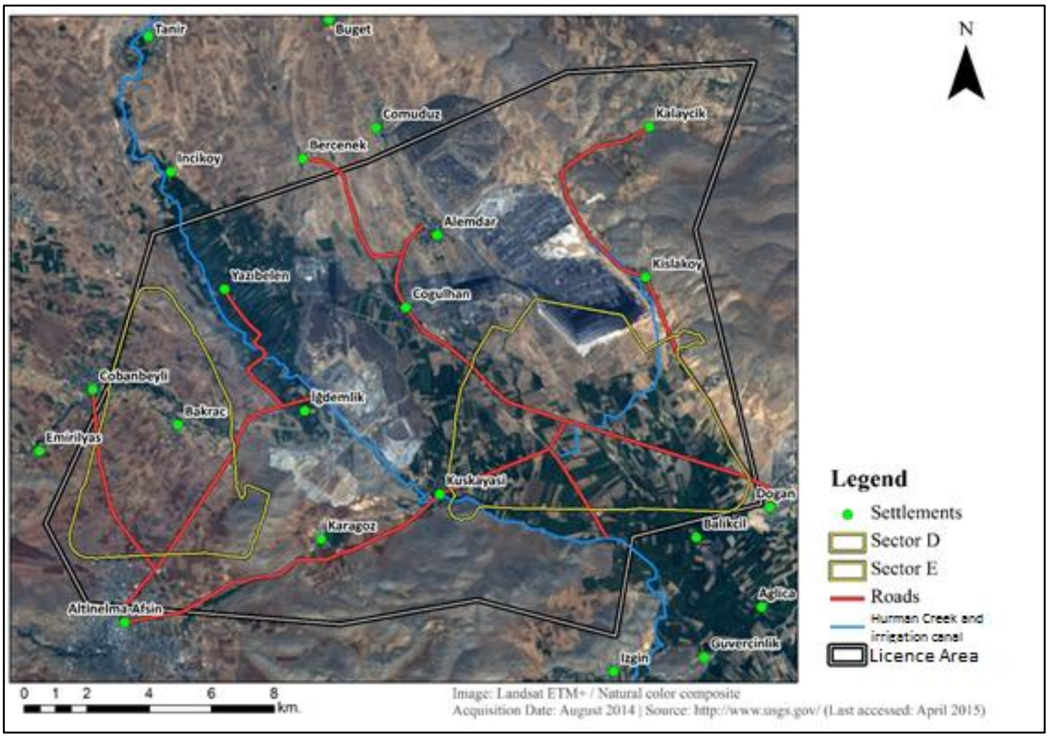

Figure 34. The satellite imagery with mine layouts, settlements and infrastructure in AECB
Source: Düzgün *et al.*, 2014

5.2.7.3. The Data Obtained from the Survey

The survey-based data is only used for the indicator with the ID of S6, which is 'percentage of local population thinking/observing the mining sector as a potential source of conflicts at the local level in terms of environmental issues, including land use and land acquisition' in the analysis.

In order to obtain this data for the no-action and other alternatives, the outcomes of the three questions are needed to be used. As quantitative information is tried to be obtained for a subject on the personal observation of the survey participants, different question results are needed to be used. The needed data is about the evaluation of the likeness of facing a positive or negative situation in the future related to the active mining operations and also possible mining operations, which are not observed or informed to locals. Therefore, this is asked to the locals and share of different opinions in the sample group is used as the quantitative data for analyze.

For this purpose, two questions results are used to provide data for the no-action alternative. These questions and obtained answers are given in Table 27 and Table 28 below. The highlighted percentages are used for calculating the percentage for the no-action situation. In fact, as there are two different results, the mean of these are used as the obtained data for analyses.

Table 27. Consideration and fulfilment of the expectation of the locals about land acquisition

(Q85)	Frequency	Percent	Valid Percent	Cumulative Percent
Increase	42	4.2	4.7	4.7
Decrease	111	11.0	**12.3**	17.0
Same no positive change in the positive direction	715	70.9	**79.5**	96.6
No idea	31	3.1	3.4	100.0
Total	899	89.1	100.0	
Missing answer	109	10.9		
Total	1008	100.0		

Table 28. Compression of the likeness change about the conflicts between the mining companies and the local communities

(Q86)	Frequency	Percent	Valid Percent	Cumulative Percent
Increase	464	46.0	**48.7**	48.7
Decrease	25	2.5	2.6	51.3
Same no positive change in the positive direction	400	39.6	42.0	93.3
No idea	64	6.3	6.7	100.0
Total	953	94.4	100.0	
Missing answer	55	10.9		
Total	1008	100.0		

Other than these for the Alternative 2 and Alternative 3, the related percentage of survey question given below is used as the data for analysis. The question, the question 39, asks the local stakeholder's expectations about the future of Afşin and Elbistan region. Several answers were provided in the questionnaire but only one choice is allowed. Regarding this question, 30.4 % of the participants chose the answer 'more mining operations and power plant investments will be practiced in the basin and all these will cause more problems'. Hence, this result is used as the data for analysis of Alternative 2 and Alternative 3 for the indicator S6.

5.2.8. Assessment and Evaluation of the Alternatives (Step 8)

The assessment step and evaluation step involve the application of transformation and weighting processes. These are discussed in detail in the following sections.

5.2.8.1. Transformation

The first step for the assessment is the transformation of the selected indicators. For this, the standardization method is applied. The reason for selecting standardization over normalization is that many of the selected indicators do not have any threshold values. Without threshold values, normalization cannot be applied. In fact, as the standardization method uses the standard deviation of values of alternatives for each indicator, the standardization is applied for each selected indicator.

The values and standardized values of the indicator under each alternative are given in Appendix J. After the application of the standardization, two indicators under the environmental set do not use further analysis. These indicators are ‘percentage of forest damaged by defoliation’ (E3) and ‘the number of sites on environmentally protected or sensitive areas, including both current and planned developments’ (E8). The reason for this is that the values for these indicators are ‘0’ in terms of all alternatives. Therefore, the standardized values are not obtained for these indicators. Hence, these two indicators are eliminated from further analysis.

5.2.8.2. Weighting

As it is discussed in Chapter 4, two weighting methods are applied. The first one is the equal weighting method, in which all the indicators are given the same weights while calculating the index score (IS) and also the sustainability index score (SIS) of each pillar. The second one is the analytical-hierarchy process (AHP), where different weights are used for each indicator in order to calculate the IS of each pillar. Additionally, the index weights of each sustainability pillar are also calculated with the AHP to obtain a final SIS of the alternatives.

a. Evaluation of the Plan Alternatives under Case 1 by using the Equal Weighting (EQW) Method

The weights of each indicator under the environmental, social and economic pillars are calculated based on the equation given below (Eq.11);

$$\frac{1}{22} = 0.045 \quad (11)$$

The standardized values of each indicator for each alternative are multiplied by a weight of 0.045 and all these are summed in order to obtain the index score of each pillar. The results are given in Table 29. The first 10 indicators are environmental indicators and as it is given in Appendix J, the environmental indicators give negative impact results.

The second group in Table 29 is social indicators, which numbers six. The standardized results of each social indicator are also multiplied by the weight and all these are summed to get the social index score (ISs). Social indicators also have a negative impact on the sustainability. Therefore, lower results of these indicators are more favorable for obtaining higher sustainability scores.

The third pillar is the economic pillar, where six indicators are given and the standardized values of them are also multiplied by the weight and afterwards the results are summed to obtain the economic index score (ISec). The economic index score has a positive impact on sustainability as it is given in Appendix J. Moreover, as the no-action alternative (Alternative 1) involves two separate mining operations, the arithmetic average of the standardized values of these two operations is used as the standardized value of Alternative 1 in Table 29.

The calculated index scores of each pillar are shown with grey rows in Table 29. The environmental pillar scores, named as the environmental index score (ISe), of Alternative 1, Alternative 2, and Alternative 3 are 0.69, 1.05, and 1.34 respectively. The social pillar score, ISs, of three alternatives are -0.02, 0.33, and 0.09 respectively. Lastly, the economic pillar score, ISec, of Alternative 1, Alternative 2, and Alternative 3 are calculated as 0.45, 0.58, and 0.36 respectively.

As it is mentioned above, the ISe has a negative effect on sustainability. Therefore, a higher ISe means a higher negative impact, so this indicates a poor sustainability situation. This must also be considered while calculating the cumulative sustainability scores (SIS) of the alternatives. In order to consider this, the ISe should be added as (-) score to the SIS calculation.

Therefore, these results must be multiplied by -1 while calculating the cumulative sustainability score (SIS). A similar situation is also applied for ISs. The scores of the social pillar indices (ISs) of the given case are -0.02, 0.33, and 0.09. As ISs also indicates a negative impact, the social index scores are also multiplied by (-1). The ISec has a positive impact on the sustainability score; therefore these results are used as obtained in Table 29.

The index scores are visualized in Figure 35. The figure mainly shows the score of each alternative for three pillars. The green line indicates the minimum sustainability level as a threshold. The threshold, shown with a green line, is determined as 0 for this case study because the SIS involves (-) and (+) index scores.

This means the sum of (+) values should be at least equal to (-) values while calculating the cumulative score in order to mitigate the possible negative impact by implementing the alternatives. The index scores of the alternatives are also shown with three different colors. In this way, it can be compared which alternative has a score equal to or higher than 0 for environmental, social, and economic pillars. Also the finalized index scores of the three pillars are given in Table 30.

Table 29. Index Scores (IS) of the alternatives with equally weighted indicators

Indicator ID	**Weight** (EQW method)	**A1**		**A1 average (No-action Alternative)**	**A2 (Sector D)**	**A3 (Sector E)**
		Sector A	**Sector B**			
E1	0.045	0.01	0.43	0.22	-0.23	2.31
E2	0.045	2.75	1.55	2.15	3.64	4.19
E4	0.045	3.63	1.50	2.57	3.55	4.09
E5	0.045	3.47	0.97	2.22	2.54	1.29
E6	0.045	-0.35	-0.76	-0.56	1.28	1.55
E7	0.045	-0.64	-0.70	-0.67	0.57	1.74
E9	0.045	4.33	1.52	2.93	2.86	3.10
E10	0.045	3.63	1.50	2.57	3.55	4.09
E11	0.045	5.18	2.67	3.93	4.63	4.99
E12	0.045	-0.43	-0.07	-0.25	0.79	2.17
Environmental Index Score (ISe)				0.69	1.05	1.34
S1	0.045	-1.00	-1.00	-1.00	1.31	-1.00
S2	0.045	-1.00	-1.00	-1.00	1.31	-1.00
S3	0.045	-1.00	0.41	-0.30	1.83	0.41
S4	0.045	-1.00	0.11	-0.45	0.66	1.77
S5	0.045	-0.21	-0.71	-0.46	1.76	1.16
S6	0.045			2.74	0.62	0.62
Social Index Score (ISs)				-0.02	0.34	0.09
Ec1	0.045	1.66	3.48	2.57	4.25	2.35
Ec2	0.045	2.76	2.30	2.53	1.12	0.21
Ec3	0.045	-0.01	-0.64	-0.33	1.54	1.70
Ec4	0.045	4.86	4.44	4.65	5.11	2.56
Ec5	0.045	0.03	1.83	0.93	-0.60	-0.62
Ec6	0.045	-0.01	-0.64	-0.33	1.54	1.70
Economic Index Score (ISec)				0.45	0.58	0.36

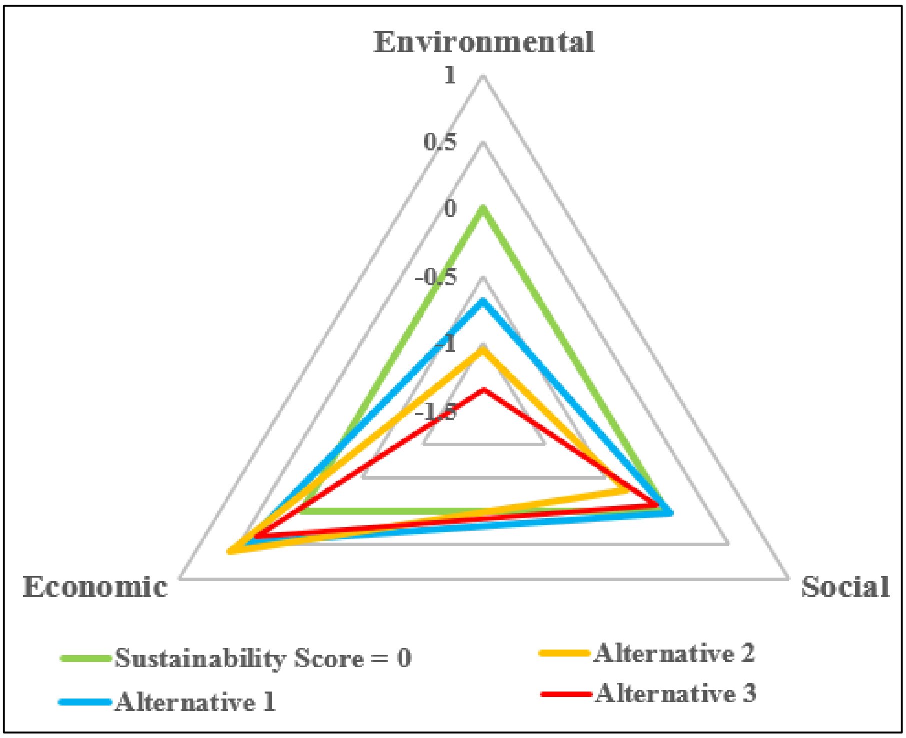

Figure 35. Index Scores (IS) of the alternatives according to the equal weighting method

Table 30. Index scores of the alternatives based on the equal weighting method

	Alternative 1	**Alternative 2**	**Alternative 3**
Environmental Index Score (ISe)	-0.69	-1.05	-1.34
Social Index Score (ISs)	0.02	-0.34	-0.09
Economic Index Score (ISec)	0.45	0.58	0.36

As it can be seen in Figure 35, all the alternatives have higher scores than 0 in the economic pillar and considerably lower scores in the environmental pillar. Among these alternatives, Alternative 1 has the closest score to 0 in the environmental pillar compared to the other two alternatives. For the social pillar, Alternative 1 has a slightly higher score and Alternative 3 has a score that is negative but very close to 0. In fact, this figure allows only the pillar-based sustainability comparison of the alternatives. For the cumulative comparison, the Sustainability Index Score (SIS) of the alternatives should be calculated.

After the calculation of all the three index scores, the final sustainability score of each alternative is obtained based on the equal weighting method. The weights of each sustainability pillar are calculated as (Eq.12);

$$\frac{1}{3} = 0.333 \quad (12)$$

The Sustainability Index Scores (SIS) of the alternatives are calculated with the equation given below (Eq.13);

$$SIS= [(- ISe \times 0.333) + (- ISs \times 0.333) + (ISec \times 0.333)] \quad (13)$$

The minus signs are given before the ISe and ISs because these two indices have negative impacts on the cumulative sustainability score, as it is discussed above. As a result, two index scores that negatively affect the total score (environmental and social indices) and an index score that positively affects the total score (economic index) are summed with equal weights in the final cumulative sustainability score of each alternative. The obtained final score of each alternative is used to compare the relative sustainability of each alternative among the others systematically. The results of the SIS calculation are given in Table 31.

Table 31. The sustainability index score of the alternatives based on the equal weighting method

	Alternative 1	**Alternative 2**	**Alternative 3**
Environmental Index Score (ISe)	-0.69	-1.05	-1.34
Social Index Score (ISs)	0.02	-0.34	-0.09
Economic Index Score (ISec)	0.45	0.58	0.36
Weight of each pillar in SIS	0.333		
Sustainability Index Score (SIS)	-0.07	-0.27	-0.36

As it can be seen in Table 31, the obtained sustainability results for Alternative 1 (the no-action alternative), Alternative 2 and Alternative 3 are -0.07, -0.27 and -0.36 respectively. This means that based on the selected indicators and the equal weighting method used, the most sustainable alternative among the suggested three alternatives is Alternative 1, which is the no-action alternative, with a SIS score of -0.07.

b. Evaluation of the Plan Alternatives under Case 1, by using the Analytical-Hierarchy Process (AHP) Method

The second method used to determine the weights of the indicators under each pillar as well as the weights of the pillars while calculating the SIS is AHP. The hierarchy system of the AHP process for selecting the sustainable mining plan alternative in AECB is given in Figure 36.

As it is given in the figure, each determined alternative is evaluated with the indicators, which have different importance weights. Additionally, the importance of each sustainability pillar is also considered while obtaining a sustainability score for each alternative.

At each criteria level in Figure 36, the contribution of each parameter, indicator or pillar is determined based on the pairwise comparison by the practitioner(s). The contribution is determined based on the judgments of the decision-makers and practitioners. However, expert or stakeholder consultation is used to avoid obtaining subjective contribution weights. For more detail about such an approach, the study by Erzurumlu and Erzurumlu (2014) can be seen.

For this study, the relative importance of the indicators are determined according to the indicator selection score matrix scores, which are given in Appendix G. The reason for this approach is minimizing the subjectivity and maximizing the reflection of local stakeholders and decision-making authorities' priorities into pairwise comparison. For these, only the scope and reliance criteria scores are considered.

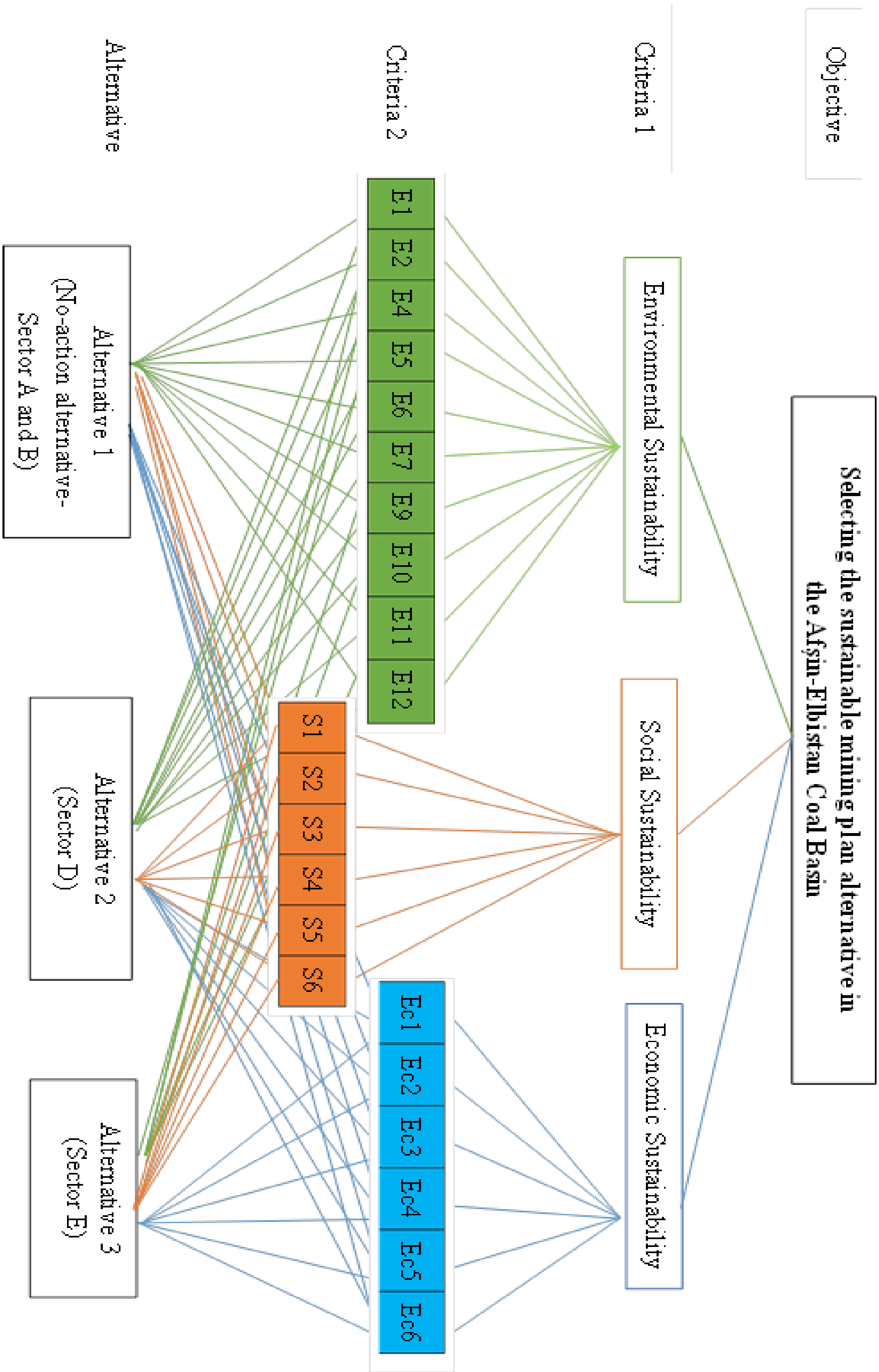

Figure 36. Decision hierarchy of selecting the sustainable mining plan alternative in AECB based on AHP

For the environmental indicators, the indicator selection scores are given in Table 32. As indicators, E3 and E8 have the same values for all the alternatives and so these do not affect the sustainability scores of the alternatives; these are not used for further analysis. For this reason, these are not also considered for the pairwise comparison and further analysis.

Table 32. Environmental indicator selection scores and pairwise comparison importance levels

Indicator ID	Scope		Relevance	Score	Importance order
	A	B			
E1	3	1	3	7	3
E2	3	2	3	8	2
E3	3	1	3	7	
E4	3	3	3	9	1
E5	3	3	3	9	1
E6	3	3	3	9	1
E7	3	3	3	9	1
E8	3	1	3	7	
E9	3	3	3	9	1
E10	3	3	3	9	1
E11	3	2	3	8	2
E12	3	1	3	7	3

As it is seen Table 32, the highest importance is given to the indicators E4, E5, E6, E7, E9, and E10. The second important indicator group involves the indicators E2 and E11. Finally, E1 and E12 are considered to be the least important indicators compared to the others. For the comparison, the scales and criteria used are given in Table 33. The original table is given by Saaty (2008), which is in Table 4.1.2.

Based on the given scales in Table 33, the comparison matrix for each indicator group under three pillars is developed. The comparison matrix of the environmental indicators is given in Table 34. While this matrix is developed, the scales are given according to the importance order determined above. As the indicators E4, E5, E6, E7, E9 and E10 are more important than others, these are scored as ‘moderately important’ compared to E2 and E11, and ‘strongly more important’ than E1 and E12. The main reason to avoid using scales of 7 and 9 is that the total indicator selection scores of all these indicators are very close to each other as it can be seen in Table 32.

Also the AHP weights are calculated with an open source Microsoft Excel-based AHP calculation template tool that is downloaded online (SCB, 2015). As a rule of thumb of the AHP, the consistency ratio (CR) of the matrix must be equal to or smaller than 0.1. Therefore, the given scores and obtained weights are determined by considering the CR during the pairwise comparison.

Table 33. Pairwise comparison scales

Definition	Scale of importance
Extremely less important	1/9
	1/8
Very strongly less important	1/7
	1/6
Strongly less important	1/5
	1/4
Moderately less important	1/3
	1/2
Equal importance	1
	2
Moderately important	3
	4
Strongly more important	5
	6
Very strongly important	7
	8
Extremely more important	9

Source: Saaty, 2008

Table 34. Pairwise comparison matrix of the environmental indicators

Indicator ID	E1	E2	E4	E5	E6	E7	E9	E10	E11	E12	AHP weight	CR
E1	1	1/3	1/5	1/5	1/5	1/5	1/5	1/5	1/3	1	0.027	0.01
E2	3	1	1/3	1/3	1/3	1/3	1/3	1/3	1	3	0.049	
E4	5	3	1	1	1	1	1	1	3	5	0.141	
E5	5	3	1	1	1	1	1	1	3	5	0.141	
E6	5	3	1	1	1	1	1	1	3	5	0.141	
E7	5	3	1	1	1	1	1	1	3	3	0.140	
E9	5	3	1	1	1	1	1	1	3	5	0.141	
E10	5	3	1	1	1	1	1	1	3	5	0.141	
E11	3	1	1/3	1/3	1/3	1/3	1/3	1/3	1	3	0.049	
E12	1	1/3	1/5	1/5	1/5	1/3	1/5	1/5	1/3	1	0.030	

In order to determine the importance level of the social indicators, the same approach is adopted. In fact, only two importance levels are determined for the social indicators. The importance levels of the indicators are given in Table 35. According to the obtained results, indicators with IDs S1, S2 and S5 are moderately more important than S3, S4 and S6. The comparison matrix of social indicators is given in Table 36.

As the third indicator set, the importance level of economic indicators is determined based on the selection scores, as it is given in Table 37. Based on this, the most important economic indicators are determined as Ec2, Ec3, Ec5 and Ec6. Ec4 is obtained in the second importance order and lastly Ec1 is determined as the least important indicator in this group.

Table 35. Social indicator selection scores and pairwise comparison importance levels

Indicator ID	Scope A	Scope B	Relevance	Score	Importance order
S1	2	3	3	8	1
S2	2	3	3	8	1
S3	2	2	3	7	2
S4	2	3	2	7	2
S5	2	3	3	8	1
S6	2	2	3	7	2

Table 36. Pairwise comparison matrix of the environmental indicators

	S1	S2	S3	S4	S5	S6	AHP weight	CR
S1	1	1	3	3	1	3	0.250	0.00
S2	1	1	3	3	1	3	0.250	
S3	1/3	1/3	1	1	1/3	1	0.083	
S4	1/3	1/3	1	1	1/3	1	0.083	
S5	1	1	3	3	1	3	0.250	
S6	1/3	1/3	1	1	1/3	1	0.083	

Considering the scores of economic indicators, it is seen that the scores are close to each other. Therefore, the same approach is used in the environmental indicator scaling for the importance of the economic indicators in Table 38. Regarding this, indicators Ec2, Ec3, Ec5 and Ec6 are scaled as moderately more important than Ec4 and strongly more important than Ec1 in Table 38. The CR for the economic indicators weight is 0.00.

Table 37. Economic indicator selection scores and pairwise comparison importance levels

Indicator ID	**Scope** A	**Scope** B	**Relevance**	**Score**	**Importance order**
Ec1	3	0	3	6	3
Ec2	2	3	3	8	1
Ec3	2	3	3	8	1
Ec4	3	1	3	7	2
Ec5	2	3	3	8	1
Ec6	2	3	3	8	1

Table 38. Pairwise comparison matrix of the environmental indicators

	Ec1	Ec2	Ec3	Ec4	Ec5	Ec6	AHP weight	CR
Ec1	1	1/5	1/5	1/3	1/5	1/5	0.043	0.00
Ec2	5	1	1	3	1	1	0.220	
Ec3	5	1	1	3	1	1	0.220	
Ec4	3	1/3	1/3	1	1/3	1/3	0.076	
Ec5	5	1	1	3	1	1	0.220	
Ec6	5	1	1	3	1	1	0.220	

After determining the AHP weights of each indicator, the index scores are calculated for each alternative. As the aim of determining the AHP weight of each indicator is to allow the contribution of each indicator to the total index score based on its relative importance determined by the stakeholders, decision-makers or experts, the obtained index score indicates a higher relevance compared to the EQW method.

For this study, the obtained AHP weights of each indicator and also the calculated scores of environmental, social and economic indices are given in Table 39. As it is discussed previously in this section, the environmental and social indices indicate a negative impact. Therefore, smaller scores for these two indices are better in terms of sustainability.

Table 39. Sustainability pillars' index scores of the alternatives based on AHP method

Indicator ID	**Weight** (AHP method)	**A1**		**A1 average (No-action Alternative)**	**A2 (Sector D)**	**A3 (Sector E)**
		Sector A	**Sector B**			
E1	0.027	0.01	0.43	0.22	-0.23	2.31
E2	0.049	2.75	1.55	2.15	3.64	4.19
E4	0.141	3.63	1.50	2.57	3.55	4.09
E5	0.141	3.47	0.97	2.22	2.54	1.29
E6	0.141	-0.35	-0.76	-0.56	1.28	1.55
E7	0.140	-0.64	-0.70	-0.67	0.57	1.74
E9	0.141	4.33	1.52	2.93	2.86	3.10
E10	0.141	3.63	1.50	2.57	3.55	4.09
E11	0.049	5.18	2.67	3.93	4.63	4.99
E12	0.030	-0.43	-0.07	-0.25	0.79	2.17
Environmental Index Score (ISe)				1.57	2.45	2.81
S1	0.250	-1.00	-1.00	-1.00	1.31	-1.00
S2	0.250	-1.00	-1.00	-1.00	1.31	-1.00
S3	0.083	-1.00	0.41	-0.30	1.83	0.41
S4	0.083	-1.00	0.11	-0.45	0.66	1.77
S5	0.250	-0.21	-0.71	-0.46	1.76	1.16
S6	0.083			2.67	0.55	0.55
Social Index Score (ISs)				-0.45	1.35	0.02
Ec1	0.043	1.66	3.48	2.57	4.25	2.35
Ec2	0.220	2.76	2.30	2.53	1.12	0.21
Ec3	0.220	-0.01	-0.64	-0.33	1.54	1.70
Ec4	0.076	4.86	4.44	4.65	5.11	2.56
Ec5	0.220	0.03	1.83	0.93	-0.60	-0.62
Ec6	0.220	-0.01	-0.64	-0.33	1.54	1.70
Economic Index Score (ISec)				1.08	1.36	0.95

Furthermore, it should be considered that even if the index score is a positive number, it will be multiplied by (-1) while cumulative sustainability score is calculated. Consequently, a positive environmental index score (ISe) and social index score (ISs) should be considered as a negative score and the negative score should be considered as positive.

Contrary to this, the economic index score indicates a positive impact of the alternative in terms of sustainability. Therefore, the bigger the economic index score is, the higher cumulative sustainability score is obtained. Regarding these explanations, on the individual pillar cases, different sustainability results are obtained. For instance, ISe values of Alternative 1, Alternative 2 and Alternative 3 are 1.57, 2.45 and 2.81, respectively.

Therefore, as Alternative 1 has a smaller ISe value, it is a relatively sustainable plan alternative among the others in terms of environmental sustainability, because, as it is explained above, the ISe values of each alternative should be multiplied by (-1). As a result, the index scores of these three alternatives become -1.57, -2.45 and -2.81, respectively. Hence, as all of them have negative values, a value closer to 0 is better. The same case is also true for the social index score (ISs).

As the smallest ISs score is obtained for Alternative 1, the ISs-based sustainable alternative is also Alternative 1. Alternative 1 has ISs of -0.45. The ISs values of the other two alternatives are 1.35 and 0.02. As the index indicates a negative impact, these scores are multiplied by (-1) and so the obtained ISs are 0.45, -1.35 and -0.02 for Alternative 1, 2 and 3, respectively. As Alternative 1 has the highest score among three alternatives, it is accepted as the sustainable alternative in terms of social sustainability priorities.

Regarding the economic index score (ISec), a higher score indicates a sustainable choice as its results positively affect the sustainability. In this respect, the highest value means the highest sustainability in terms of economic sustainability of the alternatives.

Among the three alternatives, Alternative 2 has the highest score, which is 1.36. Compared to this score, Alternative 1 with an ISec of 1.08 and Alternative 3 with an ISec of 0.95 are less sustainable than Alternative 2. Based on these, the finalized index scores of the three pillars are given in Table 40.

Table 40. Index scores of the alternatives based on the AHP method

	Alternative 1	**Alternative 2**	**Alternative 3**
Environmental Index Score (ISe)	-1.57	-2.45	-2.81
Social Index Score (ISs)	0.45	-1.35	-0.02
Economic Index Score (ISec)	1.08	1.36	0.95

The index scores are visualized in Figure 37. The figure mainly shows the score of each alternative for three pillars. The green line indicates the minimum sustainability level as a threshold. The threshold, shown with the green line, is determined as 0 for this case study. The index scores of the alternatives are also shown with three different colors. In this way, it can be compared which alternative has a score equal to or higher than 0 for the environmental, social and economic pillars.

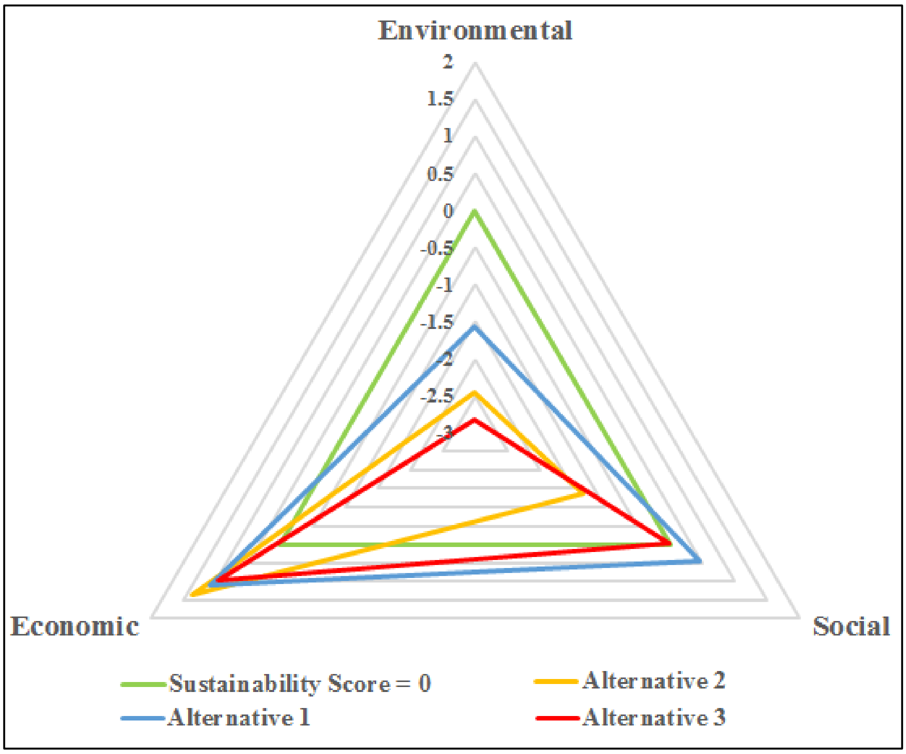

Figure 37. Index Scores (IS) of the alternatives based on AHP method

Even though it is possible to discuss the sustainability of the alternatives under environmental, social and economic sustainability pillars separately, it is aimed to obtain a single sustainability value for each of the alternatives. Such a single value indicates a cumulative score that can be used to compare the alternatives at the same scale.

For this purpose, the AHP weights of three pillars are also determined under this study. As different relative importance can be determined among these pillars based on the understanding and priorities of different stakeholders, several AHP weights are calculated. These are discussed under the reporting step of the proposed framework.

5.2.9. Reporting (Step 9)

The reporting step of the developed framework does not involve any specific outline. Any available reporting format from the literature or the standard reporting format of the authority, who performed the analysis can be used. For this reason, the reporting section under this study is used to apply the sensitivity analysis to the outcomes of the assessment results of the case study. For this purpose, the obtained assessment results are discussed in a greater detail under three main parts, which are;

- Equal weighting method (EQW) results for Case 1
- Analytical-hierarch process method (AHP) results for Case 1
- Energy priority focused further analysis results as Case 2

5.2.9.1. Sustainability Index Score based on EQW Method for Case 1

A total of 22 indicators are used to evaluate the environmental, social and economic impacts of three alternatives and based on this evaluation, these alternative are scored. As EQW is practiced, the contribution of all 22 indicators to the total score is the same. This means that none of the indicators used are counted more important than the others. The same approach is applied for the pillars of the sustainability, which are environmental, social and economic pillars. These three pillars are considered as equally important, so their contribution to the total sustainability score of the alternatives is the same.

The results of EQW method, given in Section 5.2.8 (Step 8), indicate that Alternative 1, which is the no-action alternative, is a more sustainable option among the three alternative mining plans in AECB. However, it should be also considered that the final score of Alternative 1 is less than 0. This means that based on the sustainability criteria, which is defined by the local stakeholders, and the selected indicators, all the evaluated alternatives are not sustainable. This is because the negative impacts are higher than positive outcomes of the alternatives. Therefore, it can be concluded that Alternative 1 is comparatively sustainable among the three alternatives because like the others, its negative impacts are still higher than its positive outcomes in total.

All the given values in Table 31 in Section 5.2.8 are also shown with a bar chart in Figure 38. In this figure, the relative sustainability of Alternative 1 is shown in a clearer manner. The score line of 0 indicates the sustainability threshold, where the negative impacts are equal to the positive ones. As the SIS of Alternative 1 is much close to the threshold line of 0 compared to the other two alternatives, it is concluded that the no-action is the best choice.

If the scores of each sustainability pillar are considered in Figure 38, the environmental impacts of three alternatives are significantly high. Especially Alternative 3, which is the mining operation in Sector E, has the highest negative impact among three alternatives. The main reason for this is that Sector E uses a large area with a considerably low recovery amount.

Regarding the social pillar, the main alternative that affects negatively is Alternative 2, which is the mining operation in Sector D. The main reason for this is that the alternative causes the resettlement of a relatively high populated settlement in the region. Contrary to Alternative 2 and 3, Alternative 1 has a positive social effect in the region because it demands less land than the other two alternatives.

Lastly, as it is shown in Figure 38, the economic pillar scores of the alternatives are positive. Alternative 2 obtains the highest score in terms of economic impacts of the mining plans in AECB. The main reason of this is that Alternative 2 has a higher recovery of the natural resource and so a high potential of total lignite production compared to the other alternatives.

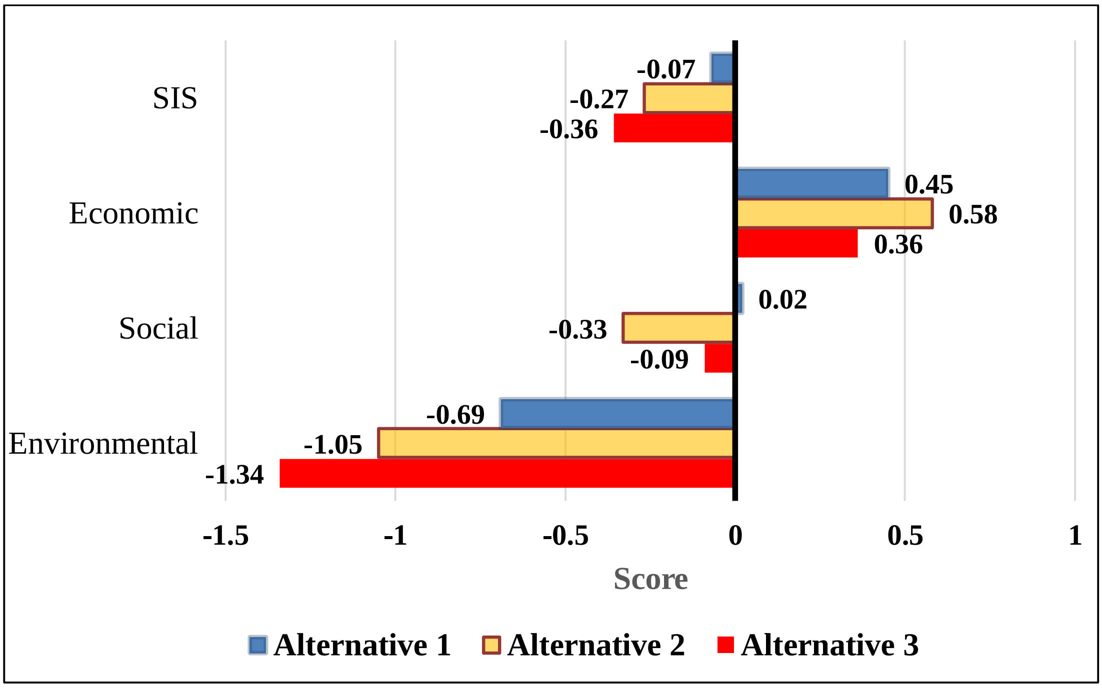

Figure 38. Sustainability scores based on EQW method

5.2.9.2. Sustainability Index Score based on the AHP Method for Case 1

The second applied method for weighting the indicators and also pillars while calculating the sustainability scores of the alternatives in Section 5.2.8 is the analytical-hierarchy process (AHP). As it is mentioned in Section 5.2.8, the AHP method works based on the relative importance of several criteria within an assessment to achieve the defined AHP objective.

Therefore, different results may be obtained by defining different importance for the criteria. These relative importance comparisons can be carried out through several approaches, such as stakeholder consultation or expert consultation (Si *et al.*, 2010; Erzurumlu and Erzurumlu, 2014). For this study, a similar approach is also conducted in a modified way due to time and financial limitations.

The framework involves an indicator selection approach. This involves the use of a scoring matrix, given in Appendix G. The matrix has several scoring criteria; scope and relevance are two of them. These two criteria are mainly used for evaluating the compatibility of the suggested indicator with the strategy's scope and localized sustainability principles. Therefore, these two criteria mainly show the given importance of the evaluated indicator by the stakeholders while conducting the sustainability assessment. In this respect, these results also show that some of the indicators are considered more important than others by the stakeholders. Based on this scoring, the indicators used in the analysis are grouped from the highest to the lowest scores. In fact, only the scope and relevance scores are considered in this stage. All these are shown in tables in Section 5.2.8.

As the pairwise comparison of indicators under the environmental, social and economic pillars are completed, the score of each pillars for the alternatives are obtained. However, it is also necessary to determine the relative importance of the three pillars for calculating the cumulative sustainability scores of the alternatives. At this stage, the best option may be using the stakeholders' opinion as well.

Nevertheless, several different priorities are decided to use while obtaining the final score for this study in order to see how the Sustainability Index Scores (SIS) of three alternatives change depending on the priority and also to discuss the impact of the different priorities on SIS. For this, the pairwise comparison matrixes are developed and the obtained AHP scores of different priorities are shown in Table 41.

As it is seen in Table 41, six different sustainability index scores (SIS) for three alternatives are obtained based on different importance levels among three pillars. There are two SISs with environmental priority, one SIS with social priority, two SISs with economic priority and also a SIS to which equal importance is given is obtained. While these are calculated through the Excel-based open source AHP calculation template tool (SCB, 2015), CR is controlled and all of the weights are calculated for CRs lower than 0.1.

In order to avoid any misunderstanding during the discussions, environmental and social pillar scores are multiplied by (-1) while the calculations are conducted. Therefore, the entire SISs in Table 41 are the final results for three alternatives.

Table 41. AHP weight calculations and sustainability index score (SIS) for different priorities

	Environmental	Social	Economic	Weight (AHP method)	CR*	SIS		
						Alternative 1	Alternative 2	Alternative 3
Environmental	1	3	5	0.650				
Social	1/3	1	3	0.234	0.04	-0.790	-1.747	-1.721
Economic	1/5	1/3	1	0.116				
Environmental	1	3	9	0.691				
Social	1/3	1	5	0.240	0.04	-0.903	-1.919	-1.881
Economic	1/9	1/5	1	0.069				
Environmental	1	1/3	1	0.200				
Social	3	1	3	0.600	0	0.175	-1.025	-0.382
Economic	1	1/3	1	0.200				
Environmental	1	1	1/5	0.146				
Social	1	1	1/3	0.203	0.03	0.568	0.257	0.206
Economic	5	3	1	0.651				
Environmental	1	1	1/9	0.091				
Social	1	1	1/9	0.091	0	0.784	0.770	0.522
Economic	9	9	1	0.818				
Environmental	1	1	1	0.333				
Social	1	1	1	0.333	0	-0.012	-0.809	-0.625
Economic	1	1	1	0.333				

*Consistency ratio (CR) must be ≤ 0.1

The calculated weights of the environmental, social, and economic pillars and the SIS of three alternatives in Table 41 are rearranged for specifically three pillars from the lowest scales to the highest. The first of these is the environmental pillar weights and the SIS scores of the alternatives, which is given in Table 42.

The lowest environmental pillar weight in Table 42 indicates that the SIS scores of the alternatives include the lowest environmental impact value. As the environmental impacts of the alternatives are negative and high in the equal weighting case (see Figure 38), it should be expected that the lower the environmental weight in SIS is, the higher the sustainability result of the alternatives becomes. And the opposite of this is also expected as higher environmental importance in the evaluation of the alternatives causes a low SIS of the alternatives.

Table 42. SIS of alternatives for different environmental pillar weights

Environmental Pillar Weight in SIS Score	SIS Score of Alternative 1	SIS Score of Alternative 2	SIS Score of Alternative 3
0.091	0.784	0.770	0.522
0.146	0.568	0.257	0.206
0.2	0.175	-1.025	-0.382
0.333	-0.012	-0.809	-0.625
0.65	-0.790	-1.747	-1.721
0.691	-0.903	-1.919	-1.881

In order to see the change, the graph of environmental pillar weight versus SIS is developed and given in Figure 39. As it is mentioned above, it is clearly seen that the SIS of the alternative decreases while the environmental weight of the alternative in SIS increases, because the trend lines of three alternatives, shown with a dash line in Figure 39, shows this situation is true for all alternatives. In fact, the drop in 0.2 weight value for Alternative 2 is more significant than the other two alternatives.

As the Figure 39 is investigated closely, it is also concluded that Alternative 2 and Alternative 3 are less sustainable than Alternative 1 in terms of environmental pillar, because these two alternatives intersect 0 sustainable value at 1.60 and 1.70 weight values respectively. However, Alternative 1 is sustainable up to 0.33 environmental weight in the SIS based on the determined pairwise importance of the indicators in Table 34.

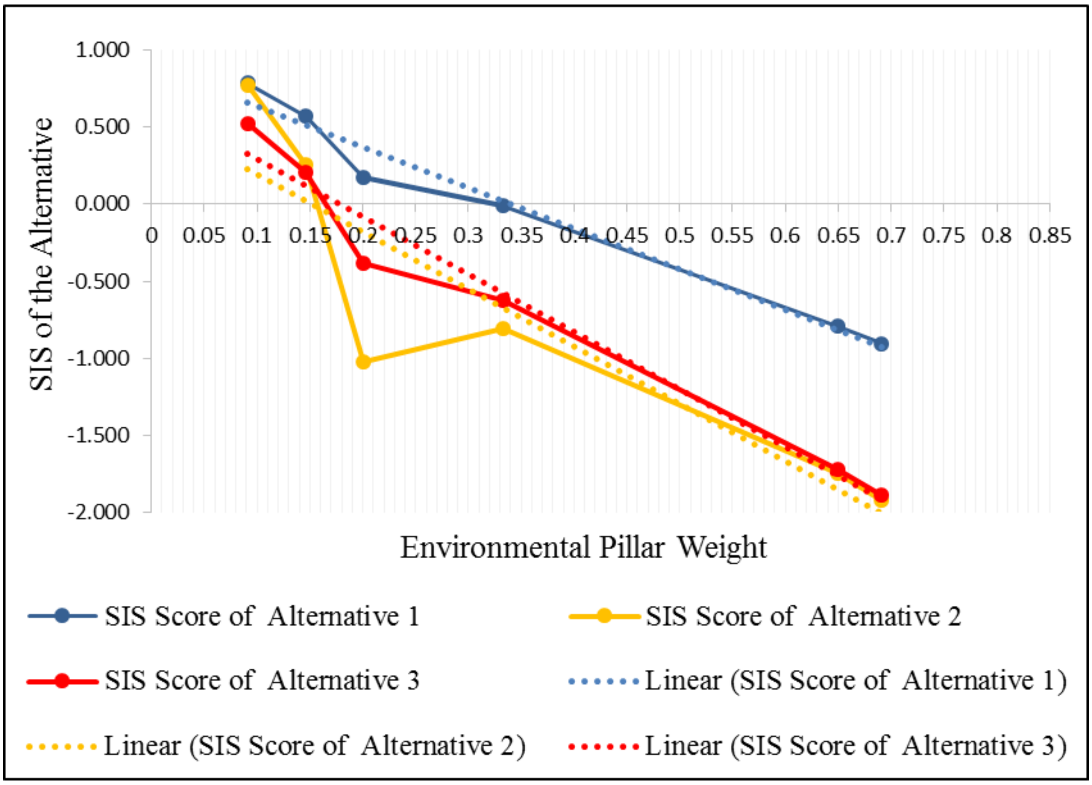

Figure 39. Sustainability index score (SIS) vs. environmental pillar weight

A similar discussion is also made for the social pillar. Firstly, the SIS values of three alternatives are calculated for different social weights with the AHP. These are also sorted from the lowest weight value to the highest in Table 43. For the social pillar, half of the weights are obtained between 0.2 and 0.25 in order to keep the CR equal to or smaller than 0.1. Figure 40 is prepared with the obtained SIS values for different weights for further discussion.

Regarding the trend lines in Figure 40, the increase in social weight in SIS causes a decrease in the SIS result. This is more significant for Alternative 2 than Alternative 3 and Alternative 1 because the application of the alternative causes resettlement of a village with a population of 1368 in the basin. Additionally, the drop from positive to negative SIS is more significant in the social pillar than the environment pillar, especially for Alternative 2 and 3.

Table 43. SIS of alternatives for different social pillar weights

Social Pillar Weight in SIS Score	SIS Score of Alternative 1	SIS Score of Alternative 2	SIS Score of Alternative 3
0.091	0.784	0.770	0.522
0.203	0.568	0.257	0.206
0.234	-0.790	-1.747	-1.721
0.24	-0.903	-1.919	-1.881
0.333	-0.012	-0.809	-0.625
0.6	0.175	-1.025	-0.382

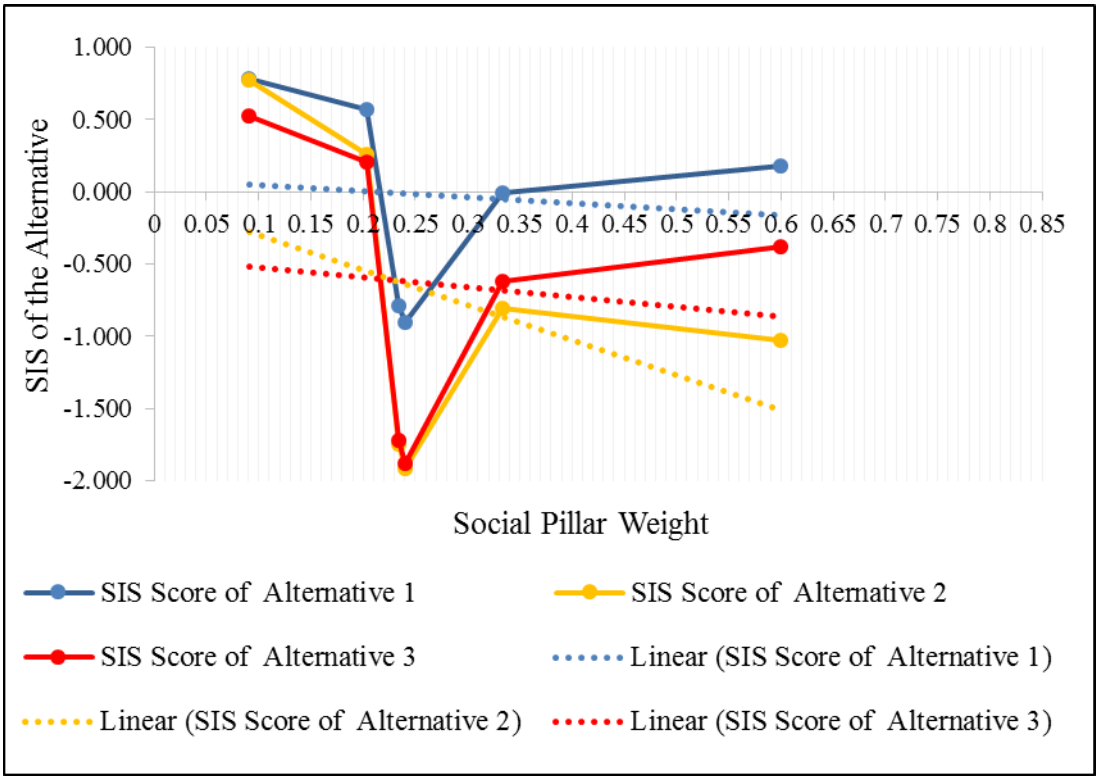

Figure 40. Sustainability index score (SIS) vs. social pillar weight

All the alternatives has positive SISs up to 0.21 weight value and the SIS values drop dramatically for higher social pillar weights of more than 0.21. The equal weight of 0.33 for three pillars in the SIS is important for further discussion because the SIS values increase also significantly for all the alternatives up to 0.33. Even Alternative 1 passes the threshold value of 0 at this weight and the SIS of the alternative continues to increase afterwards. The SIS of Alternative 3 also increases significantly for the social pillar weights higher than 0.24 and smaller than 0.33. Also it has a slight increase towards the threshold value of 0 for weights higher than 0.33.

In fact, different weights are calculated in order to see if and where the SIS line of Alternative 3 will intersect with the threshold value. The highest possible score for a criterion within a three-criterion AHP matrix with a CR value, equal to and smaller than 0.1, is 0.818. This value is used for calculating the SIS of three alternatives but it is seen that the SIS line does not intersect with the threshold value at 0 even for the highest possible social pillar weight for Alternative 3.

Lastly, the same discussions are preceded for economic weight effect in SIS values of the alternatives. The calculated SIS for different economic pillar weights are given in Table 44. Also these values are shown in a chart in Figure 41. As it is shown in the figure, three alternatives have increasing SIS values with increasing economic pillar weights starting from 0.069.

Among the three alternatives, Alternative 1 is the first one to intersect with the sustainability threshold value at the economic pillar weight of 0.185. The SIS lines of Alternative 2 and Alternative 3 intersect with the sustainability threshold value of 0 at 0.575 as it is shown in Figure 41.

Table 44. SIS of alternatives for different economic pillar weights

Economic Pillar Weight in SIS Score	**SIS Score of Alternative 1**	**SIS Score of Alternative 2**	**SIS Score of Alternative 3**
0.069	-0.903	-1.919	-1.881
0.116	-0.790	-1.747	-1.721
0.2	0.175	-1.025	-0.382
0.333	-0.012	-0.809	-0.625
0.651	0.568	0.257	0.206
0.818	0.784	0.770	0.522

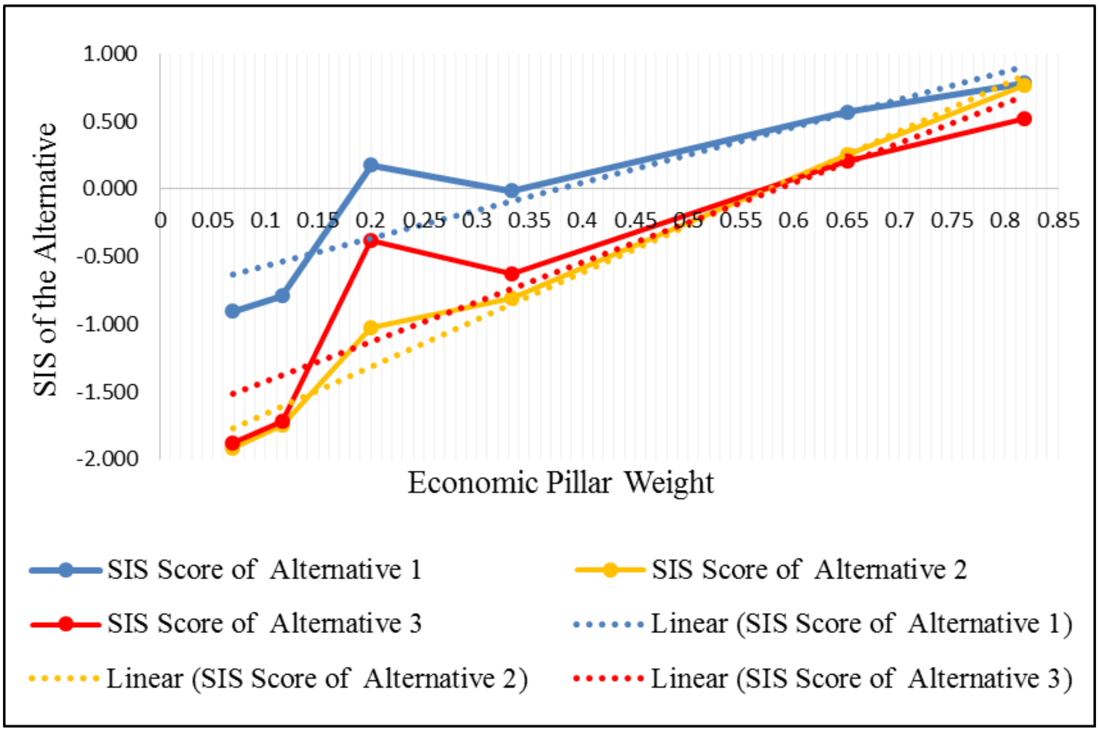

Figure 41. Sustainability index score (SIS) vs. economic pillar weight

In order to obtain a final result that is based on the AHP method, the importance levels of the environmental, social and economic pillars are determined based on the results of the applied survey in the basin by Düzgün *et al.* (2014). The locals who participated in the survey believe that the most important problems in the basin are air pollution from thermal power plants (37.6%), unemployment (25.4%), decrease of water amount (8.2%), lack of infrastructure (8.2%), water pollution (4.7%) and financial difficulties - high cost of living in the basin (2.8%).

As the main purpose of the lignite mining in the basin is to generate electricity at two thermal power plants, the air pollution should also be considered for determining the pillars' weight. As a result of this, the priority of the locals in the basin is environmental, because 50.5% of the participants believe that the main problems in the basin are air pollution, water pollution and a decrease in water amount.

Secondly, unemployment is considered as a significant problem in the basin by 25.4% of the participants and financial difficulties of the locals is also seen as an economic problem by 2.8% of the participants. Therefore, the importance of the economic pillar for the AHP weight calculation is considered as 28.2%. Lastly, 8.2%

of the participants say the lack of infrastructure is an important issue for them with other social issues, such as transportation difficulties and problems (1.3%). Hence, the weight of the social pillar is determined as 21.3% in the final calculation here.

Considering the priority obtained from stakeholder consultation through applied questionnaires in AECB and also the focus group meetings organized in Afşin and Elbistan Districts, weights for the environmental, social and economic pillars used for the AHP method are determined as it is given in Table 45 and these are 0.50, 0.21 and 0.29 respectively. Based on the determined AHP weights in Table 45, the calculated SIS of three alternatives, shown in Figure 42, are -0.38 for Alternative 1, -1.11 for Alternative 2, and -1.13 for Alternative 3.

Table 45. AHP weights based on AECB local stakeholder survey

	Environmental	Social	Economic	Weight (AHP)	CR
Environmental	1	2	2	0.50	0.05
Social	1/2	1	1/2	0.21	
Economic	1/2	2	1	0.29	

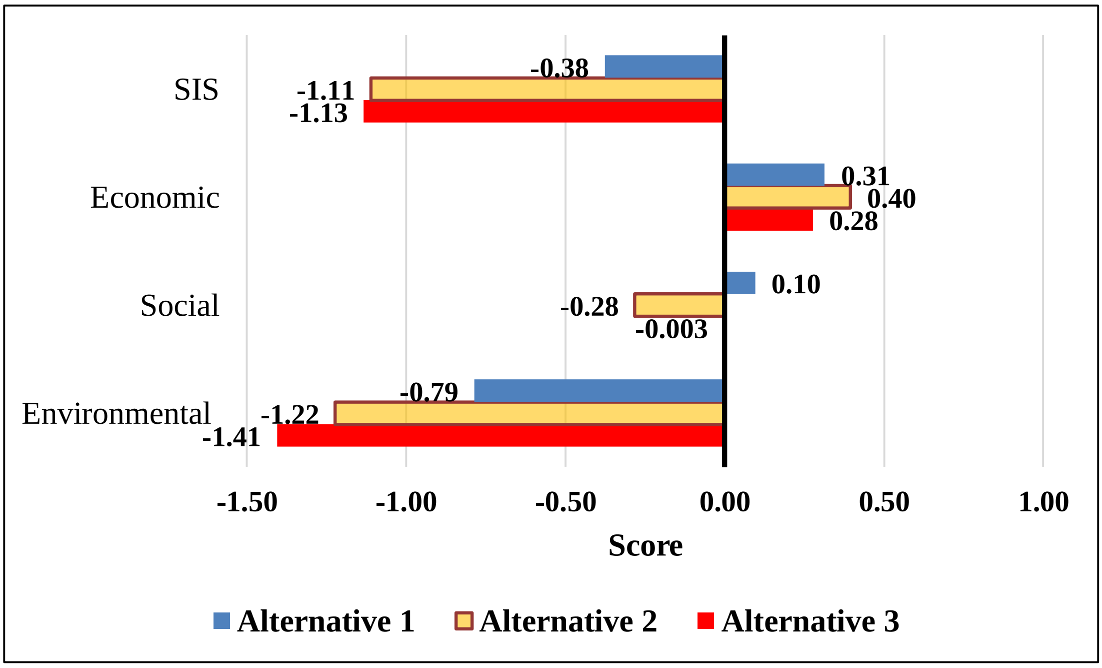

Figure 42. Sustainability scores based on AHP method

5.2.9.3. Implementation of the Framework for the Energy Priority Focused Case

The framework is implemented once more to evaluate the mining sector plan alternatives in AECB with a specific focus of the objective of security of energy supply. For this application, the indicators are selected based on the following strategic objectives and scopes that are obtained from the electricity sector report by EÜAŞ (EÜAŞ, 2015a).

The objectives of the energy policy are given as;

- Considering the environmental sensitivity in the activities of the energy and natural resources sector;
- Increasing the contribution of domestic natural resources to the country's economy.

The strategic target is given as;

- Using the proven lignite and hard coal reserves in electricity generation

The selection of the indicator in terms of the new objective and scope criteria are given in Appendix K. The final sets of indicators are obtained for environmental, social and economic pillars and these are given in Table 46, Table 47, and Table 48 respectively.

Table 46. Final environmental indicator set for Case 2

ID	Indicator	Unit
E1	Percentage of each resource left relative to the total amount of the permitted reserves of that resource*	%
E2	Total area of permitted development (mines and all other facilities)	ha
E3	Total land area newly opened for extraction activities (including area for overburden storage and tailings)	ha
E4	Percentage of newly opened land area relative to total permitted development	%

*The original indicator is needed to be transformed to negative impact as all other selected indicators in the set indicate negative impact conditions (the original version is given in Chapter 3 and Appendix K). This way the obtained index score will indicate that smaller score is more sustainable

The selected indicators, given in Table 46, Table 47, and Table 48 are analyzed with two weighting methods. The first method is the equal weighting method, which considers the importance of the indicators as well as the pillar equally while calculating the sustainability scores of each alternative.

Table 47. Final social indicator set for Case 2

ID	Indicator	Unit
S1	Total new land acquisition*	ha
S2	Percentage of local population thinking/observing the mining sector as a potential source of conflicts at the local level in terms of environmental issues, including land use, and land acquisition**	%

* As the strategic action strongly stresses the use of all the proven lignite resources for electricity generation and as the energy policy highlights increasing the natural resources' contribution to country's economy, the acquisition of land contributes to the achievement of these two. Therefore, this indicator is accepted as positive.
**Hence the indicator indicates a negative impact. For the sake of the social index, the indicator needs to indicate positive outcome in order to obtain a cumulative positive result from the economic index. Therefore, the indicator value will be standardized as a dominator of 1.

The second weighting method is the analytical-hierarchy process (AHP). As it is discussed in Section 5.2.8 that the weights and the pillars of the indicators are determined based on the relative importance compression of the indicator- and pillar-pairs.

In order to develop the index, before the weighting, transformation must be applied to the selected indicators. Also the values of the selected indicators are standardized before the weighting. The standardization process is given in Appendix L. As it is also conducted in Section 5.2.8, the standardization is applied for each selected indicator.

Table 48. Final economic indicator set for Case 2

ID	Indicator	Unit
Ec1	Production amount of sellable products	tonnes
Ec2	Produced goods or services per land input	%
Ec3	Recovery of reserve (ratio of alternative’s tonne / estimated tonne)	%
Ec4	The number of families (individuals) needing to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations. *	Nbr

* The vocational qualifications of the locals need to be improved for shifting the source of income from traditional economic activities to employment in the industry and in the service sector. In addition to this, resettlement etc. is necessary. Hence the indicator indicates a negative economic impact. For the sake of the economic index, the indicator needs to indicate positive outcome in order to obtain a cumulative positive result from the economic index. Therefore, the indicator value will be standardized as a dominator of 1.

a. Sustainability Index Score for Case 2 based on the EQW Method

The weights of each indicator under the environmental, social and economic pillars are calculated based on the equation given below (Eq.14);

$$\frac{1}{10} = 0.1 \quad (14)$$

The standardized values of each indicator for each alternative are multiplied by the weight of 0.111 and all these are summed in order to obtain the index score of each pillar. The results are given in Table 49. The first four indicators are environmental indicators and the values of the environmental indicators indicate negative impact results. Therefore, the Environmental Index Score (ISe) obtained is multiplied by (-1), when the sustainability score is calculated later.

The social index includes two indicators. In fact, as it is mentioned in Chapter 4, in order to obtain an index, there must be at least two indicators, but at the first scoring only S1 is selected. However, due to a rule of thumb, the slightly related indicator (S2) is also used for further analysis. As the social index results are positive, the obtained Social Index Score (ISs) is used as it is obtained while calculating the sustainability score of the alternatives.

Table 49. Index scores (IS) for Case 2 based on the EQW method

Indicator ID	**Weight** (EQW method)	**A1**		**A1 average (No-action Alternative)**	**A2 (Sector D)**	**A3 (Sector E)**
		Sector A	**Sector B**			
E1	0.1	0.01	0.43	0.22	-0.23	2.31
E2	0.1	3.47	0.97	2.22	2.54	1.29
E3	0.1	-0.35	-0.76	-0.56	1.28	1.55
E4	0.1	-0.64	-0.7	-0.67	0.57	1.74
Environmental Index Score (ISe)				0.12	0.42	0.69
S1	0.1	-0.21	-0.71	-0.46	1.76	1.16
S2	0.1			0.62	2.74	2.74
Social Index Score (ISs)				0.02	0.45	0.39
Ec1	0.1	1.66	3.48	2.57	4.25	2.35
Ec2	0.1	2.76	2.3	2.53	1.12	0.21
Ec3	0.1	4.86	4.44	4.65	5.11	2.56
Ec4	0.1	0.03	1.83	0.93	-0.6	-0.62
Economic Index Score (ISec)				1.07	0.99	0.45

The third pillar is the economic pillar, where four indicators are given in Table 48 and standardized values of them are also multiplied by the weights of each indicator. The economic index score has a positive impact on sustainability as it is given in Appendix L. Moreover, as the no-action alternative (Alternative 1) involves two separate mining operations, the arithmetic average of the standardized values of these two operations is used as the standardized value of the indicators for Alternative 1. The obtained environmental, social and economic index scores are given in Table 49.

The calculated index scores of each pillar are shown with grey rows in Table 50. The environmental pillar scores, named as the environmental index score (ISe), of Alternative 1, Alternative 2 and Alternative 3 are 0.12, 0.42 and 0.69 respectively. The social pillar scores, ISs, of three alternatives are 0.02, 0.45 and 0.39 respectively.

Lastly, the economic pillar scores, ISec, of Alternative 1, Alternative 2 and Alternative 3 are calculated as 1.07, 0.99 and 0.45 respectively.

Table 50. EQW method based index scores Case 2

	Alternative 1	**Alternative 2**	**Alternative 3**
Environmental Index Score (ISe)	0.12	0.42	0.69
Social Index Score (ISs)	0.02	0.45	0.39
Economic Index Score (ISec)	1.07	0.99	0.45

As the social and economic pillars positively contribute to sustainability scoring, the higher the scores of these two pillars are, the higher the sustainability level of the alternative is. However, the environmental index score indicates a negative impact. Hence, a high index score indicates poor sustainability of the alternative. In fact, the calculated results for all the pillars are given as they are obtained from the calculation in Table 50 and multiplication of the environmental scores by (-1) is practiced in the calculation of total sustainability scores in Table 51.

Table 51. Sustainability index score for Case 2 based on the EQW method

	Alternative 1	**Alternative 2**	**Alternative 3**
Environmental Index Score (ISe)	-0.12	-0.42	-0.69
Social Index Score (ISs)	0.02	0.45	0.39
Economic Index Score (ISec)	1.07	0.99	0.45
Weight of each pillar in SIS	0.333		
Sustainability Index Score (SIS)	0.32	0.34	0.05

As it is mentioned above, ISe has a negative effect on sustainability. Therefore, a higher ISe means a higher negative impact, so this indicates a poor sustainability situation. This must also be considered while calculating the cumulative sustainability scores (SIS) of the alternatives. In order to consider this, the ISe should be multiplied by (-1) while calculating the SIS. The obtained index scores are also shown in Figure 43.

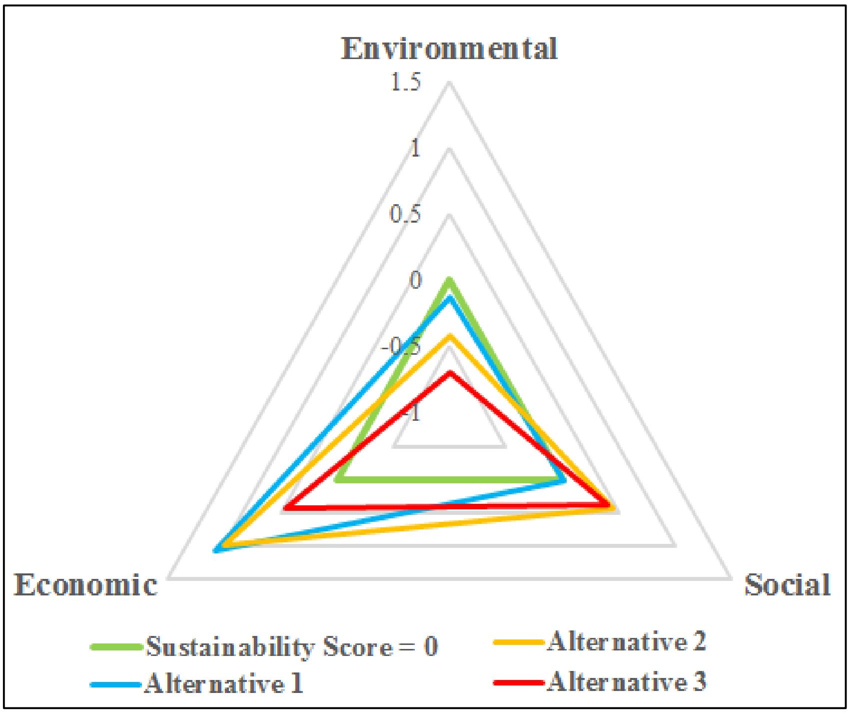

Figure 43. Index scores (IS) for Case 2 based on the EQW method

The green line in Figure 43 indicates the minimum sustainability level at 0. Therefore, any negative value in the environmental, social and economic indices indicates a non-sustainable situation of the alternative. In this respect, three alternatives are non-sustainable in terms of environmental pillar as the values are lower than 0. Contrary to this, all the alternatives have positive values in the social and economic pillars. This means that in terms of economic and social indices, the alternatives create benefits.

However, one cannot say which alternative is more sustainable than the others based on the defined scope and selected indicators. Therefore, the final sustainability scores of these alternatives need to be calculated. In order to do this, the equal weighting method is also applied to determine the weights of pillars. As there are three pillars, the weights are calculated with the equation below (Eq.15);

$$\frac{1}{3} = 0.333 \quad (15)$$

The obtained sustainability results of three alternatives are given in Table 51. According to these results, the Alternative 2 obtained a higher score than the other two. This means that the decision-making authority should choose to apply Alternative 2. Also the results of the SIS as well as the scores of three pillars are compared in Figure 44. As it is given in Figure 44, even if the environmental sustainability is relatively higher in Alternative 1 than the other two, the overall sustainability score of Alternative 2 is higher than Alternative 1 and Alternative 3.

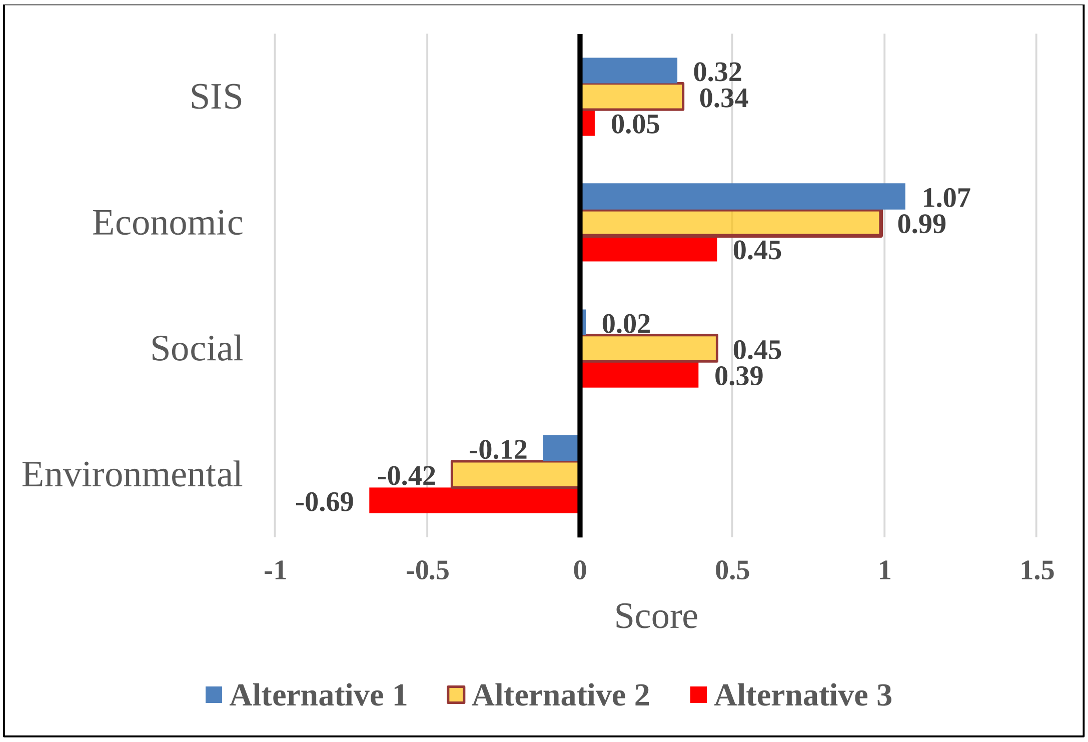

Figure 44. Sustainability scores for Case 2 based on the EQW method

Regarding these results, if all the selected indicators and pillars are considered equally important, the application of Alternative 2 generates more positive outcomes in terms of the determined strategic objective and targets. In fact, in this case study Alternative 1 (no-action) means continuing the mining operations in Sector A and Sector B.

Therefore the analysis shows that the excavation of lignite reserve in Sector D contributes to the sustainability more than Alternative 3 in terms of strategic objective and target, which benefits the available domestic natural resources while considering the environmental sensitivity. As it is applied in the main case in Section 5.2.8, AHP method is also applied for the energy and natural resource priority focused case application while determining the weights of the indicators and pillars.

As it is given in Table 52, the scores of E1, E3 and E4 are the same and the scores of these are slightly higher than those of E2. Hence, the importance of E1, E3 and E4 is considered the same in the pairwise comparison.

The importance of these over E2 is considered as slightly more important because the scores are very close to each other. The pairwise importance and weights of the indicator in the environmental pillar are shown in Table 53.

Table 52. Determination of environmental indicator importance for Case 2

Indicator ID	**Scope**		**Relevance**	**Score**	**Importance order**
	A	B			
E1	1	3	3	7	1
E2	3	1	2	6	2
E3	3	2	2	7	1
E4	3	2	2	7	1

Table 53. Pairwise comparison matrix of the environmental indicators

Indicator ID	E1	E2	E3	E4	AHP weight	CR
E1	1	2	1	1	0.286	0
E2	1/2	1	1/2	1/2	0.143	
E3	1	2	1	1	0.286	
E4	1	2	1	1	0.286	

In order to determine the importance level of the social indicators, the same approach is adopted. The importance levels of the indicators are given in Table 54. According to the obtained results, indicator S1 is more important than S2.

Based on this, the comparison matrix of social indicators is given in Table 55. As the third indicator set, the importance level of economic indicators are determined based on the selection scores, as it is given in Table 56.

Table 54. Determination of social indicator importance for Case 2

Indicator ID	**Scope** A	B	**Relevance**	**Score**	**Importance order**
S1	2	2	3	7	1
S2	2	1	1	4	2

Table 55. Pairwise comparison matrix of the social indicators

	S1	S2	AHP weight	CR
S1	1	4	0.80	0
S2	1/4	1	0.20	

Table 56. Determination of economic indicator importance for Case 2

Indicator ID	**Scope** A	B	**Relevance**	**Score**	**Importance order**
Ec1	2	3	3	8	1
Ec2	2	3	2	7	2
Ec3	2	3	3	8	1
Ec4	1	2	1	4	3

Hence Ec1 and Ec3 are slightly more important than Ec2 and significantly more important than Ec4; Ec2 is more important than Ec3. Hence, the calculated weights are given in Table 57. AHP-based calculated index scores are given in Table 58.

Table 57. Pairwise comparison matrix of the environmental indicators

	S1	S2	S3	S4	AHP weight	CR
Ec1	1	2	1	6	0.374	0.1
Ec2	1/2	1	1/2	5	0.194	
Ec3	1	2	1	6	0.374	
Ec4	1/6	1/5	1/6	1	0.057	

Table 58. Index scores (IS) for Case 2 based on AHP method

Indicator ID	**Weight** (AHP method)	**A1**		**A1 average (No-action Alternative)**	**A2 (Sector D)**	**A3 (Sector E)**
		Sector A	**Sector B**			
E1	0.286	0.01	0.43	0.22	-0.23	2.31
E2	0.143	3.47	0.97	2.22	2.54	1.29
E3	0.286	-0.35	-0.76	-0.56	1.28	1.55
E4	0.286	-0.64	-0.7	-0.67	0.57	1.74
Environmental Index Score (ISe)				0.03	0.83	1.79
S1	0.8	-0.21	-0.71	-0.46	1.76	1.16
S2	0.2			0.62	2.74	2.74
Social Index Score (ISs)				-0.24	1.96	1.48
Ec1	0.374	1.66	3.48	2.57	4.25	2.35
Ec2	0.194	2.76	2.3	2.53	1.12	0.21
Ec3	0.374	4.86	4.44	4.65	5.11	2.56
Ec4	0.057	0.03	1.83	0.93	-0.6	-0.62
Economic Index Score (ISec)				3.24	3.68	1.84

The environmental pillar scores, (ISe), of Alternative 1, Alternative 2 and Alternative 3 are 0.03, 0.83 and 1.79 respectively. The social pillar score, ISs, of three alternatives are -0.24, 1.96 and 1.48 respectively. Lastly, the economic pillar score, ISec, of Alternative 1, Alternative 2 and Alternative 3 are calculated as 3.24, 3.68 and 1.84 respectively. The calculated index results for all the pillars are given as they are obtained from the calculation in Table 59.

Table 59. AHP-based index scores for Case 2

	Alternative 1	**Alternative 2**	**Alternative 3**
Environmental Index Score (ISe)	0.03	0.83	1.79
Social Index Score (ISs)	-0.24	1.96	1.48
Economic Index Score (ISec)	3.24	3.68	1.84

The obtained index scores are also shown in Figure 45. However, as the environmental pillar indicates a negative impact, the multiplication of the environmental scores by (-1) is practiced in the calculation of total sustainability scores in Table 60.

Table 60. Sustainability index score with equally important sustainability pillars based on the AHP method

	Alternative 1	**Alternative 2**	**Alternative 3**	Weight of each pillar in SIS
Environmental Index Score (ISe)	-0.12	-0.42	-0.69	0.333
Social Index Score (ISs)	0.02	0.45	0.39	0.333
Economic Index Score (ISec)	1.07	0.99	0.45	0.333
Sustainability Index Score (SIS)	0.99	1.60	0.51	

The green line in Figure 45 indicates the minimum sustainability level at 0. Therefore, any negative value in the environmental, social and economic indices indicates a non-sustainable situation of the alternative. In this respect, three alternatives are non-sustainable in terms of the environmental pillar as the values are lower than 0. Contrary to this, all the alternatives have positive values in the social and economic pillars, which mean that in terms of economic and social indices, the alternatives create benefits.

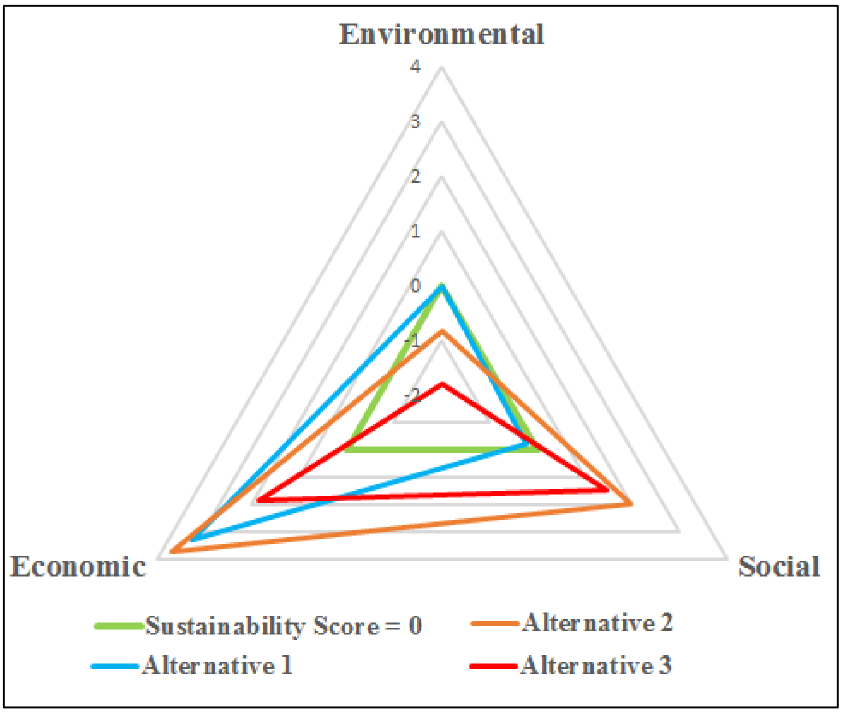

Figure 45. Index Scores (IS) for Case 2 based on AHP method

However, one cannot say which alternative is more sustainable than others based on the defined scope and selected indicators. Therefore, the final sustainability scores of these alternatives need to be calculated. In order to do this, the AHP method is also applied for determining the weights of pillars.

For the first case, the importance of three pillars is considered as equally important. In such a case, the weight of each pillar becomes 0.333 with a consistency ratio of 0. The obtained sustainability results of three alternatives are given in Table 60. According to these results, the Alternative 2 obtained a higher score than the other two. This means that the decision-making authority should choose the application of Alternative 2.

As the second case, the importance of the economic pillar is considered to be slightly higher than that of the environmental pillar and moderately more important than the social pillar. The obtained SIS values, with a consistency ratio of 0.1, are given in Table 61. According to these results, the Alternative 2 obtained a higher score than the other two. In fact, the score of Alternative 1 is closer to Alternative 2 and the score difference between these two and Alternative 3 is significantly high.

Table 61. Sustainability index score with economic priority based on the AHP method

	Alternative 1	**Alternative 2**	**Alternative 3**	Weight of each pillar in SIS
Environmental Index Score (ISe)	-0.12	-0.42	-0.69	0.287
Social Index Score (ISs)	0.02	0.45	0.39	0.168
Economic Index Score (ISec)	1.07	0.99	0.45	0.545
Sustainability Index Score (SIS)	1.72	2.10	0.74	

As the third case, the importance of the social pillar is considered slightly higher than the environmental and economic pillar. The obtained SIS values, with a consistency ratio of 0, are given in Table 62. According to these results, the Alternative 2 obtained a higher score than the other two. However, in this case and the first time Alternative 3 obtained a higher score than Alternative 1. In fact, the score differences between Alternative 2 and other two Alternatives are significantly high.

Table 62. Sustainability index score with social priority based on the AHP method

	Alternative 1	**Alternative 2**	**Alternative 3**	Weight of each pillar in SIS
Environmental Index Score (ISe)	-0.12	-0.42	-0.69	0.25
Social Index Score (ISs)	0.02	0.45	0.39	0.50
Economic Index Score (ISec)	1.07	0.99	0.45	0.25
Sustainability Index Score (SIS)	0.68	1.69	0.75	

As the fourth case, the importance of the environmental pillar is considered slightly higher than the social and economic pillar. The obtained SIS values, with a consistency ratio of 0, are given in Table 63. According to these results, the

Alternative 2 obtained a higher score than the other two. However, in this case Alternative 3 obtained a negative sustainability score.

Table 63. Sustainability index score with environmental priority based on the AHP method

	Alternative 1	**Alternative 2**	**Alternative 3**	Weight of each pillar in SIS
Environmental Index Score (ISe)	-0.12	-0.42	-0.69	0.50
Social Index Score (ISs)	0.02	0.45	0.39	0.25
Economic Index Score (ISec)	1.07	0.99	0.45	0.25
Sustainability Index Score (SIS)	0.74	1.00	-0.07	

As a result of the application of the AHP method for determining the indicator weights and sustainability pillar weights while calculating the alternatives' SIS, the application of Alternative 2 can be considered as sustainable. This is because the alternative gives the highest score for the cases of equal importance, environmental, social and economic priority cases compared to other alternatives.

Considering the strategic objective and the target, this result becomes quite reasonable because Alternative 2 has the highest recovery ratio of lignite reserve compared to the other alternatives. As the main aim is to excavate the available domestic coal resources, set by the energy policy without any solid consideration of social and environmental sustainability, the obtained result is highly fitting into this objective. The other important result of the energy policy focused assessment is the obtained SIS of Alternative 3. In the previous application of the framework with local sustainability criteria in Section 5.2.8, Alternative 3 could not get positive results with social priority cases. In fact, the analyses here show that even with environmental priority, the SIS of Alternative 3 is almost 0.

5.3. Discussions on Two Sustainability Assessment Cases

The methods of the equal weighting (EQW) method and analytical-hierarchy process (AHP) method are applied in order to determine the sustainability levels of the three alternatives by considering two different scopes in Section 5.2.8 and Section 5.2.9.

The objectives of these two cases are the same, which is contributing to the security of energy supply through operationalization of the domestic hard coal and lignite reserves in Turkey by 2023; however, the main difference between these two cases is the scopes of them. The first case, which is analyzed with the proposed framework, focuses on the localized sustainability criteria and evaluating the alternatives according to these. The second application focuses primarily on the energy generation with a general concept of considering the environmental protection in AECB.

The obtained four SIS results of the three alternatives for these two different scopes are shown in Table 64. The determined sustainability index score (SIS) of three alternatives in the first case with the localized sustainability criteria focused analysis based on EQW method indicates that Alternative 1 is comparatively more sustainable than the other two plans (SIS 1 in Table 64).

Table 64. SIS results of the three alternatives for two different scopes based on EQW and AHP methods

ID	Explanation	Alternative 1	Alternative 2	Alternative 3
SIS 1	EQW method for localized sustainability criteria case	-0.07	-0.27	-0.36
SIS 2	AHP (equal importance of three pillars) for localized sustainability criteria case	-0.012	-0.809	-0.625
SIS 3	EQW method for energy generation focused case	0.32	0.34	0.05
SIS 4	AHP (equal importance of three pillars) method for energy generation focused case	0.99	1.60	0.51

The AHP method-based analysis of the first case also produces similar results. Alternative 1 is also comparatively more sustainable than the other two plans. In fact, the result of SIS 2 is obtained based on the equal importance of the three pillars, namely environmental, social and economic pillars (SIS 2 in Table 64).

Contrary to these results, the energy focused case indicates that Alternative 2 is the sustainable choice among these three alternatives both for the equal weight method and the AHP method. This can be seen in Table 64 with the results of SIS 3 and SIS 4. In addition to these, different from SIS 1 and SIS 2, the calculation results are positive for SIS 3 and SIS 4. This means that all the alternatives can be accepted as meeting the minimum sustainability conditions by obtaining a score higher than 0.

However, one should keep in mind that sustainability of a system is determined by the least sustainable component of it (Mayer, 2008). This is significantly important to consider in this study, too. This is because even though the sustainability of the alternatives are analyzed separately, it must be considered that the final decision about the sustainable alternative should be given by considering the integrated case if any alternative other than Alternative 1 is selected. The reason for this is that selecting any alternative other than Alternative 1, which is the no-action alternative, must also include the sustainability of the Alternative 1 in the case of AECB.

In other words, the sustainability comparison in this study must be done by considering the current situation and also the new alternative(s) besides the current situation simultaneously. Therefore, the consideration of the least sustainable alternative of the practicing system (either the no-action or a combination of the no-action and the other two alternatives) is necessary. For this purpose, the comparison table is developed and given in Table 65.

Regarding the obtained results in Table 65, the assessment results for the cases, conducted based on the scope of the thesis (SIS 1 and SIS 2), show that Alternative 1 (the no-action alternative) is more sustainable than any other combination of mining plan alternatives in AECB. This is because the results in the combinations include less sustainable scores. Hence, if the decision-making authority selects one of these combinations, the system in AECB becomes less sustainable than the current situation in terms of the mining sector operations. Therefore, Alternative 1 boxes in SIS 1 and SIS 2 are highlighted with the green color.

Table 65. SIS comparison of the no-action and combination of all the alternatives cumulatively

	ID	No-action Alternative 1	A1 & A2	A1 & A3	A1 & A2 &A3
Local sustainability criteria with land degradation focus	**SIS 1 (EQW method)**	-0.07	-0.07 vs. -0.27	-0.07 vs. -0.36	-0.07 vs. -0.27 vs. -0.36
		-0.07	**- 0.27**	**- 0.36**	**- 0.36**
	SIS 2 (AHP method)	-0.012	-0.012 vs. -0.809	-0.012 vs. -0.625	-0.012 vs. -0.809 vs. -0.625
		-0.012	**-0.809**	**-0.625**	**-0.809**
General sustainability concept with energy priority focus	**SIS 3 (EQW method)**	0.32	0.32 vs. 0.34	0.32 0.05	0.32 vs. 0.34 vs. 0.05
		0.32	**0.32**	**0.05**	**0.05**
	SIS 4 (AHP method)	0.99	0.99 vs. 1.60	0.99 vs. 0.51	0.99 vs. 1.60 vs. 0.51
		0.99	**0.99**	**0.51**	**0.51**

Regarding the results for SIS 3 and SIS 4, which are the scores of energy generation focused cases, in Table 65, as Alternative 2 obtained higher score than the others and based on the scores, Alternative 3 is the least sustainable among these three, either Alternative 1 or the mine plan includes the combination of Alternative 1 and Alternative 2 should be selected. The main reason for this is that Alternative 1 has a higher score than Alternative 3, so any combination including Alternative 3 causes deterioration of the current sustainability conditions of the system in AECB.

Also, in case of selecting the combination of Alternative 1 and Alternative 2, the sustainability level of the system in AECB does not increase, because a system cannot be more sustainable than its least sustainable alternative. For this reason, in case of selecting two alternatives, Alternative 1, as the no-action alternative, and Alternative 2, the sustainability in AECB does not decline.

In fact, based on the objective and scope as well as the selected indicators in the energy focused case in Section 5.2.9, practicing Alternative 1 and Alternative 2 contributes to sustainability in AECB more than implementing only Alternative 1.

Consequently, in such a case, it is better to implement the mining plans given with Alternative 2 in AECB than selecting the no-action alternative.

CHAPTER 6

CONCLUSION

The indicator-based sustainability assessment framework is developed for evaluating the sustainability of the current and proposed mining sector plan alternatives in terms of land degradation at the strategic level. The results are evaluated in different perspectives like the contribution of the study to the knowledge of the field, advantages of the developed framework over similar frameworks, case specific results and recommendations for the future studies.

In this respect the contribution of the study to the knowledge of the field can be concluded under;

- Practicing early public and stakeholder consultations for determination of the local sustainability criteria;
- Using the sustainability indicators systematically for the assessment of the mining sector plans at the strategic-level,
- Classification of the indicators in order to apply the framework at the strategic- and project-level assessment practices;
- Proposing indicators, which are not given in the literature and which are specifically appropriate for the mining sector and Turkish conditions at the strategic-level.

First of all, the proposed framework considers and also integrates the public and local stakeholder understanding and priorities on sustainability in the field of the mining sector at the early steps of the application based on a bottom-up approach. In fact, all the alternatives are defined and also sustainability indicators for evaluating these alternatives are selected based on the bottom-up approach by integrating the public consultation outcomes into the decision-making process.

In this way, the developed framework allows the integration of the stakeholder priorities at the early steps of the process through defining the sustainability criteria based on their local needs, faced problems and expectations. As a result, the sustainability concept for the mining sector and its local understanding in Afşin-Elbistan Coal Basin (AECB) are determined as;

- Creating long-lasting social well-being through;
  - **Employment:** Prioritizing local employment and capacity building in local communities (improvement of qualifications for both sectoral employment and auxiliary industry development);
  - **Land acquisition management:** Minimizing the land acquisition and lump sum land acquisition;
  - **Infrastructure:** Improvement in the infrastructure.
- Obtaining comparable information on possible trade-offs and their consequences
  - **Change in the local economic activities:** Impact of land acquisition and land use change due to mining operations versus created local employment in the mining sector and auxiliary sectors;
  - **Change in the practice of the local economic activities:** Impact of land acquisition and land use change on the agriculture due to mining operations versus positive impact on the practice of the agriculture due to accessing groundwater, used for irrigation.
- Balancing costs and benefits by effective natural resource management through;
  - **Land use management:** Minimizing land use for mining operations;
  - **Land acquisition management**: Minimizing land acquisition;
  - **Water management:** Minimizing groundwater drainage and using drained water for agricultural purposes.

The developed sustainability assessment framework uses indicators for the assessment of the alternatives in terms of the focused strategy and sustainability criteria. For this purpose selection of appropriate indicators is necessary and important issue. Additionally, weighting of the indicators are also important for obtaining objective and scientifically acceptable results. Therefore, besides the analytical-hierarchy process (AHP) method, equal weighting (EQW) method is applied in order to mitigate subjectivity within the weighting process.

In this respect, a systematic methodology is defined for determination and selection of the indicators among the available indicator sets. In order to practice the selection of indicators systematically, a scoring matrix is also proposed. The localized and study-specific sustainability criteria, strategic objective and study scope are used as the scoring parameters versus the indicators in the matrix. In this way, the proper indicator selection is achieved with a limited time, financial-resources and expert human-resources. Additionally, the use of indicators is significantly helpful for measuring and presenting the outcomes of the assessment to stakeholders easily and effectively.

Another important outcome of integrating the indicators into the assessment framework is the classification of the mining sector-related sustainability indicators in terms of the characteristics of the strategic-level and project-level assessment tools and frameworks. Such classification is significantly important for the mining sector related sustainability assessment literature. This is mainly because the available studies focus on the project-level and corporate-level sustainability in the mining sector.

Therefore, the majority of the sustainability indicators, obtained from the literature, are developed and used for the project-level assessment practices. In this respect, the obtained strategic-level sustainability indicator sets in the environmental, social and economic pillars are the third contribution of the thesis to the sustainability studies in the mining sector.

Regarding the classification of the sustainability indicators in terms of strategic- and project-level assessments, it is figured out that, the available sustainability indicators do not cover all the sustainability issues, specifically in the field of land degradation. In this respect, 13 social and 11 economic sustainability indicators are proposed under this study in order to fulfill the missing issues for the sustainability assessment of the mining sector plans in terms of land degradation.

In addition to the highlighted contributions of the study, the developed framework also has advantages over the available frameworks and approaches that are summarized under flexibility and communication capacities. Regarding the flexibility, the framework can be applied in different countries and regions as well as by the different sectoral actors.

The classification of the indicators under this study allows the application of the project-level and cooperation specific sustainability assessments with the developed framework in the mining sector. In fact, if a new global indicator set is developed and indicators are selected by following the process defined in the thesis, the framework can also be applied for different sectors.

Especially the defined sustainability and indicator selection process can be used efficiently for the sectors, which exploit the natural resources, such as energy and agriculture. Besides the public authorities, responsible for regulating these sectors, investing companies, project managers and financial crediting organizations, can also practice the framework with the project-level indicators in order to evaluate and report the sustainability of the operations and projects in a systematic way.

The application process of the developed framework does not need specific expertise like modelling-based frameworks. This is mainly achieved by selecting the flexible assessment method, which is the multi-criteria analysis (MCA). MCA is a highly preferred assessment method for natural resource management studies. Also, integrating the indicators as assessment parameters contributes to obtaining a flexible framework.

The third flexibility issue of the developed framework is that it considers the data limitations and quantification capacity of the indicators as important parameters for the selection of the indicators for the assessment. This is highly important for both strategic-and project-level applications of the framework. Additionally, this minimizes or prevents the implementation of analyses with the indicators, lacking of data and limited quantification capacity.

Regarding the communication capacities, the developed framework grants the presentation and communication capacity of the obtained results to share with the decision-makers and stakeholders. This is highly related to transparency feature of the framework because the third party, who does not participate in the assessment process, can follow the localization of the sustainability criteria, indicator selection and the obtained numeric results, based on EQW and AHP methods. This is also related to minimal need of expertise characteristic of the framework. As a result of this, the decision-making authorities and investing mining companies can use the obtained results to communicate with the stakeholders in an effective way and the stakeholder parties can follow the process easier than highly technical approaches.

Additionally, the successful integration of the public concerns into the process is valuable because the stakeholder consultation contribute to two important steps in the framework. The first one is the localization of the sustainability concept. The second one is the determination of the weighting criteria during the assessment. This approach is also very important to minimize the subjectivity of the determined weights of the used indicators and also pillars in the assessment.

As a result of application of the developed framework, the following results can be concluded for the bottom-up approach case and top-down approach case, used for the definition and scoping of the sustainability, strategy and study focus, give completely different results.

For the first case, which is bottom-up approach for determining the sustainability criteria, the assessment results indicates that no-action alternative obtains higher sustainability index score in terms of land degradation based on both equal weighting and analytical-hierarchy process methods. For the second case application, which is the top-down approach for determining the sustainability criteria, Alternative 2 (mining in Sector D) obtains higher scores than the other two alternatives in both equal weighting and analytical-hierarchy process methods.

In this respect, application of two cases shows that the developed framework acknowledges the change of the priority of the assessment in terms of obtained results. Additionally, the results of the two cases show that using either the bottom-up approach, which integrates the stakeholders' concerns into the decision-making process, or the top-down approach, in which the assessment criteria are determined by the decision-making authority as well as by the practicing party, may produce different results.

Regarding these obtained case specific results of bottom-up approach, the decision-making authority, EÜAŞ, must focus on minimizing the recent environmental and social impacts in the region in order to practice mining operations in Sector D and Sector E. Regarding the environmental impacts, the mining sector related land degradation is significantly important concern of the local stakeholders as they are significantly depend on the agriculture in AECB. Additionally, land acquisition for the mining operations is seen as the main reason for negative social impacts in AECB.

The second recommendation for the decision-making authority is initiating an employment program for the local community members, who will be directly affected from the degradation and acquisition of the agricultural land due to the mining sector. Considering the wide land need for lignite mining in AECB, such an employment program must be conducted in order to decrease the negative social impacts in the basin and so for obtaining higher sustainability scores for the new plan alternatives. Additionally, this is important for creating transparent recruitment practices in the mining sector in AECB.

In this respect, the following strategies are recommended for minimizing the social negative impacts, which are mainly sourced from the mining sector related land degradation in AECB. These strategies are;

- Development and implementation of re-skilling programs;
- Contributing to the establishment of SMEs that are independent from the mining sector;
- Providing training and education to gain and improve skills that are needed for the mining sector employment.

Besides the specific discussions about AECB, the decision-making authority, the Ministry of Energy and Natural Resources of Turkish Republic, should practice a strategic level mining sector sustainability assessment for the similar basins in Turkey. This is significantly important because the energy policy aims to exploitation of all domestic coal reserves for electricity generation. However, the case application for the mining sector plan alternatives in AECB shows that if a comprehensive sustainability assessment will not be practiced, the defined strategic target will cause significant and irreversible environmental and social losses.

In this respect, before setting the program targets in the Five-Year Development Programs of the Turkish Republic, the sustainability assessment should be practiced as a decision-support tool and the outputs of the studies must be integrated into strategic planning. The best period for this is the working groups, where the sectoral strategy reports are prepared, for development of the five years' development plans. In this way, the application can be successfully conducted because these working groups are specifically focusing on a sector through participation of the stakeholders and experts from the ministries, universities, sectoral NGOs, and also the private sector organizations.

Last but not the least, the recommendation for future studies can be summarized under the case specific and framework related for general applications. The first case specific recommendation for the future studies is to apply the framework for the possible mining operations in AECB after resetting the subsectors.

The recent subsectors were determined in AECB by EÜAŞ. However due the need for leaving pillars between recently active mining operations and also between the focused and possible future mining operations in other sectors, loss of reserve is significant in AECB. Such loss is a very important barrier for contributing the sustainability in AECB in terms of the mining sector with a specific focus of land degradation. Therefore, a new assessment with rearranged subsectors should be conducted for the basin in the future.

In addition to this, Hurman Creek is a significant factor for the basin in terms of the mining sector strategic planning. A future study should also discuss the possible sustainability levels of the mining operations, which directly interacting with the Hurman Creek. Moreover, consideration of the groundwater resource management in AECB should be also integrated into the future sustainability studies in the basin.

Besides these, consideration of the current and planned thermal power plants in the basin is significantly important field of study. This mainly because, the main purpose of the mining operations in the basin is generating electricity. Therefore, these two operations and sector are highly integrated. In this respect, more comprehensive sustainability study with the developed framework will be very valuable.

In addition to case specific recommendations, the developed framework related recommendations should be also highlighted for future studies. The localization of the sustainability concept, indicator selection and determination of weights of indicators and pillars in the assessment are key factors affecting the reliability and the success of the obtained results. For this reason, the application of the steps about these three key factors is significantly important.

The process of the localization of the sustainability concept is conducted by considering the importance of the process in this study. However, due to the time and administrative limitations, the same comprehensive process could not be practiced for the indicator selection steps. Consequently, it is recommended that the indicator selection should be conducted with more than one expert and even with the consultation of the stakeholders in the future applications.

Furthermore, health- and safety-related matters are very important for the mining sector. There are regulations and strict rules for the operations at the project-level. However, the consideration and integration of these into the strategic-level assessment is a challenge. For this reason, the strategic-level analysis related health and safety concerns should be integrated into the decision-making process in the future studies.

REFERENCES

Afgan, N.H. and Carvalho, M.G., Multi-criteria assessment of new and renewable energy power plants, Energy, 27(8), pp.739-755, 2002

Afgan, N.H. and Carvalho, M.G., Sustainability assessment of a hybrid Energy system, Energy Policy, 36, pp.2903-2910, 2008

Allsman, P.T., Current and future status of surface mining in Pfleider, E.P.; Clark, G.B.; Hartman, H.L.; Soderberg, A. (eds.) Surface Mining, New York, pp.3-16, 1968

Australian Bureau of Statistics, 4102.0 - Australian Social Trends, April 2013, web page: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Main+Features10April+2013#p4, date of access: 01.07.2015

Azapagic, A., Developing a Framework for Sustainable Development Indicators for the Mining and Minerals Industry, Journal of Cleaner Production, Volum:12 (6), pp. 639–662, 2004

Badera, J. and Kocoń, P., Local community opinions regarding the socio-environmental aspects of lignite surface mining: Experiences from central Poland, Energy Policy, 66(2014), pp.507-516, 2014

Basurko, O.C. and Mesbahi, E., Methodology fort the sustainability assessment of marine technologies, Journal of Cleaner Production, 2012, in press, doi: 10.1016/j.jclepro.2012.01.022

Başaran, M., Problems and recommendation for making new investments in Afşin-Elbistan Basin, DEK-TMK Türkiye 11th Energy Congress, Tepekule, İzmir, 2009, web page:

http://www.dektmk.org.tr/pdf/enerji_kongresi_11/mbasaran.pdf, date of access: 01.06.2015

Balkema, A.J.; Preisig, H.A.; Otterpohl, R. and Lambert F.J.D., Indicators for the sustainability assessment of wastewater treatment systems, Urban Water, 4 (2002), pp. 153-161, 2002

Bell, F.G and Donnelly, L.J, Mining and Its Impact on the Environment, Taylor & Francis, New York, 2006

Besbelli, B.; Karaca, K. and Gökmenoğlu, O., Sector HB and Sector HD Geology, Reserve and Hydrogeology Report of the Afşin-Elbistan Coal Basin, General Directorate of Mineral Research and Exploration, Department of Energy Raw Material Research and Exploration, in Turkish, 2009

Binder, C.R., Feola, G., Steinberger, J.K, Considering the normative, systematic and procedural dimensions in indicator-based sustainability assessments in agriculture, Environmental Impact Assessment Review, 30, pp.71-81, 2010

BPMSG, BPMSG AHP priority calculator, 2015, web page: http://bpmsg.com/academic/ahp_calc.php, accessed: 01.07.2015

Buxton, A., MMSD+10: Reflecting on a decade of mining and sustainable development, International Institute for Environment and Development (IIED), 2012, web page: http://pubs.iied.org/pdfs/16041IIED.pdf?, date of access: 20.05.2014

Carrera, D.G. and Mack, A., Sustainability assessment of energy technologies via social indicators: Results of a survey among European energy experts, Energy Policy, 38, pp.1030-1039, 2010

Castellani, V. and Sala, S., Sustainability indicators integrating consumption patterns in strategic environmental assessment for urban planning, Sustainability, 5 (2013), pp.3426-3446, 2013

Chikkatur, A.P.; Sagar, A.D. and Sankar, T.L., Sustainable development of the Indian coal sector, Energy, 34 (2009), pp.942-953, 2009

Çankaya F., Determining an ultimate pit limit in Afşin-Elbistan (B) opencast mining field, Çukurova University, Institute of the Applied and Natural Sciences, MSc. Thesis, in Turkish, 2005

Department for Communities and Local Government of UK, Multi-criteria analysis: A manual, London, 2009 web page: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7612/1132618.pdf, date of access: 25.12.2014

Dobranskyte-Niskota, A.; Perujo, A.; Jesinghaus, J. and Jensen, P., Indicators to Assess Sustainability of Transport Activities, European Commission - Joint Research Centre, Institute for Environment and Sustainability, Transport and Air Quality Unit, ISBN 978-92-79-14121-8, Italy, 2009

Dontala, S.P.; Reddy, T.B. and Vadde, R., Environmental aspects and impacts its mitigation measures of corporate coal mining, Procedia Earth and Planetary Science, 11(2015), pp. 2-7, 2015

Douglas, I. and Lawson, N., Land use: the geomorphic and land use impacts of mining, in Rajaram, V.; Dutta, S.; Parameswaran, K. (eds) Sustainable mining practices: A global perspective, A.A. Balkema, New York, 2005

Doyle, W.S., Strip mining of coal: environmental solutions, Noyes Data Corp., New Jersey, 1976

Duarte, C.G.; Gaudreau, K.; Gibson, R.B. and Malheiros, T.F., Sustainability assessment of sugarcane-ethanol production in Brazil: A Case study of a sugarcane mill in Sao Paulo state, Ecological Indicators, 30, 2013

Dutta, P.; Sandip, M. and De, P., Opencast mining impact: A methodology for cumulative impact assessment of opencast mining projects with special references to air quality assessment, IAIA Impact Assessment and Project Appraisal, Vol. 22 no. 3, pp. 235- 250, 2004

Düzgün, H.Ş. and Demirel, N., Remote Sensing of the Mine Environment, CRC Press, Taylor & Francis Group, The Netherlands, 2011

Düzgün, H.Ş.; Yaylacı, E.D.; Alp, E.; Ural, S.; Kalaycıoğlu, H.S.; Kentel, E. and Arıcan, İ., Developing indicator-based sustainability assessment methodology for integrated open cast lignite mining and electricity generation plans in Afşin-Elbistan Basin, 113M463 Numbered TUBİTAK 1001 Research Project Mid-term Project Report, Middle East Technical University, Ankara, not published, in Turkish, 2014

European Association for Mining Industries, Metal Ores and Industrial Minerals, The EUROMINES guidelines for sustainable development, 2012, web page: http://www.euromines.org/sites/default/files/content/files/sustainable-development-issues/euromines-sustainable-development-guidelines-jan2012.pdf, date of access: 20.05.2014

European Commission, SEA Directive, 2001, web page: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0042&from=EN, date of access: 15.09.2014

Eastern Mediterranean Development Agency, TR63 Region current status analysis report, Draft report, in Turkish, 2014, web page: http://www.dogaka.org.tr/Icerik/Dosya/www.dogaka.gov.tr_500_LK6T40MO_TR63-Bolgesi-Mevcut-Durum-Analizi.pdf, date of access: 12.07.2014

Eastern Mediterranean Development Agency, TR63 Regional Plan 2014-2023, Draft report, in Turkish, 2015, web page: http://www.dogaka.org.tr/Planlama-detay.asp?P=46&Planlama=bolge-plani&PD=500&PlanlamaDetay=tr63-bolge-plani-2014-2023, date of access: 12.07.2015

Environmental Protection Agency of United States, Overview of greenhouse gasses, web page: http://epa.gov/climatechange/ghgemissions/gases/ch4.html, date of access: 19.03.2015

Erzurumlu, S.S. and Erzurumlu, Y.O., Sustainable mining development with community using design thinking and multi-criteria decision analysis, Resource Policy (in press), 2014, http:/dx.doi.org/10.1016/j.resourpol.2014.10.001

Electricity Generation Company of Turkish Republic, 2014 Electricity Generation Sector Report, Ankara, in Turkish, 2015a, web page:

http://www.euas.gov.tr/Documents/Sektor_Raporu_2014.pdf, date of access: 11.05.2015

Electricity Generation Company of Turkish Republic, EÜAŞ, 2014 Annual Report, Ankara, in Turkish, 2015b, web page: http://www.euas.gov.tr/Documents/YILLIKRAPOR_2014.pdf, date of access: 11.05.2015

Food and Agricultural Organization of United Nations, EAF planning and implementation tools, 2015, web page: http://www.fao.org/fishery/eaf-net/eaftool/eaf_tool_31, date of access: 11.04.2015

Ford, C., Towards sustainable mining: The Canadian Mining Industry Sustainability Initiative, in Villas Bôas, R.C.; Shields D., Šolar, S.; Anciaux, P.; Önal, G. (eds.) A review on indicators of sustainability for the minerals extraction industries, Rio de Janeiro: CETEM/MCT/ CNPq/CYTED/IMPC, pp.31-46, 2005

Franks, D.; Brereton, D. and Moren, C., Managing the cumulative impacts of coal mining on regional communities and environments in Australia, Impact Assessment and Project Appraisal, Vol: 28 no:4, pp.299-312, 2010

Freitas, A.H.A. and Magrini, A., Multi-criteria decision-making to support sustainable water management in a mining complex in Brazil, Journal of Cleaner Production, 47 (2013), pp. 118-128, 2013

Gibson, R.B., Sustainability assessment and conflict resolution: Reaching agreement to proceed with the Voisesy's Bay Nickel Mine, Journal of Cleaner Production, 14 (2006), pp.334-348, 2006a

Gibson, R.B, Sustainability assessment: basic components of a practical approach, Impact Assessment and Project Appraisal, Vol.24 no: 3, pp.170-182, 2006b

Giurco, D. and Cooper, C., Mining and sustainability: Asking the right question, Minerals Engineering, 29 (2012), pp.3-12, 2012

Glasson, J.; Thérivel, R. and Chadwick, A., Introduction to environmental impact assessment: Principles and procedures, process, practice and prospects, Spon Press, London, 2002

Government of Ireland, Implementation of SEA Directive (2001/42/EC): Assessment of the effects of certain plans and programmes on the environment, Guidelines for Regional Authorities and Planning Authorities, Dublin, 2004, web page: http://www.environ.ie/en/Publications/DevelopmentandHousing/Planning/FileDownLoad,1616,en.pdf, date of access: 15.03.2013

Governor's Office of Kahramanmaraş, Geographical structure of Kahramanmaraş, 2014, web page: http://kahramanmaras.gov.tr/CografiYapi.aspx, date of access: 22.06.2014

Govindan, K., Kannan D., Shankar, K.M., Evaluating the drivers of corporate social responsibility in the mining industry with multi-criteria approach: A multi-stakeholder perspective, Journal of Cleaner Production, in press, 2014, http://dx.doi.org/10.1016/j.jclepro.2013.12.065

Graymore, M.L.M.; Sipe, N.G. and Rickson, R.E., Regional sustainability: How useful are current tools of sustainability assessment at the regional scale?, Ecological Economics, 67, pp.362-372, 2008

Graymore, M.L.M.; Wallis, A.M. and Richards, A.J., An index of regional sustainability: A GIS-based multiple criteria analysis decision support system for progressing sustainability, Ecological Complexity, 6 (2009), pp. 453-462, 2009

Global Reporting Initiative, Sustainability reporting framework, the fourth generation of the Guidelines, G4, 2013, web page: https://www.globalreporting.org/reporting/g4/Pages/default.aspx, date of access: 15.03.2015

Global Reporting Initiative, Sustainability Reporting Guidelines & Mining and Metals Sector Supplement 2000-2010 GRI Final Version 3.0/MMSS Final Version, 2011, web page: https://www.icmm.com/document/815, date of access: 15.03.2013

Güneş, M., Planning of relocation of belt distribution center project using CPM at the EÜAŞ/AEL, MSc Thesis, Çukurova University, Institute of Natural and

Applied Sciences, Department of Mining Engineering, Adana, in Turkish, 2007

Helbron, H., Strategic Environmental Assessment in regional land use planning, indicator system for the assessment of degradation of natural resources and land use with environmental potential for adaptation of global climate change (LUCCA), PhD Thesis at Brandenburg University of Technology, Cottbus, Germany, 2008

Hens, L., Instruments for environmental management: Introduction In: Noth, B.; Hens, L.; Compton, P. and Devuyst, D. (ed) Environmental Management in Practice: Volume 1, Routledge, ScottLondon, New York, pp: 65-68, 1998

Hilson, G. and Basu, A.J., Devising indicators of sustainable development for the mining and minerals industry: An analysis of critical background issues, Journal of Sustainable Development and World Ecology, Vol. 10 No. 4, pp.319-331, 2003

Hilson, G., Corporate social responsibility in the extractive industries: Experiences from developing countries, Resource Policy, 37, pp.131-137, 2012

Hilson, G. and Murck, B., Sustainable development in the mining industry: clarifying the corporate perspective, Resource Policy, 26 (2000), pp.227-238, 2000

Hiremath, R.B; Balachandra, P.; Kumar, B.; Bansode, S.S. and Murali, J., Indicator-based urban sustainability – A review, Energy for Sustainable Development, 17 (2013), pp. 555-563, 2013

Horsley, J., Prout, S., Tonts, M. and Ali, S.H., Sustainable livelihoods and indicators for regional development in mining economies, The Extractive Industries and Society, Vol.2 No.2, pp.368-380, 2015

International Council on Mining and Metals, 2003, web page: http://www.icmm.com/our-work/sustainable-development-framework/10-principles & http://www.icmm.com/document/429, date of access: 20.05.2014

International Organization for Standardization, Guidelines on Social Responsibility, ISO 26000:2010, 2014 web page:

http://www.iso.org/iso/catalogue_detail?csnumber=42546, date of access: 01.04.2015

João, E, Key principles of sea in Schmidt, M.; João, E. and Albrecht, E. (eds.) Implementing Strategic Environmental Assessment, Springer, Berlin, pp.3-15., 2005

Juwana, I.; Muttil, N. and Perera, B.J.C., Indicator-based water sustainability assessment- A review, Science of the Environment, 438 (2012), pp. 357-371, 2012

Kirsch, S., Sustainable Mining, Dialect Anthropol, (2010) 34, Springer, DOI 10.1007/s10624-009-9113-x, pp. 87-93, 2009

Kiss, A. and Shelton, D., Manual of European Environmental Law, Cambridge University Press, Cambridge, 1997

Kotey, B. and Rolfe, J., Demographic and economic impact of mining on remote communities in Australia, Resource Policy, 42, pp. 65-72, 2014

Laurence D., Establishing a sustainable mining operation: An overview, Journal of Cleaner Production 19(2011), pp. 278-284, 2011

Lee, N. and Kirkpatrick, C., Methodologies for sustainability impact assessment of proposals for new trade agreements, Journal of Environmental Assessment Policy and Management, Vol.3 No.3, pp. 395-412, 2004

Lins, C. and Horwitz, E., Sustainability in the mining sector, FBDS, Rio de Janerio, Brasil, 2007, web page: http://www.fbds.org.br/IMG/pdf/doc-295.pdf, date of access: 20.05.2014

Liu, G., Development of a general sustainability indicator for renewable energy systems: A review, Renewable and Sustainable Energy Reviews, 31 (2014), pp.611-621, 2014

Marnika, E.; Christodoulou, E. and Xenidis, A., Sustainable development indicators for mining sites in protected areas: tool development, ranking and scoring of potential environmental impacts and assessment of management scenarios, Journal of Cleaner Production, 2015, http://dx.doi.org/10.1016/j.jclepro.2015.03.098

Mascarenhas, A.; Nunes, L.M. and Ramos, T.B., Selection of sustainability indicators for planning: combining stakeholders' participation and data reduction techniques, Journal of Cleaner Production, 92 (2015), pp. 295-307, 2015

Mayer, A.L., Strengths and weaknesses of common sustainability indices for multidimensional systems, Environment International 34, pp. 277-291, 2008

Maxim, A., Sustainability assessment of electricity generation technologies using weighted multi-criteria decision analysis, Energy Policy, 65 (2014), pp. 284-297, 2014

Ministry of Development, 10th Development Plan 2014-2018, in Turkish, 2013, web page: http://www.kalkinma.gov.tr/Lists/Kalknma%20Planlar/Attachments/12/Onuncu%20Kalk%C4%B1nma%20Plan%C4%B1.pdf, date of access: 30.09.2014

Mert, B.İ., The research of the possibilities of the use of Geographical Information Systems and global positioning systems on the mining activities in the Afşin-Elbistan Coal Field, PhD Thesis, Çukurova University, Institute of Natural and Applied Sciences, Department of Mining Engineering, Adana, in Turkish, 2010

Ministry of Environment and Urban Development of Turkish Republic, Provincial Directorate of Ministry of Environment and Urban Planning, Kahramanmaraş Province Environmental Status Report, Kahramanmaraş, in Turkish, 2011, web page: http://www.csb.gov.tr/turkce/dosya/ced/icdr2011/kmaras_icdr2011.pdf, date of access: 02.03.2014

Ministry of Environment and Urbanization of Turkish Republic, Draft SEA Legislation, in Turkish, 2012, web page: www.csb.gov.tr/dosyalar/images/.../Taslak_Stratejik_CED_Yonetmelik.docx, date of access: 30.04.2013

Ministry of Mines, India and ERM India, sustainable development framework for Indian mining, 2011, web page:

http://mines.nic.in/writereaddata/filelinks/2155afeb_FINAL%20REPORT%20SDF%2029Nov11.pdf, date of access: 20.05.2014

Moles, R.; Foley, W.; Morrissey J. and O'Regan, B., Practical appraisal of sustainable development – Methodologies for sustainability measurement at settlement level, Environmental Impact Assessment Review, 28, pp. 144-165, 2008

Morrison-Saunders, A.; Pope, J.; Bond, A. and Retief, F., Towards sustainability assessment follow-up, Environmental Impact Assessment Review, 45 (2014), pp. 38-45, 2014

Musango, J.K. and Brent, A.C., A conceptual framework for energy technology sustainability assessment, Energy for Sustainable Development, Vol. 15 No. 1, p.84-91, 2011

Ministry of Science, Industry and Technology, Status Report of 81 Province, in Turkish, 2012, web page: http://www.sanayi.gov.tr/Files/Documents/81-il-durum-raporu-2012-11052012113452.pdf, date of acces: 07.08.2014

Ness, B.; Urbel-Piirsalu, E.; Anderberg, S. and Olsson, L., Categorising tools for sustainability assessment, Ecological Economics, 60 (2007), pp. 498-508, 2007

Northey, S.; Haque, N. and Mudd, G., Using sustainability reporting to assess the environmental footprint of copper mining, Journal of Cleaner Production, 40, pp. 118-128, 2013

Office of the Deputy Prime Minister, A practical guide to the Strategic Environmental Assessment Directive, ODPM Publications, London, 2005a, web page: http://www.doeni.gov.uk/niea/bm_sea_practicalguide.pdf, date of access: 30.04.2013

Office of Deputy Prime Minister, Sustainability appraisal of regional spatial strategies and local development documents, 2005b, web page: http://webarchive.nationalarchives.gov.uk/20061101024838/http:/www.communities.gov.uk/pub/346/SustainabilityAppraisalofRegionalSpatialStrategiesandLocalDevelopmentDocuments_id1161346.pdf, date of access: 03.02.2014

Organization for Economic Co-operation and Development, Aggregated environmental indices: review of aggregation methodologies in use. Paris, France: Organization for Economic Co-operation and Development Report No. ENV/EPOC/SE(2001)2/FINAL, 2002, web page: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC/SE%282001%292/FINAL&docLanguage=En, date of access: 20.01.2015

Oudenhoven, A.P.E. van; Petz, K.; Alkemade, R.; Hein, L. and Groot, R.S. de; Framework for systematic indicator selection to assess effects of land management on ecosystem services, Ecological Indicators, 21 (2012), p.110-122, 2012

Partidário M., EIA and SEA differences and Relationship, 2011, MSc course presentation, web page: https://dspace.ist.utl.pt/bitstream/2295/1013154/1/6.%20SEA%20and%20EIA.pdf, date of access: 30.04.2013

Ridder, W.D.; Turnpenny, J.; Nılsson, M. and Raggamby, A.V., A framework for tool selection and use in integrated assessment for sustainable development in Sheate, W.R. (eds) Tools, Techniques & Approaches for Sustainability: Collected Writings in Environmental Assessment Policy and Management, Worlds Scientific, Singapour, p. 125-144, 2010

The Royal Society for the Protection of Birds, 2013, web page: http://www.rspb.org.uk/Images/environmentalassessment_tcm9-257008.pdf, date of access: 30.09.2013

Saaty, T.L., Relative measurement and its generalization in decision making why pairwise comparisons are central in mathematics for the measurement of intangible factors the analytic hierarchy/network process, Revista de la Real Academia de Ciencias Exactas, Físicas y Naturales. Serie A. Matemáticas (RACSAM), Vol.102 No. 2, pp. 251-318, 2008

Sawyer, L.E. and Crowl, J.M., Land reclamation, in Pfleider, E.P.; Clark, G.B.; Hartman, H.L.; Soderberg, A. (eds.) Surface Mining, New York, p.247-266, 1968

SCB Associates Ltd., Excel AHP Template - 3 to 15 criteria, web page: www.scbuk.com/AHP%20Template%20SCBUK.xls, date of access: 28.05.2015

Sengupta, M., Environmental impacts of mining: monitoring, restoration, and control, Boca Raton, Florida, USA, 1993

Serrano, J.G.E., Indicator system implementation for the mining industry, in IAIA12 Conference Proceedings Energy Future The Role of Impact Assessment, 32nd Annual Meeting of the International Association for Impact Assessment, 2012, web page: http://www.iaia.org/conferences/iaia12/uploadpapers/Final%20papers%20review%20process/Escobar,%20Jos%C3%A9.%20%20INDICATOR%20SYSTEM%20IMPLEMENTATION%20FOR%20THE%20MINING%20INDUSTRY.pdf, date of access: 03.11.2014

Sharma S., The impact of mining on women: Lessons from the Coal Mining Bowen Basin of Queensland, Australia, Impact Assessment and Project Appraisal, Vol. D28 No.3, pp. 201-215, 2010

Shen, L., Muduli, K., Barve, A., Developing a sustainable development framework in the context of mining industry: AHP approach, Resource Policy, in press, 2013, http://dx.doi.org/10.1016/j.resourpol.2013.10.006

Sherbinin, A.; Reuben, A.; Levy, M.A. and Johnson, L., Indicators in practice: How environmental indicators are being used in policy and management contexts, Center for International Earth Science Information Network, Columbia University and Center for Environmental Law and Policy, Yale University, New Haven and New York, 2013, web page: http://www.ciesin.org/binaries/web/global/news/2013/indicatorsinpractice.pdf, date of access: 16.05.2015

Si, H., Haipu, B., Li, X. and Yang, C., Environmental evaluation for sustainable development of coal mining in Qijiang, Western China, International Journal of Coal Geology, 81 (2010), pp. 163-168, 2010

Singh, R.K.; Murty, H.R.; Gupta, S.K. and Dikshit, A.K., An overview of sustainability assessment methodologies, Ecological Indicators, 15 (2012), pp.281-299, 2012

Söderholm, P. and Svahn, N., Mining, regional development and benefit-sharing in developed countries, Resource Policy, 45 (2015), pp. 78-91, 2015

Turkish Electricity Transmission Company of Republic of Turkey, 5 Years Generation Capacity Projection of Turkey Electricity Energy Report (2013-2017), Ankara, in Turkish, 2013, web page: http://www.teias.gov.tr/YayinRapor/APK/projeksiyon/KAPASITEPROJEKSIYONU2013.pdf, date of access: 18.05.2015

Thérivel, R., Strategic Environmental Assessment in Action (second edition), Earthscan, London, 2004

Thérivel, R. and Wood, G., Tools for SEA, in Schmidt, M.; João, E. and Albrecht, E. (eds.) Implementing Strategic Environmental Assessment, Springer, Berlin, pp. 349-364, 2005

General Directorate of Turkish Coal Enterprise, 2010 Lignite Sector Report, Ankara, in Turkish, 2011, web page: http://www.enerji.gov.tr/File/?path=ROOT%2F1%2FDocuments%2FSekt%C3%B6r+Raporu%2FSektor_Raporu_TKI_2010.pdf, date of access: 15.06.2014

Union of Turkish Engineer and Architecture Chambers, TMMOB Afşin Elbistan Mine Accident Report, Ankara, in Turkish, 2012, web page: http://www.yerbilimleri.com/wp-content/uploads/2012/02/collolar_maden_kazasi_tmmob_raporu.pdf, accessed: 05.06.2015

Turkish Statistics Institution, Population statistics based on registered address, 2015, web page: http://tuikapp.tuik.gov.tr/adnksdagitapp/adnks.zul, accessed: 16.05.2015

Tutluoğlu, L., Öge, İ.F., Karpuz, C., Two and three dimensional analysis of a slope failure in a lignite mine, Computers & Geosciences, 37 (2011), pp. 232 -240, 2011

United Nations, Report of the World Commission on Environment and Development: Our Common Future, 1987, web page: http://www.un-documents.net/our-common-future.pdf, date of accessed: 03.11.2014

United Nations, Indicators of Sustainable Development: Guidelines and Methodologies, Third Edition, 2007, web page: http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf, date of access: 04.12.2013

United Nations Environmental Programme, Guidelines for social life cycle assessment of products, 2009, web page: http://www.unep.org/pdf/DTIE_PDFS/DTIx1164xPA-guidelines_sLCA.pdf, date of access: 02.04.2015

United Nations Framework Convention on Climate Change, Multicriteria Analysis (MCA), web page: http://unfccc.int/files/adaptation/methodologies_for/vulnerability_and_adaptation/application/pdf/multicriteria_analysis__mca_pdf.pdf, 2015, accessed: 15.01.2015

Ural, S.; Dağ, A.; Güneş, M. and Yayla, E., Determination of optimal pit area in the Afşin-Elbistan A (Kışlaköy) surface mining operation, 19th Mining Congress and Exhibition of Turkey (IMCET 2005), İzmir, Turkey, in Turkish, 2005, web page: http://www.maden.org.tr/resimler/ekler/e53d253d6bc3258_ek.pdf, date of access: 15.01.2015

Ural, S., 2014, History of mining and energy investments in Afşin-Elbistan Coal Basin, not published, personal communication

Ural, S., 2015, Discussion on Afşin-Elbistan Coal Basin Reserve Alternatives, not published, personal communication

Vanclay, F., The Triple Bottom Line And Impact Assessment: How Do TBL, EIA, SEA and EMS Relate to Each Other?, in Sheate W.R. eds Tools, Techniques & Approaches for Sustainability: Collected Writings in Environmental Assessment Policy and Management, Worlds Scientific, Singapour, p. 101-124, 2010

Yaylacı, E.D., An Indicator-Based Evaluation Framework for SEA, MSc. Thesis, International Master Course Environmental and Resource Management, Brandenburg Technical University, Cottbus, Germany, 2005

Yong-feng, L.; Yuan-hua, L.; Zhuan-ping, D.U. and Jie, C., Effect of coal resources development and compensation for damage to cultivated land in mining areas, Mining Science and Technology, 19 (2009), pp. 620-625, 2009

Yörükoğlu, M., Afşin-Elbistan Project and Mining Activities in AELİ operation of TKİ, Madencilik Vol. XXX, No.3, in Turkish, pp. 13-29, 1991, web page: http://www.maden.org.tr/resimler/ekler/e53d253d6bc3258_ek.pdf, date of access: 05.01.2015

Wang, J.J., Jing,Y.Y, Zhang, C.F., Zhao, J.H., Review on multi-criteria decision analysis aid in sustainable energy decision-making, Renewable & Sustainable Energy Reviews, 13 (2009), 2263-2278, 2009

Warhurst A., 2002, Sustainability indicators and sustainability performance management, International Institute for Environment and Development and World Business Council for Sustainable Development, Report No: 43 http://www.commdev.org/files/681_file_sustainability_indicators.pdf, date of access: 30.04.2013

World Bank, West Africa Mineral Sector Strategic Assessment (WAMSSA): An Environmental and Social Strategic Assessment for the Development of the Mineral Sector in the Mano River Union, Report No. 53738 - AFR-West Africa, 2010, web page: WA_MineralSec_SEA.pdf, date of access: 10.04.2013

World Bank, Strategic Environmental Assessment, 2013, web page: http://www.worldbank.org/en/topic/environment/brief/strategic-environmental-assessment, date of access: 10.04.2014

Wilkinson, D.; Fergusson, M., Bowyer, C.; Brown, J.; Ladefoged, A.; Monkhouse, C., and Zdanowicz A., Sustainable development in the European Commission's integrated impact assessment for 2003 – Final Report, London, 2004

Wood, C., Environmental Impact Assessment: A Comparative Review, Longman Scientific & Technical, Harlow, 1995

Wood, C., Environmental Impact Assessment: A Comparative Review, 2nd edition, Prentice-Hall, Harlow, 2003

Wood, C.; Barker, A.; Jones, C. and Hughes, J., Evaluation of the performance of EIA process, Final Report Vol. 1: Main Report, University of Manchester, Manchester, 1996

Wood, R. and Garnett, S., Regional sustainability in Northern Australia – A quantitative assessment of social, economic and environmental impacts, Ecological Economics, 69, pp.1877-1882, 2010

Worrall, R.; Neil, D.; Brereton, D. and Mulligan, D., Towards a sustainable criteria and indicators framework for legacy mine land, Journal of Cleaner Production, Elsevier, 17(2009), pp. 1426-1434, 2009

Xu, Z. and Coors, V., Combining system dynamics model, GIS and 3D visualization in sustainability assessment of urban residential development, Building and Environment, 47, pp. 272-287, 2012

Zhengfu, B.; Inyang, H.I.; Daniels, J.L.; Otto, F. and Struthers, S., Environmental issues from coal mining and their solutions, Mining Science and Technology, 20 (2010), pp. 215-223, 2010

APPENDIX A

The Mining Sector Related Sustainability Focused Research and Projects

Table A. The mining sector related sustainability focused research and projects

Time	Name	Who?/How?	Why?/Outcome
1997	Global Reporting Initiative (GRI)	Established by non-profit organizations the Coalition for Environmentally Responsible Economies (CERES) and the Tellus Institute.[4]	"To create an accountability mechanism to ensure companies were following the CERES Principles for responsible environmental conduct. Investors were the framework's original target audience."[4]
1999[1]	Global Mining Initiative (GMI)	"launched by CEOs of nine of the largest mining and metals companies" [1,2]	"To create an industry association that would focus on sustainable development in the mining, metals and minerals sectors."[2]
2000	First GRI Guideline	Global Reporting Initiative (GRI)	"The first version of the Guidelines was launched in 2000."[4]
2000	Mining, Minerals and Sustainable Development (MMSD) Project	"initiated after GMI managed by the International Institute for Environment and Development (IIED), supported by the World Business Council for Sustainable Development (WBCSD)"[2]	"an independent two-year process of consultation and research to maximize the contribution of the mining and minerals sector to sustainable development at the global, national, regional and local levels." [2]
2000	The Extractive Industries Review (EIR)	World Bank (WB)	"Created by WB in 2000 as a comprehensive review of its investments in the mining industry."[2]
2001	International Council on Mining and Metals (ICMM)	the International Council on Metals and the Environment (ICME)	"The board of the metals industry's representative organization, ICME agrees to broaden the group's mandate and transform itself into ICMM."[1]
2001	Mining & Minerals Sustainability Survey 2001[7]	the Mining Minerals and Sustainable Development (MMSD=	"To produce an authoritative analysis of the key issues for the mining and minerals industry in addressing Sustainable Development."[7]
2002	The second generations of GRI Guidelines (G2)	GRI	"G2, was unveiled at the World Summit on Sustainable Development in Johannesburg. GRI was referenced in the World Summit's Plan of Implementation."[4]

Table A. continued

Time	Name	Who?/How?	Why?/Outcome
2002	Toronto Global Conference	ICMM	"ICMM member companies sign the Toronto Declaration committing to engage in constructive dialogue with key stakeholders."[1]
2002	Breaking New Ground Report[6]	MMSD Project publication	"Report on sustainable mining presents the main findings of the MMSD's research, analysis and stakeholder engagement process. The report was also used as template for future ICMM activities."[2]
2002	Sustainability Indicators and Sustainability Performance Management Document	Warhurst A. for IIED	"Development and use of Sustainability Performance Indicators (also referred to as Sustainability Indicators) to communicate to the internal and external stakeholders of mining companies about the sustainable development goals."[3]
2002	Sustainability Reporting Guidelines	GRI	"a model for sustainability reporting used across sectors"[2]
2003	10 guiding principles	ICMM	"ICMM Council adopt 10 guiding principles, the first element of ICMM's Sustainable Development Framework."[1]
2003	Mining and Metals Sector Supplement to GRI 2002 Guidelines.	GRI-ICMM Working Group[1]	"the basis for ICMM members to report their economic, environmental, human rights and social performances with the specific performance indicators."[2] "A pilot version phase ran from October 2003 through February 2005."[8]

Table A. continued

Time	Name	Who?/How?	Why?/Outcome
2005	Sustainability Reporting	ICMM members	ICMM Council commits corporate members to report to the highest standards of non-financial reporting, that is "in accordance" with the GRI framework.[1]
2006	Third generation of Guidelines, G3.	GRI	"Over 3,000 experts from business, civil society and the labor movement participated in G3's development."[4]
2008	Finalized Mining and Metals Sector Supplement to GRI 2006 Guidelines (G3).	ICMM	"Reporting the experience, using the pilot version, and brought it up to date with the G3 Guidelines (2006) and developed indicator protocols. Both phases included public consultations."[8]
2008	An upgraded Assurance procedure	ICMM	"Published, outlining ICMM members' commitment to independent external assurance."[1]
2009	Sustainable Development Framework.	ICMM	"ICMM conducts an assessment of the progress that each member company is making against their commitments under the Sustainable Development Framework."[1]
2010	Final version of Mining and Metals Sector Supplement	ICMM	"The final version of the supplement was released in March 2010. ICMM members are required to reporting in line with this supplement and to self-declare an application level A."[8]
2011	G3.1 Guidelines	GRI	"GRI published the G3.1 Guidelines – an update and completion of G3, with expanded guidance on reporting gender, community and human rights-related performance."[4]

Table A. continued

Time	Name	Who?/How?	Why?/Outcome
2012	MMSD+10: Reflecting on a decade of mining and sustainable development	Buxton A. For IIED	"Intended as a 'conversation starter' – providing an initial assessment of the mining and minerals sector's achievements against the MMSD agenda and open to further discussion."[5]
2013	Fourth generation guidelines G4	GRI	G4 was released by GRI[4]

[1] http://www.icmm.com/about-us/our-history, accessed: 20.05.2014
[2] Lins C. and Horwitz E., 2007, Sustainability in the Mining Sector, RJ, Brazil, web page: http://www.fbds.org.br/IMG/pdf/doc-295.pdf, accessed: 20.05.2014
[3] Warhurst, A., Sustainability Indicators and Sustainability Performance Management, IIED and WBCSD Report No: 43, 2002, web page: http://www.commdev.org/files/681_file_sustainability_indicators.pdf, accessed: 20.05.2014
[4] Global Reporting Initiative, web page: https://www.globalreporting.org/information/about-gri/what-is-GRI/Pages/default.aspx, accessed: 20.05.2014
[5] Buxton A., 2012, MMSD+10: Reflecting on a decade of mining and sustainable development, International Institute for Environment and Development (IIED), web page: http://pubs.iied.org/pdfs/16041IIED.pdf? accessed: 20.05.2014
[6] Breaking New Ground: Mining, Minerals and Sustainable Development Final Report, web page: http://www.iied.org/mmsd-final-report, accessed: 20.05.2014
[7] MMSD Mining and Minerals Sustainability Survey, 2001, web page: http://pubs.iied.org/pdfs/G00742.pdf?, accessed: 20.05.2014
[8] ICMM, 2014, http://www.icmm.com/our-work/sustainable-development-framework/public-reporting, accessed: 20.05.2014

APPENDIX B

List of the Global Mining Sector Related Sustainability Indicators

Table B.1. List of the global mining sector related sustainability indicators under the environmental pillar

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
1	Mineral Resources	Extraction	tonnes/ year	Breakdown of the amount of each saleable primary resource extracted	Azapagic, 2004p, p.653
2			%	Total products' yield as percentage of the amount of saleable products relative to the total amount of material extracted	
3			%/yr	Percentage of each resource extracted relative to the total amount of the permitted reserves of that resource	
4		Impact on land		Solid loss and habitat	Serrano, 2012
5				Reduction of landscape quality	
6	Materials		tonnes/yr	Breakdown by type and the total amount of chemicals used	Azapagic, 2004, p.653
7			%	Percentage of waste chemicals (processed or unprocessed) used from both internal and external sources	
8			tonnes/yr	Breakdown by type and the total amount of packaging used	
9			%	Percentage of recycled or re-used packaging relative to the total amount of packaging	
10			tonnes or m^3	Materials used by weight or volume	GRI,2011:32
11			%	Percentage of materials used that are recycled input materials	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
12	Compliance and voluntary activities	Compliance	Nbr/yr & Description	Total number of prosecutions for environmental non-compliance and a summery for each region and country if applicable	Azapagic, 2004: 655
13			%	Percentage of planning permissions refused on environmental and social grounds relative to the number applications for permissions	
14		Voluntary activities	%	Percentage of sites certified to an EMS (e.g. ISO 14001/EMAS)	
15			Description	Summary of any other environmental voluntary activities	
16		Monitory spending	US$	Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with environmental laws and regulations.	GRI,2011:34
17			US$ & Description	Total environmental protection expenditures and investments by type.	
18	Water & Liquid effluents	Water use	m^3/yr	Total water use for production of mineral resources	Azapagic, 2004: 653
19			Description	Total water withdrawal by source	GRI,2011:32
20			m^3	Water use intensity by activity	Helbron 2008
21			%	Percentage change of groundwater development rate	UN 2007,

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
22	Water & Liquid effluents (cont.)	Discharge	m^3	Proportion of total water resources affected	UN 2007, Helbron 2008
23			Nbr	Water sources significantly affected by withdrawal of water	GRI,2011:32
24				Decrease the groundwater level	Serrano, 2012
25				Shortage of water that sustains biodiversity sectors	
26			m^3/yr	Total volume of water discharge into waterways	Azapagic, 2004: 655
27			m^3/yr and description	Total volume of tailings and disposal methods	Azapagic, 2004: 655
28			tonnes/yr	Breakdown of substances discharged with liquid effluents	
29			m^3/yr and description	Total water discharge by quality and destination	GRI,2011:33
30		Water quality and pollution	Description	Describe any measures put in place to prevent acid main drainage, if applicable	Azapagic, 2004: 655
31			%	Percentage of permitted sites causing downstream and/or underground water quality problems relative to the total number of permitted sites	
32			amount	Releases of nitrogen and phosphorus to surface water	UN, 2007
33			amount	Presence of faecal coliforms in freshwater	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
34	Water & Liquid effluents (cont.)	Water quality and pollution (cont.)	amount	Biochemical oxygen demand in water bodies	UN, 2007
35			amount	Concentration of faecal coliform in freshwater	
36			Description	Human health problems, wildlife and high mountain vegetation disease due to liquid industrial waste dumping of rivers and groundwater	Serrano, 2012
37			Description	Loss of wildlife habitat due to liquid industrial waste dumping of rivers and groundwater	
38		Recycled and reused water	%	Percentage of water recycled and reused (e.g. cooling, waste, rain water) relative to the total water withdrawn from source	Azapagic, 2004: 653
39			% & m^3	Percentage and total volume of water recycled and reused.	GRI,2011:32
40	Closure and rehabilitation		Nbr/yr	Number of mines closed	Azapagic, 2004: 654
41			Nbr/yr	Number of sites rehabilitated	
42			ha/yr	Total land area rehabilitated	
43			%/yr	% of the land area rehabilitated relative to the total land area occupied by the closed mines/quarries awaiting rehabilitation	Azapagic, 2004: 654
44			Nbr / yr	Number of awards for rehabilitation and a summary, if applicable	
45			Nbr/yr & description	Number of sites officially designated for biological, recreational or other interest as a result of rehabilitation	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
46	Closure and rehabilitation (cont.)		Nbr/yr & description	Net number of trees planted (after thinning and after subtracting any trees removed for the extraction activities)	Azapagic, 2004: 654
47			Nbr/yr & Description	Summary of the policy for closure and rehabilitation	
48	Biodiversity	Impacts on biodiversity	Description	Description of the major impacts on biodiversity associated with company activities and/or products and services in terrestrial, freshwater, and marine environments	Azapagic, 2004: 654
49			Description	Significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	GRI,2011:33
50			Nbr	Number of IUCN Red List species with habitats in areas affected by operations (Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.)	Azapagic, 2004: 654 (GRI,2011:33)
51				Change in threat status of species	UN, 2007
52		Flora	%	Percentage of forest damaged by defoliation	
53		Fauna	%	Threatened species as a percent of total native species	
54		Management Plans	%	Percentage fragmentation of habitats	UN 2007,
55			Description	Description of the activities for habitat protected or rehabilitation	Azapagic, 2004: 654
56			Description	Summary of the biodiversity policy	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
57	Biodiversity (cont.)	Management Plans (cont.)	Description	Strategies, current actions, and future plans for managing impacts on biodiversity	GRI,2011:33
58			Nbr & Description	The number and percentage of total sites identified as requiring biodiversity management plans according to stated criteria, and the number (percentage) of those sites with plans in place.	
59			Description	Habitats protected or restored.	GRI,2011:33
60		Occupation of Land	-	Loss of high mountain vegetation	Serrano, 2012
61			-	Loss of wildlife habitat	
62			-	Death and displacement of wildlife	
63			ha	Effected area of selected key ecosystems	UN 2007,
64			Description & ha	Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.	GRI,2011:33
65			ha	Amount of land (owned or leased, and managed for production activities or extractive use) disturbed or rehabilitated.	
66	Air emissions	Mitigation of emission	Nbr/yr	Equivalent number of fully grown trees that would be required for sequestration of the total CO_2 emissions	Azapagic, 2004: 654
67			tonnes	The amount of CO_2 emissions that can (theoretically) be sequestered by the trees planted by the company	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
68	**Air emissions (cont.)**	Mitigation of emission (cont.)	tonnes/yr	Net emissions of CO_2 (total CO_2 emissions minus CO_2 emissions potentially sequestered by trees)	Azapagic, 2004: 654
69			Description	Initiatives to reduce greenhouse gas emissions and reductions achieved	GRI,2011:33
70		Emissions (traffic activity, crushing stage, milling of are etc.)	tonnes/yr	Emissions of ozone depleting substances, breakdown by substance	Azapagic, 2004: 655; GRI,2011:33
71			tonnes/yr	Emissions of acid gases (NOx, SO_2 and other) breakdown by substance	Azapagic, 2004: 655
72			tonnes/yr	Emissions of particles	
73			tonnes/yr	Toxic emissions (including heavy metals, dioxins, crystalline silica and others), breakdown by substance	
74			tonnes/yr	Other emissions; breakdown by substance	
75			Description	Respiratory diseases	Serrano, 2012
76			Description	Loss of wildlife habitat	
77		Air pollutants & Climate change	tonnes/yr	CO_2	UN 2007, Dobranskyte-Niskota et.al, 2009, Azapagic, 2004: 654; GRI,2011:33
78			tonnes/yr	NOx	
79			tonnes/yr	VOCs	
80			tonnes/yr	PM_{10} and $PM_{2.5}$	
81			tonnes/yr	SOx	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
82	**Air emissions (cont.)**	Air pollutants & Climate change (cont.)	tonnes/yr	N_20	UN 2007, Dobranskyte-Niskota et.al, 2009, Azapagic, 2004: 654; GRI,2011:33
83			tonnes/yr	CH_4	
84			tonnes/yr	O_3	
85			tonnes/yr	CO_2	
86			tonnes/yr	O_3	
87			tonnes/yr	HFCs,	Azapagic, 2004: 654, GRI,2011:33
88			tonnes/yr	SF_6	
89			tonnes/yr	PFCs,	
90			tonnes/yr	Other relevant indirect greenhouse gas emissions by weight.	GRI,2011:33
91			tonnes/yr	NO, SO, and other significant air emissions by type and weight.	
92	**Land**	Land use	ha	Total area of permitted development (mines and all other facilities)	Azapagic, 2004: 653
93			ha/yr	Total land area newly opened for extraction activities (including area for overburden storage and tailings)	
94			%	Percentage of newly opened land area relative to total permitted development	
95			ha/yr	Total land area covered by ancient or rain forest that was cleared for the extraction activities	
96			Number and description	Number of sites on environmentally protected or sensitive areas and a description, including both current and planned developments	

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
97	**Land (cont.)**	Impact of land use	ha	Loss of arable land	GoI-2004: 30
98			ha	Loss of arable land	UN 2007, Dobranskyte-Niskota et.al, 2009
99			ha	Amount of land consumption	GoI-2004: 30
100			ha	Area	Converted from GoI-2004: 30
101		Soil	%	Percentage change in agricultural productivity	GoI 2004
102			ha	Land under erosion risk	UN 2007
103			ha	Land under salinization risk	
104			ha	Land under contamination threat	
105	**Waste**	Solid	tonnes/ year	Total waste extracted (non-saleable material, including overburden)	Azapagic, 2004:653
106			tonnes/yr & Description	Total non-hazardous solid waste and breakdown by type and description of disposal methods	Azapagic, 2004: 655
107			%	Percentage of permitted sites that have a problem of land contamination relative to the total number of permitted sites	
108			Tonnes & Description	Total weight of waste by type and disposal method.	GRI,2011:33

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
109	Waste (cont.)	Solid (cont.)	Tonnes & Description	Total amounts of overburden, rock, tailings, and sludge and their associated risks.	GRI,2011:33
110		Hazardous	tonne or kg	Weight of transported, imported, exported, or treated waste	GRI,2011:34
111			tonnes/yr & Description	Total hazardous solid waste and breakdown by type and description of disposal methods	Azapagic, 2004: 655
112	Transport and logistics		km/yr	Total transport distance, including in the mine/quarry, transport of products to customers, business travel and commuting for 'fly-in, fly-out' operations	Azapagic, 2004: 656
113			km/tonnes	Total distance for all transport per tonne of products	Azapagic, 2004: 656
114			%	Percentage of distance for transport of products to customers covered by road, rail and water transport, breakdown by type	
115			Description	Significant environmental impacts of transporting products, goods and materials used for the organization's operations, and transporting members of the workforce.	GRI,2011:34
116	Energy		Mj/yr	Breakdown by type of the amount of the primary energy used (including natural gas, diesel, LPG, petrol and other fuels) [Direct energy consumption by primary energy source]	Azapagic, 2004: 653 [GRI,2011:32]
117			Mj/yr	Indirect energy consumption by primary source	GRI,2011:32
118			Mj/yr	Breakdown by type of the amount of the secondary energy used (electricity and heat) used and exported	Azapagic, 2004: 653

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
119	**Energy (cont.)**		Mj/yr	Energy from renewable sources used and exported	Azapagic, 2004: 653
120			Mj/yr	Total primary and secondary energy used	
121			Mj/yr	Energy saved due to conservation and efficiency improvements	GRI,2011:32
122			%	Percentage of renewable energy used relative to total energy consumption	Azapagic, 2004: 653
123			Description	Initiatives to reduce indirect energy consumption and reductions achieved.	GRI,2011:32
124			Description	Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these initiatives.	
125			Description	Summary of energy policy	Azapagic, 2004: 653
126	**Miscellaneous**	Noise emissions		Discomfort and possible diseases	Serrano, 2012
127				Loss of wildlife habitat	
128		Cutting infra-structure (power lines, roads, water lines etc.)		Reduction of landscape value	
129				Cut the Biological wildlife corridor	
130				Loss of wildlife habitat	
131		Nuisance	Number/yr	Total number of external complaints related to noise, road dirt and dust, visual impact and other nuisance	Azapagic, 2004: 655

Table B.1. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
132	**Miscellaneous (cont.)**	Suppliers and contractors	Description	Summary of any assessments of suppliers and contractors quality and environmental performance	Azapagic, 2004: 656
133		Products	Description	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.	GRI,2011:34
134			%	Percentage of products sold and their packaging materials, reclaimed by category.	GRI,2011:34
135	**Risks and Damages**	Risk of accidents/ incidences polluting air, water, soil		Possibility	Dobranskyte-Niskota et.al, 2009
136				Frequency	
137				Effect	
138				Recovery period in case of damage	
139				Area possibly affected	
140		Hazardous materials		Amount	
141				Possible effect	
142				Recovery period in case of damage	
143				Total number and volume of significant spills	GRI,2011:33
144				Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization's discharges of water and runoff.	GRI,2011:34
145			Nbr/yr and description	Number of environmental accidents and a summary for each region or country, as applicable	Azapagic, 2004: 655
146			Description	Describe any measures put in place to prevent tailings dam(s) failure	Azapagic, 2004: 655

Table B.2. List of the global mining sector related sustainability indicators under the social pillar

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
1	Labor practices and decent work	Employment	Number	Breakdown by region or country of the number of direct employees (on company payroll)	Azapagic, 2004:658
2			Number	Number of indirect employees (e.g. contractors, consultants) expressed as full-time equivalents	
3			%	Percentage of indirect relative to direct jobs	
4			%	Net employment creation expressed as percentage contribution to employment in a region or country	
5			%/yr	Employee turnover expressed as percentage of employees leaving company relative to the total number of new employees	
6			Number & description	Total workforce by employment type, employment contract, and region.	GRI,2011:36
7			Number & %	Total number and rate of employee turnover by age group, gender, and region.	
8			Description	Benefits provided to full-time employees that are not provided to temporary or part-time employees, by major operations.	
9		Labor / management relations	Ranking & description	Ranking of the company as an employer in the internal surveys	Azapagic, 2004:658
10			Description	Policy procedures involving consultation and negotiation with employees over changes in the company (e.g. restructuring, redundancies etc.)	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
11	**Labor practices and decent work (contd.)**		%	Percentage of employees covered by collective bargaining agreements.	GRI,2011:36
12			Description	Freedom of association and collective bargaining	GRI,2011:38
13			Description	Minimum notice period(s) regarding operational changes, including whether it is specified in collective agreements.	GRI,2011:36
14			Number	Number of strikes and lock-outs exceeding one week's duration, by country.	
15		Health and safety	%	Percentage of hours of training regarding health and safety relative to the total number of hours worked	Azapagic, 2004:658
16			Nbr/yr	Number of fatalities at work	
17			hr/yr	Lost-time accidents	
18			%	Lost-time accidents relative to the total hours worked	
19			%	Percentage of total absence-hours on health and safety grounds relative to the total hours worked	
20			Nbr	Number of compensated occupational diseases	
21			Description	Summary of the policy on HIV/AIDS	
22			%	Percentage of total workforce represented in formal joint management–worker health and safety committees that help monitor and advice on occupational health and safety programs.	GRI,2011:36
23			Nbr/yr	Rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities by region.	GRI,2011:36

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
24			Description	Education, training, counselling, prevention, and risk-control programs in place to assist employees, their families, or community members regarding serious diseases.	GRI,2011:36
25			Description	Health and safety topics covered in formal agreements with trade unions.	
26			%	Percentage of hours training (excl. Health and safety) relative to the total hours worked (e.g. Management, production, technical, administrative, cultural etc.)	Azapagic, 2004:658
27		Training and education	Nbr/yr & description	Number of employees that are financially sponsored by the company for further education	
28	**Labor practices and decent work (contd.)**		Description	Summary of programs to support the continued employability of employees and to manage career endings	
29			hr/yr	Average hours of training per year per employee by employee category.	GRI,2011:36
30			Description	Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	
31			%	Percentage of employees receiving regular performance and career development reviews	
32		Suppliers and contractors	%/yr & description	Percentage of contracts that are paid in accordance with agreed terms	GRI,2011:36
33			%	Percentage of local suppliers, relative to the total number of suppliers	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
34	Labor practices and decent work (contd.)	Non-discrimination diversity and opportunity	%	Percentage of women employed relative to the total number of employees	GRI,2011:36
35			%	Percentage of women in senior executive and senior and middle management ranks	Azapagic, 2004:658
36			%	Percentage of ethnic minorities employed relative to the total number of employees, with an explain of how representative that is of the regional or national population makeup	
37			% & description	Percentage of ethnic minorities in senior executive and senior and middle management ranks	
38			Description	Summary of the equal opportunity policy	
39			% & description	Composition of governance bodies and breakdown of employees per category according to gender, age group, minority group membership, and other diversity indicators	GRI,2011:36
40			%	Ratio of basic salary of men to women by employee category.	
41			Nbr	Total number of incidents of discrimination and actions taken.	GRI,2011:38
42	Human Rights	Strategy and management	Description	Summary of the policy concerning human rights relevant to company's activities	Azapagic, 2004:659
43		Freedom of association	Description	Statement on whether the company conforms with the ILO Conventions on the Right to Organize (no.87&98)	
44		Child labor	Description	Summary of the policy on excluding child labor as defined by the ILO Convention 138	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
45			Description	Specify any verified incidences of non-compliance with child labor national and international laws	
46			Description	Operations identified as having significant risk for incidents of child labor, and measures taken to contribute to the elimination of child labor	GRI,2011:38
47		Forced and compulsory labor	Description	Summary of the policy to prevent forced and compulsory labor as specified in ILO Convention No. 29, Article 2	Azapagic, 2004:659
48			Description	Operations identified as having significant risk for incidents of forced or compulsory labor, and measures to contribute to the elimination of forced or compulsory labor.	GRI,2011:38
49			%	Percentage of quarries/mines on sites sacred for indigenous people relative to the total number of quarries/mines	Azapagic, 2004:659
50			Description	Summary of the policy to addresses the needs and particularly the land rights of indigenous people	
51	**Human Rights (cont.)**	Indigenous rights	Nbr	Total number of operations taking place in or adjacent to Indigenous Peoples' territories	
52			Nbr & %	Number and percentage of operations or sites where there are formal agreements with Indigenous Peoples' communities	GRI,2011:38
53			Nbr	Total number of incidents of violations involving rights of indigenous people and actions taken.	
54		Investment and Procurement Practices	% & Nbr	Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.	GRI,2011:38
55			%	Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
56	Human Rights (cont.)		hr/yr	Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained.	GRI,2011:38
57		Security Practices	%	Percentage of security personnel trained in the organization's policies or procedures concerning aspects of human rights that are relevant to operations.	
58	Society	Local Communities	Nbr & description	Total number of health and safety complaints from local communities, with a summary, if applicable	Azapagic, 2004:659
59			Nbr & description	Number of proposed developments that require resettlement of communities, with a description, if applicable	
60			%	Percentage of sites with 'fly-in, fly-out' operations relative to the total number of sites	
61			%	Percentage of employees sourced from local communities relative to the total number of employees	Azapagic, 2004:660
62			Description	Specify any community projects in which the company has been involved	
63			Description	Awards received for social and ethical behavior in relation to local communities	
64			Description	Summary of the policy for liaison with local communities	
65			Description	Summary a Community Sustainable Development Plan to manage impacts on communities in areas affected by its activities during the mine operation and post-closure	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
66	**Society (contd.)**	Local Communities (contd.)	Description	Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities	GRI,2011:40
67			Nbr & description	Number and description of significant disputes relating to land use, customary rights of local communities and Indigenous Peoples.	GRI,2011:40
68			Description	The extent to which grievance mechanisms were used to resolve disputes relating to land use, customary rights of local communities and Indigenous Peoples, and the outcomes.	
69		Resettlement	%	Reduction of basic services for the people (health, education, recreation, etc.)	Serrano, 2012
70			Nbr & description	Sites where resettlements tookplace, the number of households resettled in each, and how their livelihoods were affected in the process.	GRI,2011:40
71		Stake-holder involvement	Description	Summary of the policy on stakeholder involvement, including the mechanisms by which stakeholders can participated in decision-making on the issues that concern them	Azapagic, 2004:660
72		Population	%	Population growth rate change before after	UN, 2007
73			%	Dependency of women and 18 older [before and after]	
74			%	Change in urban population	
75			%	Net migration rate incomers/outgoing	
76			%	Change in qualified population	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
77	Culture and Heritage	Archaeo-logical sites	Nbr	Number of archaeological sites affecting from the strategy	Warhurst 2002:28
78		Change in social life	Nbr	Displaced population	Warhurst 2002:28
79			%	Prostitution	
80			Description	Alcoholism	
81			Description	Cultural disruption	
82		Impact of migration	%	Percentage of migrated population to different city in displaced population	Warhurst, 2002:64
83	Life Quality	Infrastructure	monetary unit	Infrastructure expenditure per capita	UN 2007, Warhurst, 2002
84		Improvement in infrastructure	Description or Nbr	Change in number of schools	
85			Description or Nbr	Change in number of health service points open to public	
86			Description or Nbr	Change in number of public buildings	
87		Accessibility	Description	Vehicle accessibility	
88			Description	Information/Communication services accessibility	
89		Visual Impact on Landscape	m^2	Recreational area per capita	
90		Income	%	House price to income ratio	
91			%	Net income change per capita	
92	Product responsibility	Customer health and safety	Nbr/yr monetary unit/yr	Number and type of instances of non-compliance with regulations concerning customer health and safety, including the penalties and fines assessed for these breaches	Azapagic, 2004:660
93			Description	Summary of the policy for preserving customer health and safety during use of products	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
94	**Product responsibility (cont.)**	Products	Description	Summary of consumer satisfaction and complaints	
95			Description	Summary of the policy related to product information and labelling	
96		Materials Stewardship	Description	Programs and progress relating to materials stewardship.	GRI,2011:42
97		Costumer Health and Safety	Description	Life cycle stages in which health and safety impacts of products and services are assessed for improvement,	
98			%	Percentage of significant products and services categories subject to health and safety impacts of products and services are assessed	
99			Nbr	Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.	
100		Product and Service Labelling	Nbr & %	Type of product and service information required by procedures and percentage of significant products and services subject to such information requirements.	
101			Nbr	Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labelling, by type of outcomes.	
102			Description	Practices related to customer satisfaction, including results of surveys measuring customer satisfaction.	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
103	Product responsibility (cont.)	Marketing & Communi-cation	Description	Programs for adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship.	GRI,2011:42
104			Nbr	Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship by type of outcomes.	
105		Customer Privacy	Nbr	Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.	GRI,2011:43
106		Compliance	monetary unit/yr	Monetary value of significant fines for noncompliance with laws and regulations concerning the provision and use of products and services.	
107	Business Ethics	Closure Planning	Nbr & %	Number and percentage of operations with closure plans	GRI,2011:40
108		Anti-competitive Behavior	Nbr	Total number of legal actions for anticompetitive behavior, anti-trust, and monopoly practices and their outcomes.	GRI,2011:41
109		Compliance	monetary unit & Nbr	Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with laws and regulations.	GRI,2011:41
110		Bribery and corruption	Description	Summary of the policy on addressing bribery and corruption that meets (and goes beyond) the requirements of the OECD Convention on Combating Bribery	Azapagic, 2004:660

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
111		Political contributions and lobbying	Description	Summary of the policy for managing political contributions an lobbying	Azapagic, 2004:660
112		Public policy	Description	Public policy positions and participation in public policy development and lobbying.	
113	**Business Ethics (contd.)**		monetary unit	Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country.	
114		Corruption	% & Nbr	Percentage and total number of business units analyzed for risks related to corruption.	GRI,2011:41
115			%	Percentage of employees trained in organization's anti-corruption policies and procedures	
116			Description	Actions in response to incidents of corruption	
117		Social justice in the workplace	Description	Socially responsible employment and working conditions	
118			Description	Socially responsible management policies and systems	
119			Description	Socially responsible approach to personal development	
120			Description	Socially responsible communication strategy and employee involvement	
121		Socially responsible external stakeholder relations	Description	Group policies with reference to internal, external CSR benchmarks and human rights issues	Warhurst 2002:99
122	**Policy and Practice**		Description	Sustained commitment to social performance evaluation, reporting at local and corporate level	
123			Description	Ongoing group social audit and verification processes conforming to AA 1000	

Table B.2. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
124	**Policy and Practice (contd.)**	Socially responsible external stakeholder relations	Description	Demonstrable use of SIA tools throughout project life, including closure	Warhurst 2002:99
125			Description	Sustained commitment to corporate social investment	
126		Government relations	Description	Corporate compliance and accountability with respect to international, national and regional regulations, restrictive measures and laws	Warhurst 2002:100
127			Description	Commitment to strategy of corporate citizenship irrespective of laws in place and government approach to enforcement	
128			Description	Identification of human rights issues and commitment to their protection	
129			Description	Proven commitment to government stakeholder dialogue and engagement as a systematic principle of corporate policy from the outset to the end of a project/investment	
130			Description	Investigate more equitable 'rent-sharing' agreements	
131			Description	Proven commitment to CSI as a mechanism for contributing to local and regional development plans in countries of operation	

Table B.3. List of the global mining sector related sustainability indicators under the economic pillar

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator(s)	Source
1	Products		Description	Breakdown by product type	Azapagic, 2004:650
2			tonnes/yr	Amount sold by product type	
3			monetary unit/yr	Net sales	
4			monetary unit/yr	Earnings before interest and tax	
5			monetary unit/yr	Value-added	
6			monetary unit/yr	Value-added per unit value of sales	
7	Customers		%	Geographic breakdown of markets, disclosing: national market share greater than 25%	Azapagic, 2004:650
8			%	Geographic breakdown of markets, disclosing: contribution to GDP greater than 5%	
9	Suppliers and contractors		monetary unit/yr	Cost of goods, materials and services purchased	Azapagic, 2004:650
10	Employees		monetary unit/yr	Total payroll costs and benefits (including pension and redundancy payments) broken down by region or country	Azapagic, 2004:650
11			%	Total cost of employment as percentage of net sales	
12			%	Health, pension and other benefits and redundancy packages provided to employees as percentage of total employment costs	Azapagic, 2004:650

Table B.3. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
13			%/country	Ratio of lowest wage to national legal minimum, breakdown by country	
14			%	Investment in employee training and education as percentage of net sales	
15			%	Percentage of employees that are shareholders in the company	
16	Providers of capital		monetary unit/yr	Distributions to providers of capital broken down by interest on debt and borrowings ad dividends on all classes of shares	Azapagic, 2004:650
17			monetary unit/yr	Average capital employed	
18			%/yr	Return on average capital employed (ROACE)	
19			%	Percentage of ethical investments relative to total investments	
20	Local communities		%	Percentage of revenues that are redistributed to local communities from the relevant areas of operation, relative to the net sales	Azapagic, 2004:650
21			%	Investments into community projects (e.g. Schools, hospitals, infrastructure) as percentage of net sales	Azapagic, 2004:651
22	Public sector		monetary unit/yr	Breakdown by country of the total sum of all types of taxes and royalties paid	Azapagic, 2004:651
23			monetary unit/yr	Fines paid for non-compliance (economic, environmental and social)	

Table B.3. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
24	Public sector (cont.)		monetary unit/yr	Total investment for pollution prevention and control (air, water and solid waste)	Azapagic, 2004:651
25			monetary unit	Total fund for mine closure and rehabilitation, including mitigating the post-closure environmental and social impacts	
26			monetary unit/yr	Amount of money paid to political parties and institutions whose prime function is to fund political parties or their candidates	
27	Economic Performance		monetary unit/yr	Direct economic value generated and distributed, including revenues, operating costs, employee compensation, donations and other community investments, retained earnings, and payments to capital providers and governments	GRI, 2011:30,
28			monetary unit	Financial implications and other risks and opportunities for the organization's activities due to climate change	
29			monetary unit	Coverage of the organization's defined benefit plan obligations	
30			monetary unit/yr	Significant financial assistance received from government	
31	Market Presence		%	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation.	GRI,2011:30
32			Description & %	Policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation.	
33			Description	Procedures for local hiring and proportion of senior management and workforce hired from the local community at locations of significant operation.	

Table B.3. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
34	Indirect Economic Impacts		monetary unit/yr	Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind, or pro bono engagement.	GRI,2011:31
35			Description	Understanding and describing significant indirect economic impacts, including the extent of impacts.	
36	Well-being of communities			Equity	Warhurst, 2002:33
37				Taxation	Warhurst, 2002, 2002:39
38			%	Percentage of purchasing from local supplier to out of region	Extended from GRI in Warhurst, 2002:53;
39			%	Percentage of royalty income to revenues	Warhurst, 2002
40	Technology	Efficiency	%	Wastewater treatment	Warhurst, 2002:39 Dobranskyte-Niskota et.al, 2009:15
41		Innovation and R&D capacity	monetary unit/yr	Innovation and R&D Investment	Warhurst, 2002:39

Table B.3. continued

NO	Dimensions & Indicator Set Theme	Sub-theme	Unit	Indicator	Source
42		Resource intensity	%	Produced goods or services per material	Wuppertal Sustainability Indicators in Warhurst, 2002:76
43			%	Produced goods or services per input	
44			%	Produced goods or services per land input	
45			%	Produced goods or services per energy input	
46			%	Transport intensity	

APPENDIX C

Project-level (PL) Indicators for the Mining Sector

Table C.1. Project-level (PL) indicators under the environmental indicator set

# in Appendix B	Indicator	Unit
1	Breakdown of the amount of each saleable primary resource extracted	tonnes/ year
2	Total products' yield as percentage of the amount of saleable products relative to the total amount of material extracted	%
3	Breakdown by type and the total amount of chemicals used	tonnes/yr
4	Percentage of waste chemicals (processed or unprocessed) used from both internal and external sources	%
5	Breakdown by type and the total amount of packaging used	tonnes/yr
6	Percentage of recycled or re-used packaging relative to the total amount of packaging	%
7	Materials used by weight or volume	tonnes or m^3
8	Percentage of materials used that are recycled input materials	%
9	Total number of prosecutions for environmental non-compliance and a summery for each region and country if applicable	Nbr/yr & Description
10	Percentage of planning permissions refused on environmental and social grounds relative to the number applications for permissions	%
11	Percentage of sites certified to an EMS (e.g. ISO 14001/EMAS)	%
12	Summary of any other environmental voluntary activities	Description
13	Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with environmental laws and regulations.	US$
14	Total environmental protection expenditures and investments by type.	US$ & Description
15	Total water use for production of mineral resources	m^3/yr

Table C.1. continued

# in Appendix B	Indicator	Unit
16	Water use intensity by activity	m^3
17	Proportion of total water resources affected	m^3
18	Total volume of water discharge into waterways	m^3/yr
19	Total volume of tailings and disposal methods	m^3/yr and description
20	Breakdown of substances discharged with liquid effluents	tonnes/yr
21	Total water discharge by quality and destination	m^3/yr and description
22	Describe any measures put in place to prevent acid main drainage, if applicable	Description
23	Percentage of permitted sites causing downstream and/or underground water quality problems relative to the total number of permitted sites	%
24	Percentage of water recycled and reused (e.g. cooling, waste, rain water) relative to the total water withdrawn from source	%
25	Percentage and total volume of water recycled and reused.	% & m^3
26	Number of mines closed	Nbr/yr
27	Number of sites rehabilitated	Nbr/yr
28	Number of awards for rehabilitation and a summary, if applicable	Nbr / yr
29	Number of sites officially designated for biological, recreational or other interest as a result of rehabilitation	Nbr/yr & description
30	Summary of the policy for closure and rehabilitation	Nbr/yr & Description
31	Description of the major impacts on biodiversity associated with company activities and/or products and services in terrestrial, freshwater, and marine environments	Description
32	Significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.	Description
33	Equivalent number of fully grown trees that would be required for sequestration of the total CO_2 emissions	Nbr/yr
34	The amount of CO_2 emissions that can (theoretically) be sequestered by the trees planted by the company	tonnes
35	Net emissions of CO_2 (total CO_2 emissions minus CO_2 emissions potentially sequestered by trees)	tonnes/yr
36	Initiatives to reduce greenhouse gas emissions and reductions achieved.	Description

Table C.1. continued

# in Appendix B	Indicator	Unit
37	Emissions of ozone depleting substances, breakdown by substance	tonnes/yr
38	Emissions of acid gases (NOx, SO_2 and other) breakdown by substance	tonnes/yr
39	Emissions of particles	tonnes/yr
40	Toxic emissions (including heavy metals, dioxins, crystalline silica and others), breakdown by substance	tonnes/yr
41	Other emissions; breakdown by substance	tonnes/yr
42	Loss of wildlife habitat *(due to emissions)*	Description
43	CO_2	tonnes/yr
44	NOx	tonnes/yr
45	VOCs	tonnes/yr
46	PM_{10} and $PM_{2.5}$	tonnes/yr
47	SOx	tonnes/yr
48	N_20	tonnes/yr
49	CH_4	tonnes/yr
50	O_3	tonnes/yr
51	CO_2	tonnes/yr
52	O_3	tonnes/yr
53	HFCs,	tonnes/yr
54	SF_6	tonnes/yr
55	PFCs,	tonnes/yr
56	Other relevant indirect greenhouse gas emissions by weight.	tonnes/yr
57	NO, SO, and other significant air emissions by type and weight.	tonnes/yr
58	Total non-hazardous solid waste and breakdown by type and description of disposal methods	tonnes/yr & Description
59	Percentage of permitted sites that have a problem of land contamination relative to the total number of permitted sites	%
60	Total weight of waste by type and disposal method	Tonnes & Description
61	Weight of transported, imported, exported, or treated waste	tonne or kg
62	Total hazardous solid waste and breakdown by type and description of disposal methods	tonnes/yr & Description
63	Total transport distance, including in the mine/quarry, transport of products to customers, business travel and commuting for ‘fly-in, fly-out’ operations	km/yr

Table C.1. continued

# in Appendix B	Indicator	Unit
64	Total distance for all transport per tonne of products	km/tonnes
65	Percentage of distance for transport of products to customers covered by road, rail and water transport, breakdown by type	%
66	Significant environmental impacts of transporting products, goods and materials used for the organization's operations, and transporting members of the workforce.	Description
67	Breakdown by type of the amount of the primary energy used (including natural gas, diesel, LPG, petrol and other fuels) [Direct energy consumption by primary energy source]	Mj/yr
68	Indirect energy consumption by primary source	Mj/yr
69	Breakdown by type of the amount of the secondary energy used (electricity and heat) used and exported	Mj/yr
70	Energy from renewable sources used and exported	Mj/yr
71	Total primary and secondary energy used	Mj/yr
72	Energy saved due to conservation and efficiency improvements	Mj/yr
73	Percentage of renewable energy used relative to total energy consumption	%
74	Initiatives to reduce indirect energy consumption and reductions achieved.	Description
75	Initiatives to provide energy-efficient or renewable energy based products and services, and reductions in energy requirements as a result of these initiatives.	Description
76	Summary of energy policy	Description
77	Discomfort and possible diseases due to noise emissions	
78	Loss of wildlife habitat due to noise emissions	
79	Loss of wildlife habitat due to infrastructure problems caused by operations	
80	Total number of external complaints related to noise, road dirt and dust, visual impact and other nuisance	Number/yr
81	Summary of any assessments of suppliers and contractors quality and environmental performance	Description
82	Initiatives to mitigate environmental impacts of products and services, and extent of impact mitigation.	Description
83	Percentage of products sold and their packaging materials, reclaimed by category	%

Table C.1. continued

# in Appendix B	Indicator	Unit
84	Frequency of accidents/ incidences polluting air, water, soil	
85	Effect of accidents/ incidences polluting air, water, soil	
86	Recovery period in case of damage	
87	Area possibly affected due to accidents/ incidences polluting air, water, soil	
88	Amount of hazardous materials that may affect human-health or ecosystems	
89	Possible effect of hazardous materials in case of accidents/ incidences	
90	Recovery period in case of damage	
91	Total number and volume of significant spills	
92	Identity, size, protected status, and biodiversity value of water bodies and related habitats significantly affected by the reporting organization's discharges of water and runoff.	
93	Number of environmental accidents and a summary for each region or country, as applicable	Nbr/yr and description
94	Describe any measures put in place to prevent tailings dam(s) failure	Description

Table C.2. Project-level (PL) indicators under the social indicator set

# in Appendix B	Indicator	Unit
1	Breakdown by region or country of the number of direct employees (on company payroll)	Number
2	Number of indirect employees (e.g. contractors, consultants) expressed as full-time equivalents	Number
3	Employee turnover expressed as percentage of employees leaving company relative to the total number of new employees	%/yr
4	Total workforce by employment type, employment contract, and region.	Number & description
5	Total number and rate of employee turnover by age group, gender, and region.	Number & %
6	Benefits provided to full-time employees that are not provided to temporary or part-time employees, by major operations.	Description
7	Ranking of the company as an employer in the internal surveys	Ranking & description
8	Policy procedures involving consultation and negotiation with employees over changes in the company (e.g. restructuring, redundancies etc.)	Description
9	Percentage of employees covered by collective bargaining agreements.	%
10	Freedom of association and collective bargaining	Description
11	Minimum notice period(s) regarding operational changes, including whether it is specified in collective agreements.	Description
12	Number of strikes and lock-outs exceeding one week's duration, by country.	Number
13	Percentage of hours of training regarding health and safety relative to the total number of hours worked	%
14	Number of fatalities at work	Nbr/yr
15	Lost-time accidents	hr/yr
16	Lost-time accidents relative to the total hours worked	%
17	Percentage of total absence-hours on health and safety grounds relative to the total hours worked	%
18	Number of compensated occupational diseases	Nbr
19	Summary of the policy on HIV/AIDS	Description
20	Percentage of total workforce represented in formal joint management–worker health and safety committees that help monitor and advice on occupational health and safety programs.	%

Table C.2. continued

# in Appendix B	Indicator	Unit
21	Rates of injury, occupational diseases, lost days, and absenteeism, and number of work-related fatalities by region.	Nbr/yr
22	Education, training, counselling, prevention, and risk-control programs in place to assist employees, their families, or community members regarding serious diseases.	Description
23	Health and safety topics covered in formal agreements with trade unions.	Description
24	Percentage of hours training (excl. Health and safety) relative to the total hours worked (e.g. Management, production, technical, administrative, cultural etc.)	%
25	Number of employees that are financially sponsored by the company for further education	Nbr/yr & description
26	Summary of programs to support the continued employability of employees and to manage career endings	Description
27	Average hours of training per year per employee by employee category.	ha/yr
28	Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings.	Description
29	Percentage of employees receiving regular performance and career development reviews	%
30	Percentage of contracts that are paid in accordance with agreed terms	%/yr & description
31	Percentage of local suppliers, relative to the total number of suppliers	%
32	Percentage of women employed relative to the total number of employees	%
33	Percentage of women in senior executive and senior and middle management ranks	%
34	Percentage of ethnic minorities employed relative to the total number of employees, with an explain of how representative that is of the regional or national population makeup	%
35	Percentage of ethnic minorities in senior executive and senior and middle management ranks	% & description
36	Summary of the equal opportunity policy	Description

Table C.2. continued

# in Appendix B	Indicator	Unit
37	Composition of governance bodies and breakdown of employees per category according to gender, age group, minority group membership, and other diversity indicators	% & description
38	Ratio of basic salary of men to women by employee category.	%
39	Total number of incidents of discrimination and actions taken.	Nbr
40	Summary of the policy concerning human rights relevant to company's activities	Description
41	Statement on whether the company conforms with the ILO Conventions on the Right to Organize (no.87&98)	Description
42	Summary of the policy on excluding child labor as defined by the ILO Convention 138	Description
43	Specify any verified incidences of non-compliance with child labor national and international laws	Description
44	Operations identified as having significant risk for incidents of child labor, and measures taken to contribute to the elimination of child labor	Description
45	Summary of the policy to prevent forced and compulsory labor as specified in ILO Convention No. 29, Article 2	Description
46	Operations identified as having significant risk for incidents of forced or compulsory labor, and measures to contribute to the elimination of forced or compulsory labor.	Description
47	Percentage of quarries/mines on sites sacred for indigenous people relative to the total number of quarries/mines	%
48	Summary of the policy to addresses the needs and particularly the land rights of indigenous people	Description
49	Total number of incidents of violations involving rights of indigenous people and actions taken.	Nbr
50	Percentage and total number of significant investment agreements that include human rights clauses or that have undergone human rights screening.	% & Nbr
51	Percentage of significant suppliers and contractors that have undergone screening on human rights and actions taken.	%

Table C.2. continued

# in Appendix B	Indicator	Unit
52	Total hours of employee training on policies and procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained.	hr/yr
53	Percentage of security personnel trained in the organization's policies or procedures concerning aspects of human rights that are relevant to operations.	%
54	Total number of health and safety complaints from local communities, with a summary, if applicable	Nbr & description
55	Percentage of sites with 'fly-in, fly-out' operations relative to the total number of sites	%
56	Specify any community projects in which the company has been involved	Description
57	Awards received for social and ethical behavior in relation to local communities	Description
58	Summary of the policy for liaison with local communities	Description
59	Summary a Community Sustainable Development Plan to manage impacts on communities in areas affected by its activities during the mine operation and post-closure	Description
60	Nature, scope, and effectiveness of any programs and practices that assess and manage the impacts of operations on communities	Description
61	Number and description of significant disputes relating to land use, customary rights of local communities and Indigenous Peoples.	Nbr & description
62	The extent to which grievance mechanisms were used to resolve disputes relating to land use, customary rights of local communities and Indigenous Peoples, and the outcomes.	Description
63	Summary of the policy on stakeholder involvement, including the mechanisms by which stakeholders can participated in decision-making on the issues that concern them	Description
64	Prostitution due to the company's operations	%
65	Alcoholism due to the company's operations	Description
66	Cultural disruption due to the company's operations	Description
67	Number and type of instances of non-compliance with regulations concerning customer health and safety, including the penalties and fines assessed for these breaches	Nbr/yr monetary unit/yr

Table C.2. continued

# in Appendix B	Indicator	Unit
68	Summary of the policy for preserving customer health and safety during use of products	Description
69	Summary of consumer satisfaction and complaints	Description
70	Summary of the policy related to product information and labelling	Description
71	Programs and progress relating to materials stewardship.	Description
72	Life cycle stages in which health and safety impacts of products and services are assessed for improvement,	Description
73	Percentage of significant products and services categories subject to health and safety impacts of products and services are assessed	%
74	Total number of incidents of non-compliance with regulations and voluntary codes concerning health and safety impacts of products and services during their life cycle, by type of outcomes.	Nbr
75	Type of product and service information required by procedures and percentage of significant products and services subject to such information requirements.	Nbr & %
76	Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labelling, by type of outcomes.	Nbr
77	Practices related to customer satisfaction, including results of surveys measuring customer satisfaction.	Description
78	Programs for adherence to laws, standards, and voluntary codes related to marketing communications, including advertising, promotion, and sponsorship.	Description
79	Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship by type of outcomes.	Nbr
80	Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data.	Nbr
81	Monetary value of significant fines for noncompliance with laws and regulations concerning the provision and use of products and services.	monetary unit/yr
82	Number and percentage of operations with closure plans	Nbr & %

Table C.2. continued

# in Appendix B	**Indicator**	**Unit**
83	Total number of legal actions for anticompetitive behavior, anti-trust, and monopoly practices and their outcomes.	Nbr
84	Monetary value of significant fines and total number of non-monetary sanctions for noncompliance with laws and regulations.	monetary unit & Nbr
85	Summary of the policy on addressing bribery and corruption that meets (and goes beyond) the requirements of the OECD Convention on Combating Bribery	Description
86	Summary of the policy for managing political contributions an lobbying	Description
87	Public policy positions and participation in public policy development and lobbying.	Description
88	Total value of financial and in-kind contributions to political parties, politicians, and related institutions by country.	monetary unit
89	Percentage and total number of business units analyzed for risks related to corruption.	% & Nbr
90	Percentage of employees trained in organization's anti-corruption policies and procedures	%
91	Actions in response to incidents of corruption	Description
92	Socially responsible employment and working conditions	Description
93	Socially responsible management policies and systems	Description
94	Socially responsible approach to personal development	Description
95	Socially responsible communication strategy and employee involvement	Description
96	Group policies with reference to internal, external CSR benchmarks and human rights issues	Description
97	Sustained commitment to social performance evaluation, reporting at local and corporate level	Description
98	Ongoing group social audit and verification processes conforming to AA 1000	Description
99	Demonstrable use of SIA tools throughout project life, including closure	Description
100	Sustained commitment to corporate social investment	Description
101	Corporate compliance and accountability with respect to international, national and regional regulations, restrictive measures and laws	Description

Table C.2. continued

# in Appendix B	Indicator	Unit
102	Commitment to strategy of corporate citizenship irrespective of laws in place and government approach to enforcement	Description
103	Identification of human rights issues and commitment to their protection	Description
104	Proven commitment to government stakeholder dialogue and engagement as a systematic principle of corporate policy from the outset to the end of a project/investment	Description
105	Investigate more equitable 'rent-sharing' agreements	Description
106	Proven commitment to CSI as a mechanism for contributing to local and regional development plans in countries of operation	Description

Table C.3. Project-level (PL) indicators under the economic indicator set

# in Appendix B	Indicator	Unit
1	Breakdown by product type	Description
2	Net sales	monetary unit/yr
3	Geographic breakdown of markets, disclosing: national market share greater than 25%	%
4	Geographic breakdown of markets, disclosing: contribution to GDP greater than 5%	%
5	Cost of goods, materials and services purchased	monetary unit/yr
6	Total payroll costs and benefits (including pension and redundancy payments) broken down by region or country	monetary unit/yr
7	Total cost of employment as percentage of net sales	%
8	Health, pension and other benefits and redundancy packages provided to employees as percentage of total employment costs	%
9	Investment in employee training and education as percentage of net sales	%
10	Percentage of employees that are shareholders in the company	%
11	Distributions to providers of capital broken down by interest on debt and borrowings ad dividends on all classes of shares	monetary unit/yr
12	Average capital employed	monetary unit/yr
13	Return on average capital employed (ROACE)	%/yr
14	Percentage of ethical investments relative to total investments	%
15	Fines paid for non-compliance (economic, environmental and social)	monetary unit/yr
16	Total investment for pollution prevention and control (air, water and solid waste)	monetary unit/yr
17	Total fund for mine closure and rehabilitation, including mitigating the post-closure environmental and social impacts	monetary unit
18	Amount of money paid to political parties and institutions whose prime function is to fund political parties or their candidates	monetary unit/yr
19	Financial implications and other risks and opportunities for the organization's activities due to climate change	monetary unit
20	Coverage of the organization's defined benefit plan obligations	monetary unit

Table C.3. continued

# in Appendix B	Indicator	Unit
21	Significant financial assistance received from government	monetary unit/yr
22	Range of ratios of standard entry level wage compared to local minimum wage at significant locations of operation.	%
23	Policy, practices, and proportion of spending on locally-based suppliers at significant locations of operation.	Description & %
24	Procedures for local hiring and proportion of senior management and workforce hired from the local community at locations of significant operation.	Description
25		
26	Understanding and describing significant indirect economic impacts, including the extent of impacts.	Description
27	Equity	
28		
29	Percentage of purchasing from local supplier to out of region	%
30		
31	Wastewater treatment	%
32	Innovation and R&D Investment	monetary unit/yr
33	Produced goods or services per material	%
34	Produced goods or services per input	%
35	Produced goods or services per energy input	%
36	Transport intensity	%

APPENDIX D

Timeline of the Mining and Energy Sector Operations in the Afşin-Elbistan Coal Basin

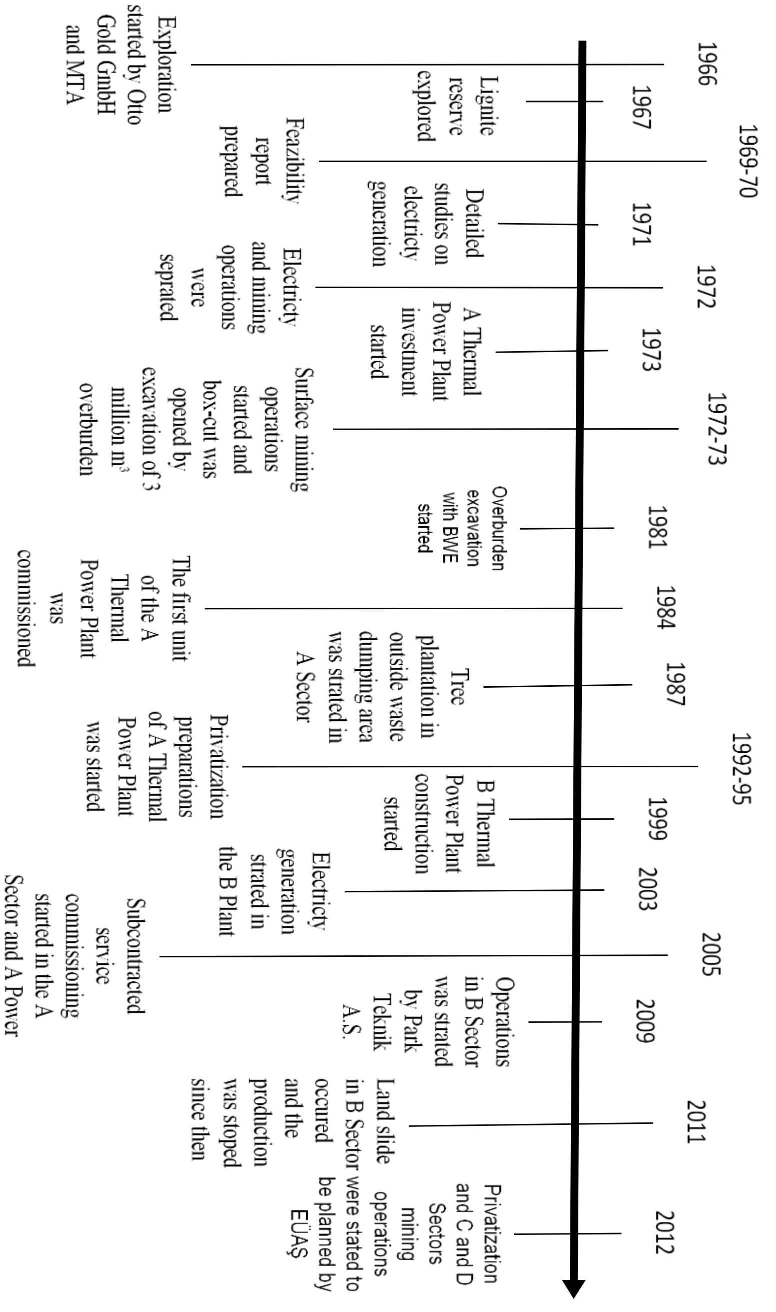

Figure D. Timeline of the Mining and Energy Sector Operations in the Afşin-Elbistan Coal Basin

APPENDIX E

Stakeholders of the Mining Operations in the Afşin-Elbistan Coal Basin

Table E. List of the stakeholders

No	Stakeholders	District/City	Importance of Stakeholders
1	EÜAŞ Department of Mine Fields	Ankara	Main actor as mine licence holder of AECB
2	EÜAŞ Department of Thermal Power Plants	Ankara	Public authority, responsible from the two thermal power plants which are active in the project area
3	EÜAŞ Directorates of A and B Plants	Afşin-Elbistan, Kahramanmaraş	Managing authority of two power plants in AECB
4	EÜAŞ Directorate of Kışlaköy Lignite	Afşin-Elbistan, Kahramanmaraş	Responsible authority from the A Sector mining operations in AECB
5	Park Teknik Çöllolar Operations' Directorate	Afşin-Elbistan, Kahramanmaraş	Responsible authority from the B Sector mining operations in AECB
6	District Governorship of Elbistan	Elbistan, Kahramanmaraş	Regulating public authority in Elbistan
7	District Governorship of Afşin	Afşin, Kahramanmaraş	Regulating public authority in Afşin
8	Elbistan Municipality	Elbistan, Kahramanmaraş	Local municipality
9	Afşin Municipality	Afşin, Kahramanmaraş	Local municipality
10	Districts Directorate of Agriculture	Afşin-Elbistan, Kahramanmaraş	Practicing and regulating public authority and expertized authority of agriculture in the basin
11	District Directorate of Property Registration	Afşin-Elbistan, Kahramanmaraş	Practicing and regulating public authority of land use in the basin

Table E. continued

No	Stakeholders	District/City	Importance of Stakeholders
12	District Directorate of Cadastre	Afşin-Elbistan, Kahramanmaraş	Regulating public authority on land use in the basin
13	District Directorate of Health	Afşin-Elbistan, Kahramanmaraş	Practicing and coordinating authority on the public health related issues
14	District Directorate of Community Health Centres	Afşin-Elbistan, Kahramanmaraş	Practicing authority on the public health related issues
15	District Directorate of Education	Afşin-Elbistan, Kahramanmaraş	Practicing and coordinating authority on the education
16	District Directorate of Family and Social Policy	Afşin-Elbistan, Kahramanmaraş	Having information and data about local social index
17	Foundation of Social Support	Afşin-Elbistan, Kahramanmaraş	Having information and data about local social index
18	District Directorate of Birth Registration Office	Afşin-Elbistan, Kahramanmaraş	Practicing and regulating public authority and source of data about local social index
19	Elbistan İş-Kur (Office of employment agency)	Elbistan, Kahramanmaraş	Practicing public authority on employment, vocational education and job placements
20	Afşin and Elbistan Chamber of Commerce and Industry	Afşin-Elbistan, Kahramanmaraş	Local NGO with data and local information about economic and social index issues
21	Elbistan Natural Protection and National Parks	Elbistan, Kahramanmaraş	Practicing public authority on inspection and auditing environment in the basin
22	Afşin Directorate of State Water Works (DSİ)	Afşin, Kahramanmaraş	Practicing public authority about any issue on water in the basin
24	Directorate of Environment and Urbanization	Kahramanmaraş	Practicing and regulating public authority on environment, permitting and auditing

Table E. continued

No	Stakeholders	District/City	Importance of Stakeholders
25	Directorate of Food, Agriculture and Livestock	Kahramanmaraş	Practicing and regulating public authority on agriculture
26	Directorate of Community Health Centres	Kahramanmaraş	Practicing and coordinating authority on the public health related issues
27	Directorate of Health	Kahramanmaraş	Practicing and coordinating authority on the public health related issues
28	Investment and Coordination of Development Agency of East Mediterranean	Kahramanmaraş	Public authority with local data, technical information, technical analysis and planning in the region
29	İş-Kur (Provincial Office of Employment Agency)	Kahramanmaraş	Having information about employment in project area

APPENDIX F

Questionnaire Form

IMPORTANT NOTE FOR THE INTERVIEWER: Interviews will be with the residents of Afşin or districts of Elbistan and villages / quarters of these who are over 18. After you are sure about these two facts, you may start the interview.

Interviewer:

Date of Interview:

Place of Interview:

QUESTIONS

Place of Birth of the Interviewee:

Residence of Interviewee (if it is different from the place of birth and interview):

A. SOCIODEMOGRAPHIC INFORMATION

1. Sex
01 Male
02 Woman

2. Age
01 18-25
02 26-35
03 36-40
04 41-45
05 46-50
06 51-55
07 56+

3. How long have you been living in the region?
01 Since I was born
02 5 years and less
03 6 – 10 years
04 11-15 years
05 more than 16 years

4. Marital Status
01 Single
02 Married
03 Widow / Divorced
04 Other:……………………………

5. Educational Background (the last school graduated will be selected)
01 Illiterate
02 Literate
03 Primary School
04 Elementary School
05 Secondary School
06 High School
07 Vocational High School
08 College (Foundation Degree, 2 year program)
09 Distance Education
10 University
11 Post Graduate/doctorate
12 Other:………………………….

6. How many people live in the household?
01 Number of Adults (18-55) ....
02Number of Children (below 18 years) ....
03 Number of Elderly (56 + years) ....
04 Number of the Disabled (if there is, what is his/her disability, is it congenital or occupational accident etc.?): ....

B. SOCIOECONOMIC INFORMATION

7. Do you work?
01 Yes (Go to 8th question)
02 No (Go to 9th question)

8. If yes, what is your profession? (If farming/stockbreeding is an extra job, please mark) (Go to 10th question)
01 Civil servant (salaried)
02 Except mine / power plant worker at government / private sector (paid)
03 Government worker at mine or thermal power plant
04 Contract worker at mine or thermal power plant
05 Farming / Stockbreeding (paying insurance)
06 Farming / Stockbreeding (unpaid family worker)
07 Owner of a shop / firm
08 Manufacturer of small / large scale or owner / employer of office, workplace etc.
09 Self-employed, having no workplace, working on piecework basis or consulting
10 Temporary, marginal jobs like street hawking
11 Doing income-generating works at home or helping family work at home / mostly for women
12 Other………………………………..

9. If no, what is the reason for not working?
01 Student
02 Can't find job as his/her qualifications are not sufficient
03 Can't find skilled job according to his/her qualifications (What is his/her qualification)
04 Quitted looking for a job / desperate about being employed (why?)
05 Doesn't looking for a job
06 Retired (Retired from mine / thermal power plant)

10. Do you have social security?
01 Government Retirement Fund
02 Social Security Administration
03 Social Security Organizations for Artisans and the Self-Employed
04 Private / Personal
05 None

11. Is there anyone working or retired in the household?
01 Yes (Go to the 12th question)
02 No (Go to the 13th question)

12. What work/s do they do – Are they retired?
01 Worker / civil servant in the public sector
02 Worker in the private sector (registered to SSA)
03 Agriculture / Farmer
04 Stockbreeding
05 Regular job not requiring qualifications (Not registered to SSA)
06 Not regular / permanent job not requiring qualifications (Not registered to SSA)
07 Permanent worker at thermal power plant / mining firm
08 Civil servant at thermal power plant / mining firm
09 Contract worker at thermal power plant / mining firm
10 Retired (from thermal power plant / mining firm)

13. What is the ownership status of your dwelling house?
01 House holder
02 Hirer
03 Lodging
04 Belongs to one of the family members, relatives, acquaintances and doesn't pay rent
05 Belongs to one of the relatives, acquaintances and pays rent

14. Do you have farm land belonging to your household?
01 Yes (Go to question15)
02 No (Go to question 17)

15. How much farm land do you have?
01 As large as meeting the needs of the household (…………….. decare) (Go to question 18)
02 less than 20 decares
03 21-50 decares

04 51-80 decares
05 81-100 decares
06 100 -500 decares
07 more than 500 decares

16. Are you engaged in agriculture?
01 Yes, I do farming in my own land for commercial purposes (Go to question 17)
02 Yes, I do farming in my own/ someone's land in order to meet household needs (Go to question 19)
03 Yes, I do farming in someone's land for commercial purposes (Go to question 18)
04 No (Go to question19)

17. What are the crops produced for commercial purposes (earning money) in your land??
Except the crops produced for household needs THERE MAY BE MULTIPLE ANSWERS
01 corn
02 sunflower
03 sugar beet
04 Wheat
05 Other legumes
06 Fruit
07 Vegetables
08 Other...

18. (IMPORTANT NOTE FOR THE INTERVIEWER: This question will be asked if he/she is engaged in farming in order to earn income and his/her land is insufficient or he/she doesn't have land. Make sure whether he/she is engaged in farming for income and he/she doesn't have lands before asking the question. If he/she does, ask the question then) How do you perform your farming activities for income purposes?
01 On the lands belonging to the relatives living in the household
02 On the lands belonging to the relatives living out of the household without giving share to them from the income
03 On the lands belonging to the relatives living out of the household and giving share to them from the income
04 By renting lands
05 On someone's land within the same village by sharing the income (sharecropper)
06 On someone's land in another village by sharing the income (sharecropper) (which village?)
07 On someone's land by receiving payment like day payment for the work

19. Do you have cattle/small cattle in your household?
01 Yes (Go to question 20)
02 No (Go to question 23)

20. For what purpose do you keep the cattle?
01 Stock farming
02 Dairying

03 For meeting the household needs

21. Do you have grasslands and meadows suitable for stockbreeding in your region?
01 Yes
02 No (Go to question 23)

22. Do you use grasslands and meadows easefully?
01 Yes
02 No (why?).. .

23. What are the sources of income of your household? (THERE MAY BE MULTIPLE ANSWERS)
01 Salary of civil servant or worker
02 Income of retired
03 Income from farming / stockbreeding
04 Income from firm, workplace of his/her own etc.
05 Regular or marginal jobs except farming (Street hawking, daily wage, part time – non-continuous etc.)
06 Real-estate rental income
07 Allowance from within the family
08 Social relief (public)
09 Other (What kind of income?)

24. Of all the income generating activities discussed above, what is the total monthly household income? (total of salary, wage and Daily wage, retirement pension, Premium, tips, income from the workplace, rental income, old age pension from the government, veteran, disabled, unemployment pay etc. from all individuals of the household)
01 500 TL and less
02 500 -1000 TL
03 1001 – 1500 TL
04 1501 – 2000 TL
05 2001 – 3000 TL
06 3001 – 4000 TL
07 4001 – 5000 TL
08 5001 – 7500 TL
09 7501 – 10000 TL
10 10000 TL and over
11 No idea / Refused

C. INFORMATION ABOUT MINE AND THERMAL POWER PLANT

25. In your opinion who are employed in mining and power plant establishments? (one option will be marked)
01 Qualified, educated people, people who are conversant with mining, operatorship, electricity and welding etc.
02 People whose fathers or relatives are working in/retired from the establishments
03 People, having connections / nepotism / favouritism
04 Unemployed men, people who should have a job and shouldn’t loaf around
05 People without an occupation, no qualifications required

06 People from the households whose lands have been expropriated
07 People from the households who had have got harmed from the establishments
08 Other………………………………..

26. In your opinion, who were employed by the mining and power plant establishments 10-15 years ago? (one option will be marked)
01 Qualified, educated people, people who are conversant with mining, operatorship, electricity and welding etc.
02 People whose fathers or relatives are working in/retired from the establishments
03 People knowing someone or having friends in right places
04 Unemployed men, people who should have a job and shouldn't loaf around
05 People without an occupation, no qualifications required
06 People from the households whose lands have been expropriated
07 People from the households who had have got harmed from the establishments
08 Other………………………………..

27. How do you think your region would be if there wouldn't be mine or power plant? (One option will be marked)
01 A very poor place
02 There would be unemployment
03 Agriculture would improve
04 Stockbreeding would improve
05 People would emigrate
06 People wouldn't immigrate / strangers wouldn't come, it would be good
07 Industry would improve
08 As mine has always existed I can't think of anything else, nothing crosses my mind
09 Mine has been a chance for us in any case, we have a living thanks to it
10 Other:………………………………….

28. Has the existence of mine and power plant in this region benefited to you and your household?
01 Yes, it has (Go to question 29)
02 Both benefits and harms (Ask questions 29 and 30)
03 Neither benefits nor harms (Go to question 31)
04 Only harms (Go to question 30)

29. What kind of benefits can you list? (More than one options can be selected)
01 Economic situation of my family has improved
02 The number of schoolers in my family has increased
03 No one has/very few people have emigrated from my family
04 We have gained social security
05 Our social life has revived
06 We left our village and started to live in city
07 Other:…………………

30. What kind of harms can you list? (More than one options can be selected)
01 Economic situation of my household has deteriorated (how?)..

02 We had to leave farming and stockbreeding
03 Schooling rate of children has decreased
04 Health problems of our household have increased (like what?)..
05 Environmental problems have increased
06 The number of strangers in our region has increased
07 Our social life, culture and morals have deteriorated compared to the former situation
08 Other:……………………..

31. Who do you think have most benefited from mining and power plant establishments? (one option will be marked)
01 People, working as Civil servants / government workers at the establishments
02 Villagers having land in the mining site
03 Owners of sub-contracting firms
04 Workers, working for the sub-contracting firms within the establishments
05 Firms selling goods and services to the mine
06 Artisans / merchants in Afşin
07 Artisans / merchants in Elbistan
08 Trading people
09 People coming from other cities
10 Other:…………………………………………

32. Who do you think have most got harmed from mining and power plant establishments? (one option will be marked)
01 People, working as Civil servants / government workers at the establishments
02 Villagers having land in the mining site
03 Owners of sub-contracting firms
04 Workers working for the sub- contracting firms within the establishments
05 Firms selling goods and services to the mine
06 Artisans / merchants in Afşin
07 Artisans / merchants in Elbistan
08 Trading people
09 People coming from other cities
10 Other:…………………………………………

D. CURRENT SITUATION AND FUTURE EXPECTATIONS ABOUT THE REGION

33. What is your favourite feature of the place where you live in? (one option will be marked)
01 I know people, everyone and I like my neighbours
02 Vast employment opportunities are good
03 Its climate, air, water is good
04 Social life is good
05 Educational, health, urban opportunities are good
06 Close to everywhere
07 Life is not expensive
08 I like my job
09 It's my hometown

10 Other:……………………………

34. What is the most antipathetic feature of the place where you live in? (<u>one option will be marked</u>)
01 I don't like its people (why?).......................................
02 Insufficiency of employment opportunities
03 High cost of living
04 Climate, air, water – environmental pollution
05 I don't like the political approached of local people
06 Strangers coming from outside
07 There is no future for the children/youth
08 Amusement places and social life is limited
09 It is a far place
10 Other:…………………………………..

35. What do you think of the future of the place where you live in? (<u>one option will be marked</u>)
01 It will be a better place to live
02 There will be no life left here, people will emigrate to other places
03 Mining and power plant operations will be over and it will be a better place
04 Mining and power plant operations will be over and it will be a worse place
05 Nothing will change, it will go on like this
06 As there are important farming lands, farming will be important
07 More mines and power plants will be established, employment opportunities will increase and it will be better
08 More mines and power plants will be established, pollution will increase and it will be worse
09 Other:…………………………………………

36. Have you ever thought of emigrating as a family because of any reason?
01 Yes (go to questions 37 and 38)
02 No (Go to question 39)

37. If yes, what are the reasons?
01 Factors connected with children
02 There is no income/living, there is no job in the region
03 Health reasons / problems
04 Drought, decrease of agricultural production
05 Expropriations
06 My house was demolished
07 Factors originating from mine / power plant (polluted air etc.)
08 Political
09 Other ....

38. If yes, where?
01 Elbistan, Afşin
02 Kahramanmaraş
03 Malatya
04 Metropolitan cities such as İstanbul, Ankara, İzmir

05 Another city / district
06 Another village within the same region

39. In your opinion, what is the most important problem of the place where you live in? (IMPORTANT NOTE FOR THE INTERVIEWER: One option will be marked- don't read the options, mark the answer or the closest answer of person among the options below)

01 Financial difficulties / high cost of living
02 Unemployment
03 Air pollution
04 Water pollution
05 Mining operations, performed in farm lands / expropriation of farm lands for mining purposes
06 Decrease of water amount
07 That sufficient water is not given for agricultural activities because of mining operations
08 That the farm lands become infertile because of power plants/mines
09 Lack of irrigated farming options / that there aren't any irrigation channels
10 Groundwater depletion compared to the past / groundwater level has dropped compared to the past
11 Decrease of surface waters compared to the past
12 That I was obliged to move from where I was born / I lived because of mines
13 Inadequacies in health services
14 Inadequacies in educational services
15 Lack of infrastructure
16 Transportation difficulties
17 Not knowing how mining activities will influence my life in the future and that my opinion is not taken
18 Injustice and grievance that local people underwent because of mines
19 That the local people were not prioritized in employment at the mines and power plants / that the local people were not employed
20 Employment of those having connections based on nepotism / favoritism at the mines and power plants
21 Grievance, injustice and mistreated on issues like land expropriation, water utilization, compulsory mobilization due to mining and power plant operations
22 Emigration from the region
23 Immigration to the region from other regions
24 Other …………………..

E. INFORMATION ABOUT ENVIRONMENT AND WILLINGNESS TO PAY

40. Where do you supply domestic water at home?

01 Municipal grid
02 River
03 Well/ ground water
04 I bring from another place (for example from the village fountain etc.)

41. Is the quality of your domestic water better compared to 10-15 years ago?

01 Yes, better. Why?..
02 No, worse. Why?..

03 The same

42. <u>IMPORTANT NOTE FOR THE INTERVIEWER</u>: <u>If he/she does farming ask the question if he/she does not go to question 45.</u>
Where do you supply the agricultural irrigation water? (THERE MAY BE MULTIPLE ANSWERS)
01 River (Go to question 46)
02 Well / Ground Water (Ask questions 43, 44 and 45)
03 From the channel coming from the mining site (The channel carrying the ground water drawn in mining site) (Go to question 46)
04 I can't do irrigated farming (Go to question 46)

43. From which depth of the well do you draw water at the moment?
01 Less than 20 m.
02 20-50 m.
03 50-80 m
04 80 -100 m.
05 Deeper than 100 m.

44. Has there been a change in the ground water level compared to 10-15 years ago?
01 Yes, it brings up from deeper
02 Yes, it brings up from closer to the surface
03 Same, no change has occurred (Go to question 45)

45. What do you think does the change in the level of ground water depend on?
01 Precipitation level
02 That too many people use groundwater
03 Mining establishments
04 Other ....

46. How do you think the following in the water resources such as streams, ponds in the neighborhood have changed compared to last years?

	Increased (01)	Decreased (02)	Not changed, same (03)
Amount of water			
Turbidity of water			
Herbs growing in it			
Smell			

47. Do you go fishing?
01 Yes (Go to question 47)
02 No (Go to question 49)

48. Where / which locality / which river do you go fishing?

49. What kind of things have changed in the fish of the river in terms of the following issues compared to 10 years ago in your opinion?

	Increased? 01	Decreased? 02	Not changed, same 03
Number of fish			
Species / types of fish			
Sizes of fish			

50. IMPORTANT NOTE FOR THE INTERVIEWER: Read the following explanation slowly and clearly, ask the person if he understands the explanation or not, it necessary explain once more. If all lands, where currently mining activities are performed and power plants are located, are turned into agricultural lands as before and are sold to the willing farmers on easy terms for doing agriculture again. Depending upon the increase of agricultural production in the region agricultural industry facilities will be able to be established, in this way local people will be able to get job in the agricultural activities and food production facilities as well as you will be able to buy the fruit and vegetables grown in your region fresh and at low cost. However under these circumstances, measures must be needed to be taken in order to reclaim these lands to agriculture that will create extra costs. In parallel with this, the increase in the cost will be reflected in the electric bills and the electric bills will increase. As explained above, do you welcome the increase in the electric bills depending on reclamation of the mining land to agricultural land?

01 Yes (Go to question 51)
02 No (Go to question 53)

51. How much increase do you accept in your monthly electric bill?

01 Less than 10 TL
02 Between 11-20 TL
03 Between 21-50 TL
04 More than 50 TL

52. For how many years do you accept the electric bills to over stand in this way?

01 Less than 5 years
02 6-10 years
03 More than 10 years

53. You said you do not accept an increase in the electric bill in order for these lands to be transformed into farm lands. In this case, is it suitable for you to reforest these lands and leave them like that without a financial burden to you?

01 Yes
02 No (Why?...

54. That the person answering the question understands this hypothetical question regarding the transformation of the current mines and thermal power plants into farm lands (THE INTERVIEWER WILL FILL IN THIS PART)

01 Very hard
02 hard
03 easy 04 very easy

Table F. Questions on the change in the Afşin-Elbistan Coal Basin

Now I'll ask some questions to you and I want to learn your ideas about this issue. I want you to give answers to these questions <u>by taking the last 10-15 years into consideration</u> and considering the mining and thermal power plant activities									
						Increased 01	Decreased 02	Not changed, same 03	No idea 04
Demographical									
55	Emigration from the villages to the district centres								
56	Emigration from the region to other cities								
57	Immigration from other cities to the place where you live								
Health									
58	The quality and facilities or health services								
	Does he/she have any of this disease?								
59	- Chronic bronchitis								
60	- Lung cancer								
61	- COPD								
62	- Asthma								
63	- Stomach Cancer								
64	- Tuberculosis								
65	- Jaundice								
66	- Do you smoke?	Yes		No					
67	Does anyone smoke in your household?	Yes		No					
68	The number of congenitally disabled babies around you								
Infrastructure									
69	Transportation facilities from the villages to the district centres								

Table F. continued

70	The quality of the services like environmental cleaning and waste collection where you live				
71	The quality of the household/grid water services				
72	The quality of electric services				
	Education				
73	Number of educational institutions				
74	Vocational education opportunities				
75	The number of vocational education students around you				
	Recreation / Natural Places				
76	Recreation and picnic areas				
77	Green areas like parks and gardens				
78	Forest lands				
79	Agricultural lands				
80	Meadows and grasslands				
81	The amount / type of harmful wild animals				
82	Natural beauty / Landscape beauty				
	Participation				
83	Getting the opinion of people about the planned issues in the future regarding the mine and power plant operations				
84	Consideration and taking measures of mines' and power plants' decision-makers about the problems faced by local people related with mining and electricity generation operations				
85	Meeting the demands and needs of local people in land expropriation practices				

Table F. continued

86	Problems experienced between mine and power plant establishments and local people				
	Job Opportunities, Economic Situation and Trade				
87	Shopping opportunities				
88	The number of families making a living only on farming / stockbreeding in the region				
89	Job opportunities in other fields except mines and power plants				
90	(Temporary) Job opportunities in mines and power plants				
91	Your living conditions and income				
92	Living conditions and income of the people around you, your relatives and your neighbours				
93	Social benefits				
94	The number of people receiving social benefits around you				
	Real Estate (In the last 5 years …..)				
95	Housing demand (will not be asked in the villages)				
96	Building new houses (will not be asked in the villages)				
97	Prices of houses (will not be asked in the villages)				
98	Rents of houses (will not be asked in the villages)				
99	Quality of houses (will not be asked in the villages)				
100	Prices of the houses in the region				
101	Purchase and sell of lands around the mine				
102	The number of people coming out of the region to buy land				

Table F. continued

Changes in Social Life and Values					
103	Women working out of the house (except the field Works)				
104	Wishing / Supporting women to work				
105	Schooling level of girls				
106	Crime rate (robbery, events about public order etc.)				
107	Solidarity				
108	Unmoral, non-traditional clothing, behaviour among locals; loose morals, prostitution etc.				
109	Negative change in social life, tradition, culture and values because of mine and power plant operations in the region				
110	Communication and doing social activities together with the people coming from other cities/regions (change in the number of the family / friends emigrated from another place that you continually keep in touch?)				

APPENDIX G

Indicator Selection Matrices of Case 1

Scope Colum A: Evaluation based on the strategy scope fulfilment

- Exploitation of lignite reserve with a recovery as high as possible in order to increase use of domestic primary energy resources
- Consideration of sustainability while exploitation of the lignite reserves in Turkey

Scope Colum B: Evaluation based on the sustainability concept fulfilment

- Minimizing the land use for the mining operations in Afşin-Elbistan Coal Basin
- Primarily employment of locals in the mining sector
- Capacity building among locals for improving their qualifications
- Improvement in the infrastructure

Relevance Colum: Evaluation based on the study scope fulfilment

- Analyzing only the reserve recovery and land disturbance related issues of the surface coal mining plan alternatives in Afşin-Elbistan Coal Basin

Score Scale:

- Score 1 for low fulfilment – slightly / very hardly related with /satisfying the issue highlighted
- Score 2 for medium fulfilment – partially / moderately related with /satisfying the issue highlighted
- Score 3 for high fulfilment – clearly / undoubtedly related with /satisfying the issue highlighted
- Score 0 is used for ‘not applicable’ or ‘no idea’ cases.
  [**s**] – means suggested by the author for this study
  [**m]** – means modified from the original indicator or unit of the indicator, given in Appendix B, by the author for this study

  Nbr: abbreviation used for ‘number’ in the matrixes
  Dscrptn: abbreviation used for ‘description’ in the matrixes
  m.u.: abbreviation used for ‘monetary unit’ in the matrixes

Table G.1. Environmental indicator selection matrix

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
% of each resource extracted relative to the total amount of the permitted reserves of that resource	%	3	1	3	3	3	13
% of expected solid loss and habitat loss compared to the current conditions (Mitigation measure in order to reduce the pressure favoring underground mining and not open pit) **[m]**	%	3	3	3	0	3	12
% of expected reduction of the landscape quality **[m]**	%	2	1	3	1	1	8
Total water withdrawal by source (expected)	m^3	3	0	0	2	3	8
Water sources significantly affected by withdrawal of water	Nbr	3	0	0	0	3	6
Decrease in the groundwater level	m^3	3	0	0	0	3	6
Shortage of water that sustains biodiversity sectors	Dscrptn	2	0	0	0	0	2
Total land area need to be rehabilitated **[m]**	ha	3	2	3	3	3	14
% of the land area rehabilitated relative to the total land area occupied by the closed mines/quarries awaiting rehabilitation	%	2	2	0	0	3	7
Net number of trees planted (after thinning and after subtracting any trees removed for the extraction activities)	Nbr	3	0	1	2	3	9
Number of IUCN Red List species with habitats in areas affected by operations	Nbr	3	0	1	1	3	8

Table G.1. continued

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
% of forest damaged by defoliation	%	3	1	3	3	3	13
The number and percentage of total site areas identified as requiring biodiversity management **[m]**	Nbr & %	3	0	2	0	3	8
Habitats protected or restored	Dscrptn	3	0	2	1	1	7
Loss of high mountain vegetation		3	0	2	1	1	7
Loss of wildlife habitat		3	0	2	1	1	7
Death and displacement of wildlife		3	0	2	1	1	7
Effected area of selected key ecosystems	ha	3	0	3	2	3	11
Size of land in/ on protected areas and areas of high biodiversity value outside protected areas **[m]**	ha	3	0	3	2	3	11
Amount of land disturbed or rehabilitated due to mining operations **[m]**	ha	3	3	3	3	3	15
Total area of permitted development (mines and all other facilities)	ha	3	3	3	3	3	15
Total land area newly opened for extraction activities (including area for overburden storage and tailings)	ha	3	3	3	3	3	15
% of newly opened land area relative to total permitted development	%	3	3	3	3	3	15
Number of sites on environmentally protected or sensitive areas, including both current and planned developments **[m]**	Nbr	3	1	3	3	3	13
Loss of arable land	ha	3	3	3	3	3	15

Table G.1. continued

Indicator \ Parameter	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
Total land area covered by ancient or rain forest that was cleared for the extraction activities	Ha	3	0	0	0	3	6
Loss of arable land (power station and other infrastructure)	ha	0	0	0	0	3	3
Amount of land consumption	ha	3	3	3	3	3	15
Area change from greenfield to brownfield	ha	3	2	3	3	3	14
Land under erosion risk as due to mining operations **[m]**	ha	3	1	3	0	3	10
Land under salinization risk due to mining operations **[m]**	ha	3	1	3	0	3	10
Land under contamination threat due to mining operations **[m]**	ha	3	0	0	0	3	6
Total waste extracted (non-saleable material, including overburden) **[m]**	m^3	3	1	3	3	3	13
Total amounts of overburden, rock, tailings, and sludge and their associated risks.	Tonne& Dscrptn	3	1	0	0	1	5
Reduction of landscape value due to infrastructure problems caused by operations	%	1	3	2	0	1	7
Cutting the biological wildlife corridor due to mining sector operations	Nbr	3	0	1	0	1	5

Table G.2. Social indicator selection matrix

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A*	B				
% of indirect relative to direct jobs	%	2	3	0	1	3	9
Net employment creation expressed as percentage contribution to employment in a region or country	%	2	3	0	1	3	9
Total number of operations taking place in or adjacent to Indigenous Peoples' territories	Nbr	0	0	0	0	3	3
Number and percentage of operations or sites where there are formal agreements with Indigenous Peoples' communities	Nbr & %	0	0	0	0	3	3
Number of proposed developments that require resettlement of communities **[m]**	Nbr	2	3	3	3	3	14
% of employees sourced from local communities relative to the total number of employees	%	2	3	0	1	3	8
Reduction of basic services for the people (health, education, recreation, etc.)	%	2	3	0	2	3	10
The number of households resettled due to proposed developments **[m]** (Displaced population)	Nbr	2	3	3	3	3	14
Population growth rate change before after	%	2	0	0	1	3	6
Dependency of women and 18 older [before and after]	%	2	0	0	0	1	3

Table G.2. continued

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A*	B				
Change in urban population	%	2	0	0	3	3	8
Net migration rate incomers/outgoing	%	2	0	0	3	3	8
Change in qualified population	%	2	3	0	1	3	9
Number of archaeological sites affecting from the strategy	Nbr	2	2	3	3	3	13
Percentage of migrated population to different city in displaced population	%	2	0	0	0	3	5
Infrastructure expenditure per capita	m.u.	2	3	0	1	3	9
Change in number of schools	Nbr	2	3	0	2	3	10
Change in number of health service points open to public	Nbr	2	3	0	2	3	10
Change in number of public buildings	Nbr	2	3	0	2	3	10
Vehicle accessibility affected settlements/population	Nbr	2	3	2	3	3	13
Information/Communication services accessibility	Dscrptn	2	3	0	2	1	8
Recreational area per capita	m^2	2	2	3	0	3	10
House price to income ratio	%	2	2	0	2	3	9
Net income change per capita	%	2	2	0	2	3	9
Total new land acquisition [s]	ha	2	3	3	3	3	14

Table G.2. continued

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A*	B				
Change in recreational area after mining operations (due to mining operations) **[s]**	ha	2	2	3	0	3	10
Percentage of local population think/ observe change in recreational area after mining operations (due to mining operations) **[s]**	%	2	2	3	0	3	10
Percentage of local population observing/expecting positive change, sourced from current/planned mining operations in their region in terms of social background **[s]**	%	2	1	0	3	3	9
Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of employment **[s]**	%	2	3	0	3	3	11
Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of infrastructure **[s]**	%	2	3	0	2	3	10
Percentage of local population think/ observe the mining sector as potential source of conflicts on the local level in terms of corruption, social instability**[s]**	%	2	2	0	1	3	8
Percentage of local population think/ observe the mining sector as potential source of conflicts on the local level in terms of environmental issues, including land use and land acquisition **[s]**	%	2	2	3	2	3	12

Table G.2. continued

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A*	B				
Percentage of local population think/ observe improvement in information/communication among the mining sector actors and local public [s]	%	2	1	0	3	3	9
Percentage of local population think/ observe accessibility to information about land management, new mining plans etc. is in place [s]	%	2	2	2	0	3	9
Percentage of local population think/ observe ways of public consultation/participation are in place[s]	%	2	0	0	2	3	7
Percentage of local population think/ observe the mining sector as potential source of problems on the local level in terms of environmental pollution [s]	%	2	0	1	3	3	9
Percentage of local population think/ observe the mining sector as potential source of problems on the local level in terms of health and safety issues [s]	%	2	0	0	3	3	8

*As the strategy does not clearly defines what sustainable exploitation means, the strategy related scores are given as 2 in the social indicator scoring unless the indicator is clearly related or unrelated with Turkey and AECB's conditions, such as indigenous people.

Table G.3. Economic indicator selection matrix

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A*	B				
Amount of sellable product production **[modified]**	tonnes	3	0	3	3	3	12
Earnings from all sellable products based on today's market price before interest and tax **[m]**	m.u	2	0	0	3	3	8
Added value to primary resources by further processing to semi-manufactured and manufactured products **[m]**	m.u /tn	2	0	0	1	3	8
Value-added per unit value of extracted reserve **[m]**	m.u /tn	2	0	0	2	3	7
Ratio of lowest wage to national legal minimum **[m]**	%	2	3	0	3	3	11
Percentage of revenues that are redistributed to local communities from the relevant areas of operation, relative to the net sales	%	2	3	0	1	3	9
Investments into community projects (e.g. Schools, hospitals, infrastructure) as percentage of net sales	%	2	3	0	1	3	9
The total sum of all types of taxes and royalties paid/will be paid by extraction of the natural resource **[m]**	m.u /yr	2	1	0	3	3	9
Direct economic value generated and distributed	m.u /yr	2	3	0	1	3	9
Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind, or pro bono engagement.	m.u /yr	2	3	0	1	2	8

Table G.3. continued

Parameter / Indicator	Unit	Scope A*	Scope B	Relevance	Data availability	Quanti-fication	Score
Understanding and describing significant indirect economic impacts, including the extent of impacts.	Dscrptn	2	3	0	0	0	5
Tax payment of the mining operations **[m]**	m.u	2	1	0	3	3	9
% of royalty payments to expected revenues from selling the extractable reserve	%	2	1	0	3	3	9
Produced goods or services per land input	%	2	3	3	3	3	14
Total cost of land acquisition [s]	m.u	2	3	3	3	3	14
Ratio of economic growth in the region before and after the mining sector investment [s]	%	2	3	0	1	3	9
Ratio of share of the region's contribution to national GDP before and after the mining sector investment [s]	%	2	0	0	1	3	6
Recovery of reserve (ratio of alternative's tonnes / estimated tonnes) [s]	%	3	1	3	3	3	13
Change in total tax payments in the region before and after the mining operations [s]	%	2	0	0	1	3	6
Ratio tax payment of the mining operation to total local/traditional economic activities' tax payments specifically in the mining license area [s]	%	2	0	0	1	3	6

Table G.3. continued

Indicator / Parameter	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A*	B				
		2	3				
Ratio of number of local families benefiting from the mining sector directly by employment in the mining company to number of families benefiting from the traditional economic activities on the mine operational area [s]	%	2	3	3	1	3	12
Ratio of number of families benefiting from the mining sector indirectly by employment in the auxiliary sectors of the mining sector to number of local families benefiting from the traditional economic activities on the mine operational area [s]	%	2	3	3	0	3	11
Ratio of unit land value in the region before and during (after) the mining operations	%	2	2	3	0	3	11
Ratio of generated economic value on per unit land before and during (after) the mining operation	%	3	0	3	0	3	9

*As the strategy does not clearly defines what sustainable exploitation means, the strategy related scores are given as 2 in the economic indicator scoring unless the indicator is clearly related or unrelated with Turkey and AECB's conditions

APPENDIX H

Afşin-Elbistan Coal Basin Lignite Reserve Model Results

Table H.1. Afşin-Elbistan Coal Basin lignite reserve model results

Sector C							
From	**To**	**Volume**	**Tonnes**	**Density**	**Calorific Value (Kcal/Kg)**	**Cum_Volume**	**Cum_Tonnes**
0	750	376561406.3	527185968.8	1.4	470.53	376561406.3	527185968.8
750	1000	192091078.1	268927509.4	1.4	878.16	568652484.4	796113478.1
1000	1250	236446593.8	331025231.3	1.4	1125.70	805099078.1	1127138709.4
1250	1500	31279078.1	43790709.4	1.4	1298.75	836378156.3	1170929418.8
1500	2300	115171.9	161240.6	1.4	1522.37	836493328.1	1171090659.4
				Average cal. Value (kcal/kg)	1034.18	**Reserve(t)**	643,904,690.6

Table H.1. continued

Sector D							
From	**To**	**Volume**	**Tonnes**	**Density**	**Calorific Value (Kcal/Kg)**	**Cum_Volume**	**Cum_Tonnes**
0	750	190705640.6	266987896.9	1.4	527.32	190705640.6	266987896.9
750	1000	162249328.1	227149059.4	1.4	884.01	352954968.8	494136956.3
1000	1250	265881234.4	372233728.1	1.4	1129.85	618836203.1	866370684.4
1250	1500	110347312.5	154486237.5	1.4	1326.74	729183515.6	1020856921.9
1500	2300	908296.9	1271615.6	1.4	1537.25	730091812.5	1022128537.5
				Average cal. Value (kcal/kg)	1096.87	**Reserve(t)**	755,140,640.6

Sector E							
From	**To**	**Volume**	**Tonnes**	**Density**	**Calorific Value (Kcal/Kg)**	**Cum_Volume**	**Cum_Tonnes**
0	750	752887406.3	1054042368.8	1.4	492.66	752887406.3	1054042368.8
750	1000	396046125.0	554464575.0	1.4	864.75	1148933531.3	1608506943.8
1000	1250	180381937.5	252534712.5	1.4	1098.23	1329315468.8	1861041656.3
1250	1500	13570031.3	18998043.8	1.4	1308.38	1342885500.0	1880039700.0
1500	2300	159890.6	223846.9	1.4	1593.65	1343045390.6	1880263546.9
				Average cal. Value (kcal/kg)	946.51	**Reserve(t)**	826,221,178.1

Table H.1. continued

Sector B (Çöllolar)							
From	**To**	**Volume**	**Tonnes**	**Density**	**Calorific Value (Kcal/Kg)**	**Cum_Volume**	**Cum_Tonnes**
0	750	615449812.5	861629737.5	1.4	324.80	615449812.5	861629737.5
750	1000	245178140.6	343249396.9	1.4	879.09	860627953.1	1204879134.4
1000	1250	205256953.1	287359734.4	1.4	1108.99	1065884906.3	1492238868.8
1250	1500	54808312.5	76731637.5	1.4	1340.36	1120693218.8	1568970506.3
1500	2300	11655984.4	16318378.1	1.4	1613.97	1132349203.1	1585288884.4
				Average cal. Value (kcal/kg)	1035.86	**Reserve(t)**	723,659,146.9

Sector A (Kışlaköy) corridor							
From	**To**	**Volume**	**Tonnes**	**Density**	**Calorific Value (Kcal/Kg)**	**Cum_Volume**	**Cum_Tonnes**
0	750	230015109.4	322021153.1	1.4	452.44	230015109.4	322021153.1
750	1000	120025546.9	168035765.6	1.4	868.61	350040656.3	490056918.8
1000	1250	118376437.5	165727012.5	1.4	1126.08	468417093.8	655783931.3
1250	1500	40208484.4	56291878.1	1.4	1324.36	508625578.1	712075809.4
1500	2300	5989359.4	8385103.1	1.4	1688.45	514614937.5	720460912.5
				Average cal. Value (kcal/kg)	1057.34	**Reserve(t)**	398,439,759.4

Table H.1. continued

B Power Plant overlain							
From	**To**	**Volume**	**Tonnes**	**Density**	**Calorific Value (Kcal/Kg)**	**Cum_Volume**	**Cum_Tonnes**
0	750	138515484.4	193921678.1	1.4	408.15	138515484.4	193921678.1
750	1000	56205984.4	78688378.1	1.4	874.51	194721468.8	272610056.3
1000	1250	58182046.9	81454865.6	1.4	1130.25	252903515.6	354064921.9
1250	1500	19424812.5	27194737.5	1.4	1319.93	272328328.1	381259659.4
1500	2300	1251281.3	1751793.8	1.4	1628.81	273579609.4	383011453.1
				Average cal. Value (kcal/kg)	1055.72	**Reserve(t)**	189.089.775.0
				Average cal. Value of Total Reserve (kcal/kg)			**Total Reserve(t)**
				1031.19			3,536,455,190.6

APPENDIX I

Afşin-Elbistan Coal Basin Reserve Model

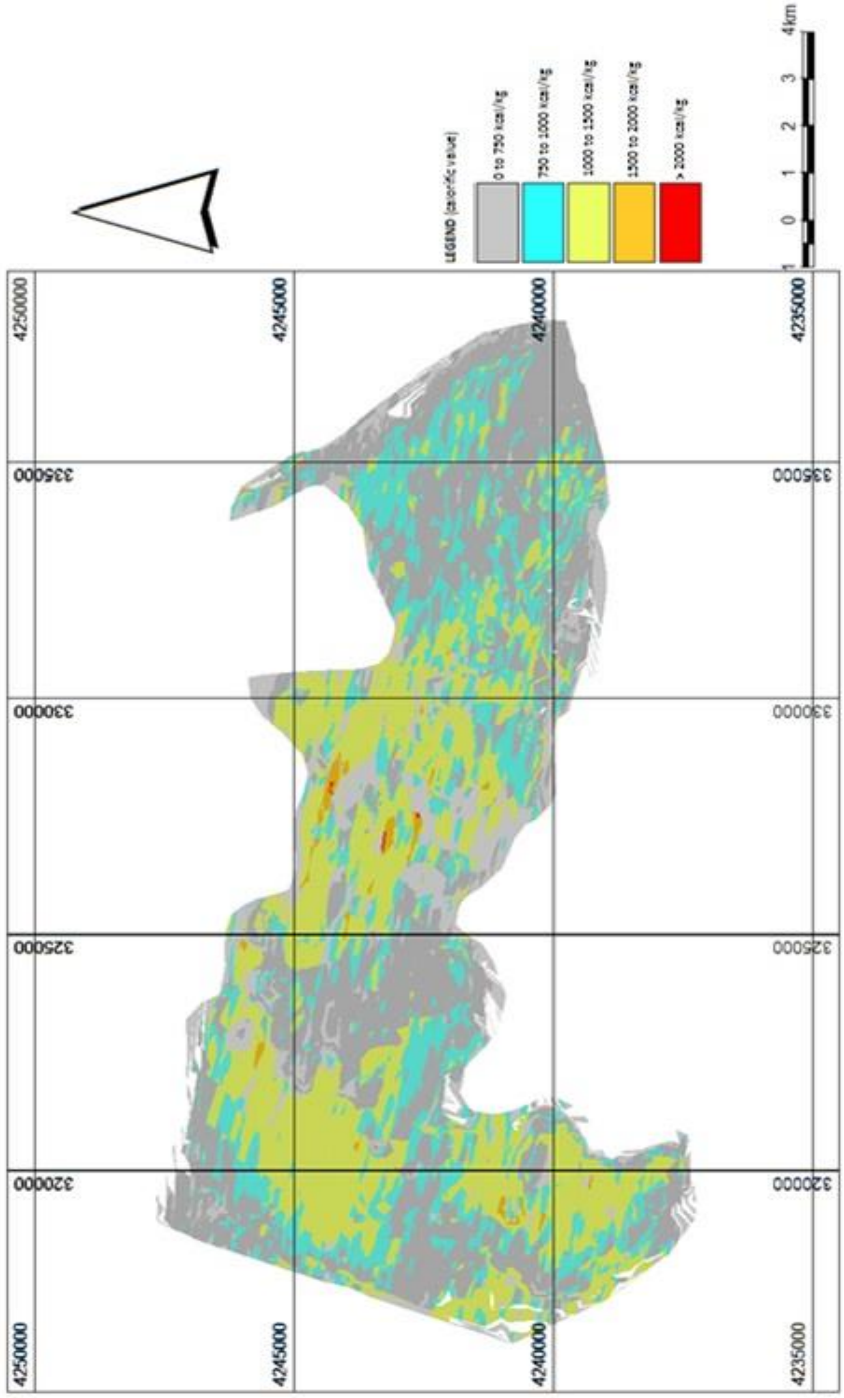

Figure I.1. Top-view of AECB lignite reserve model

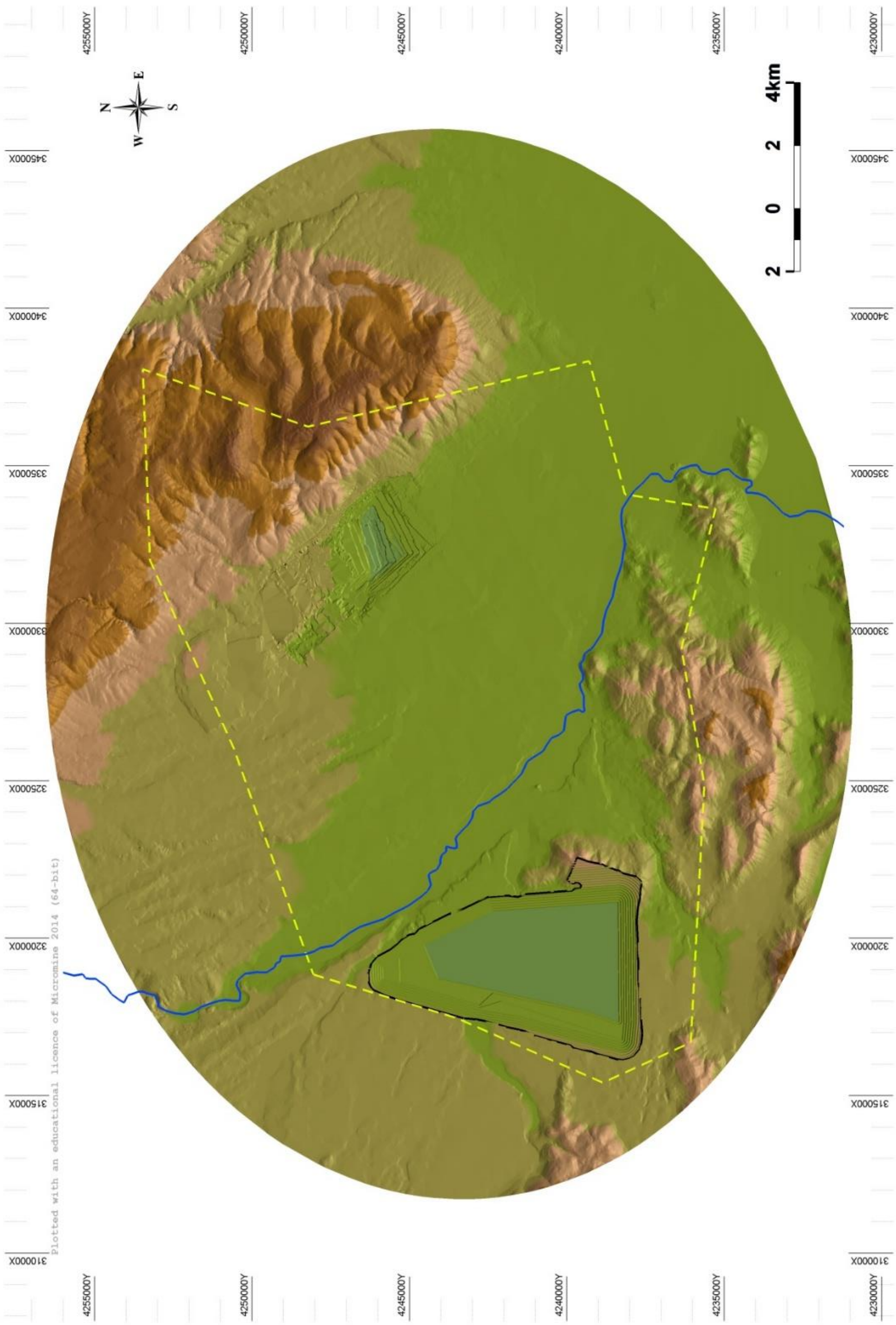

Figure I.2. Top-view of the Sector D mine layout

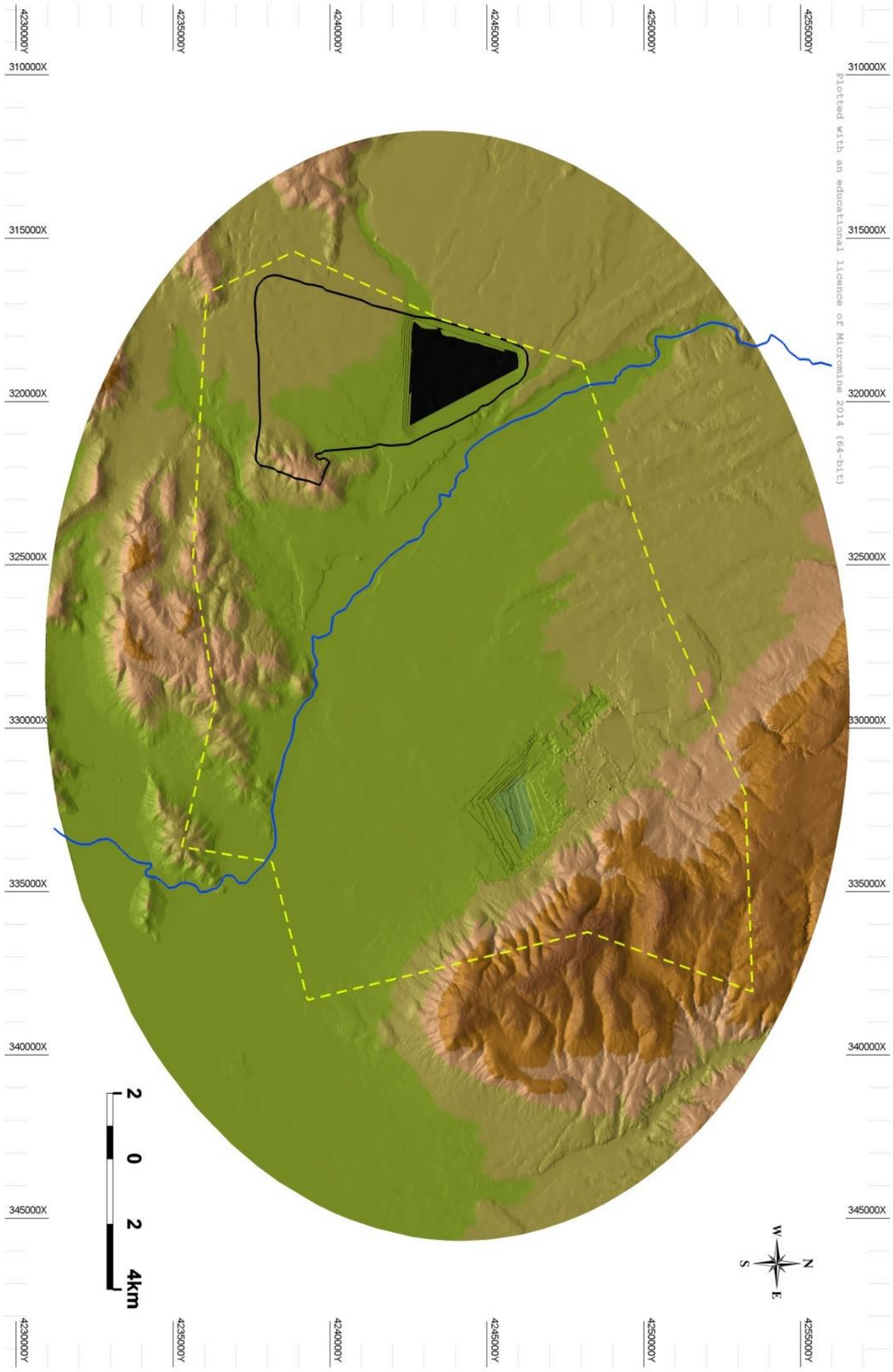

Figure I.3. Top-view of box-cut in the Sector D mine layout

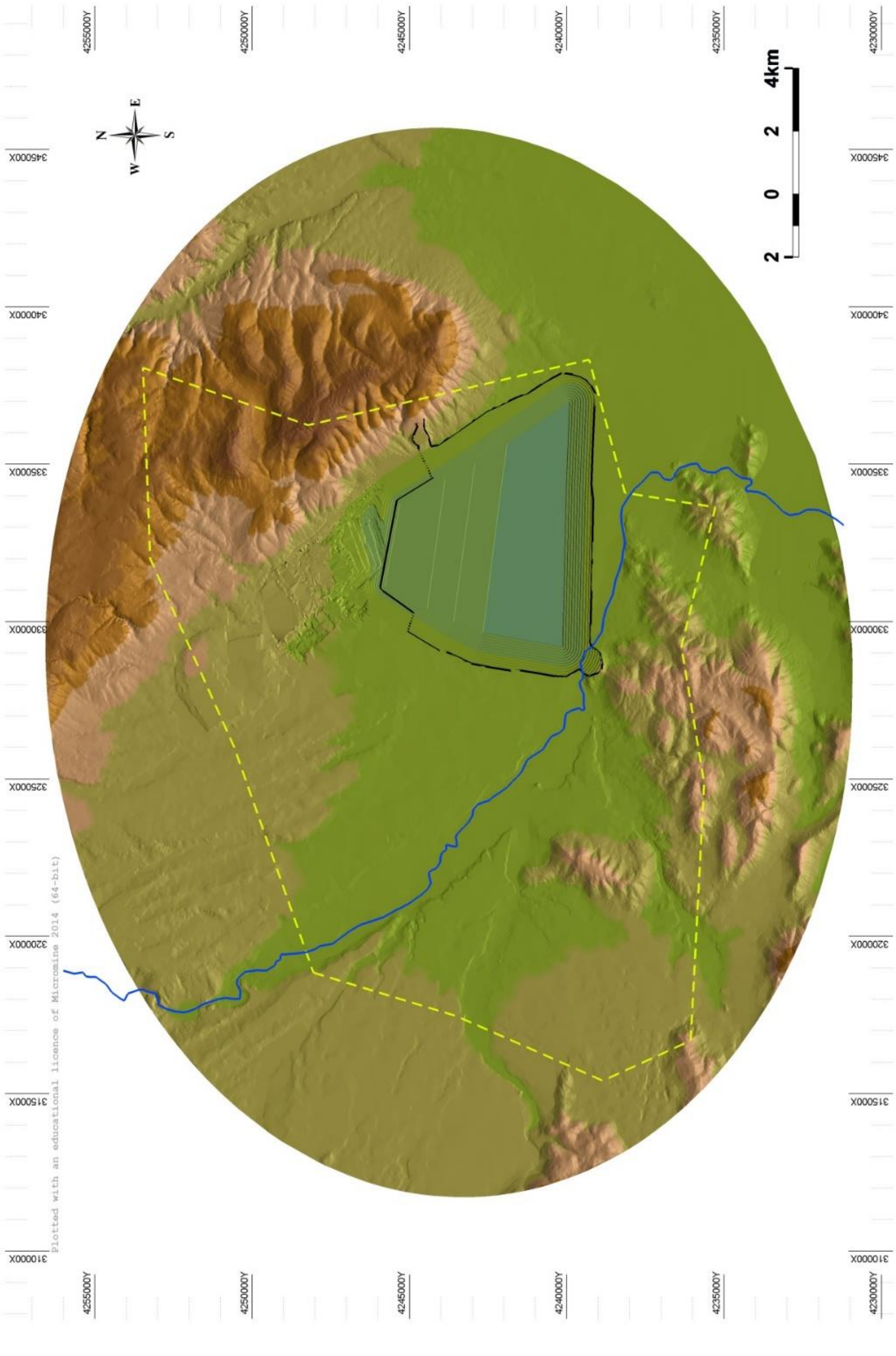

Figure I.4. Top-view of the Sector E mine layout

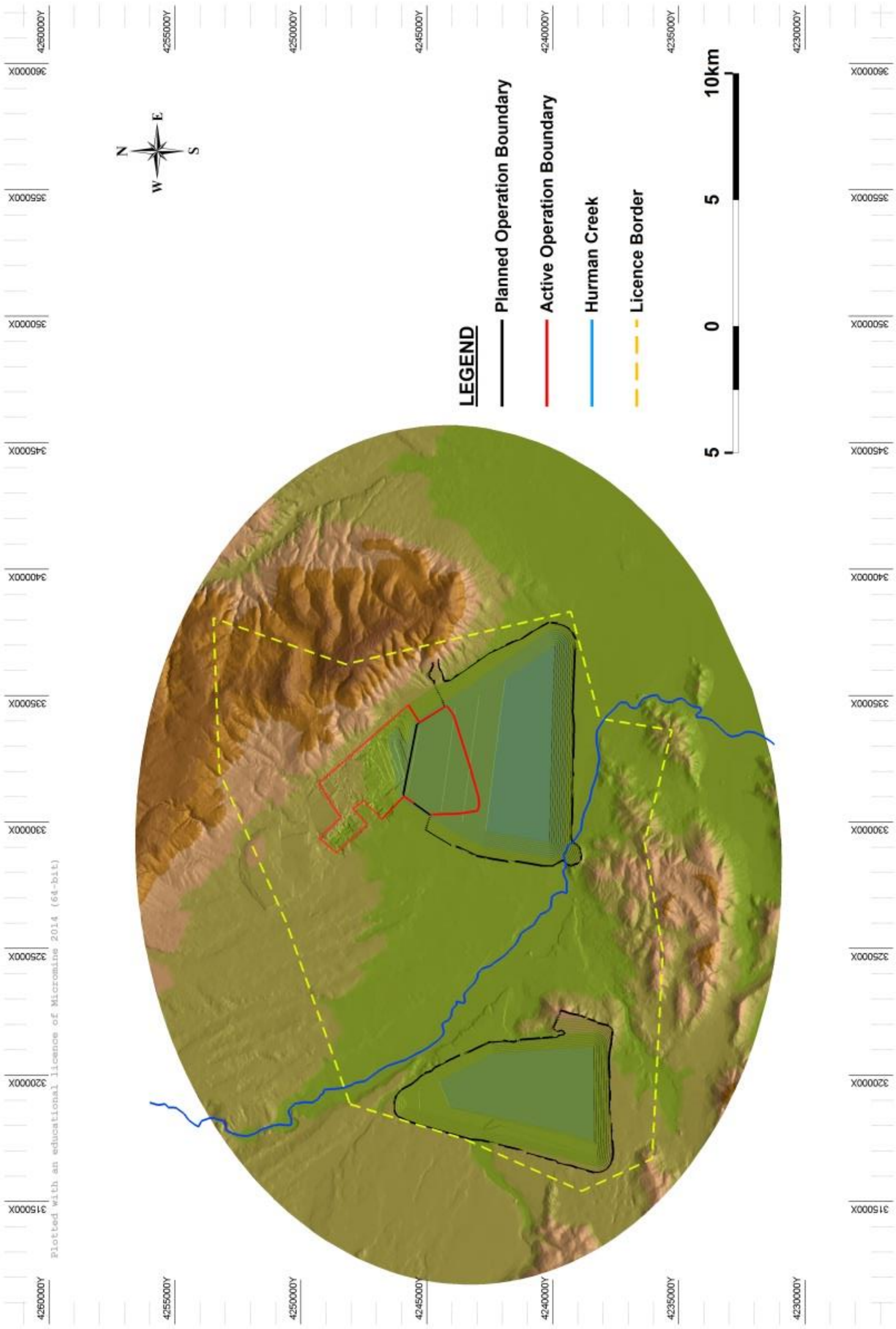

Figure I.5. Mine layout of all alternatives in AECB

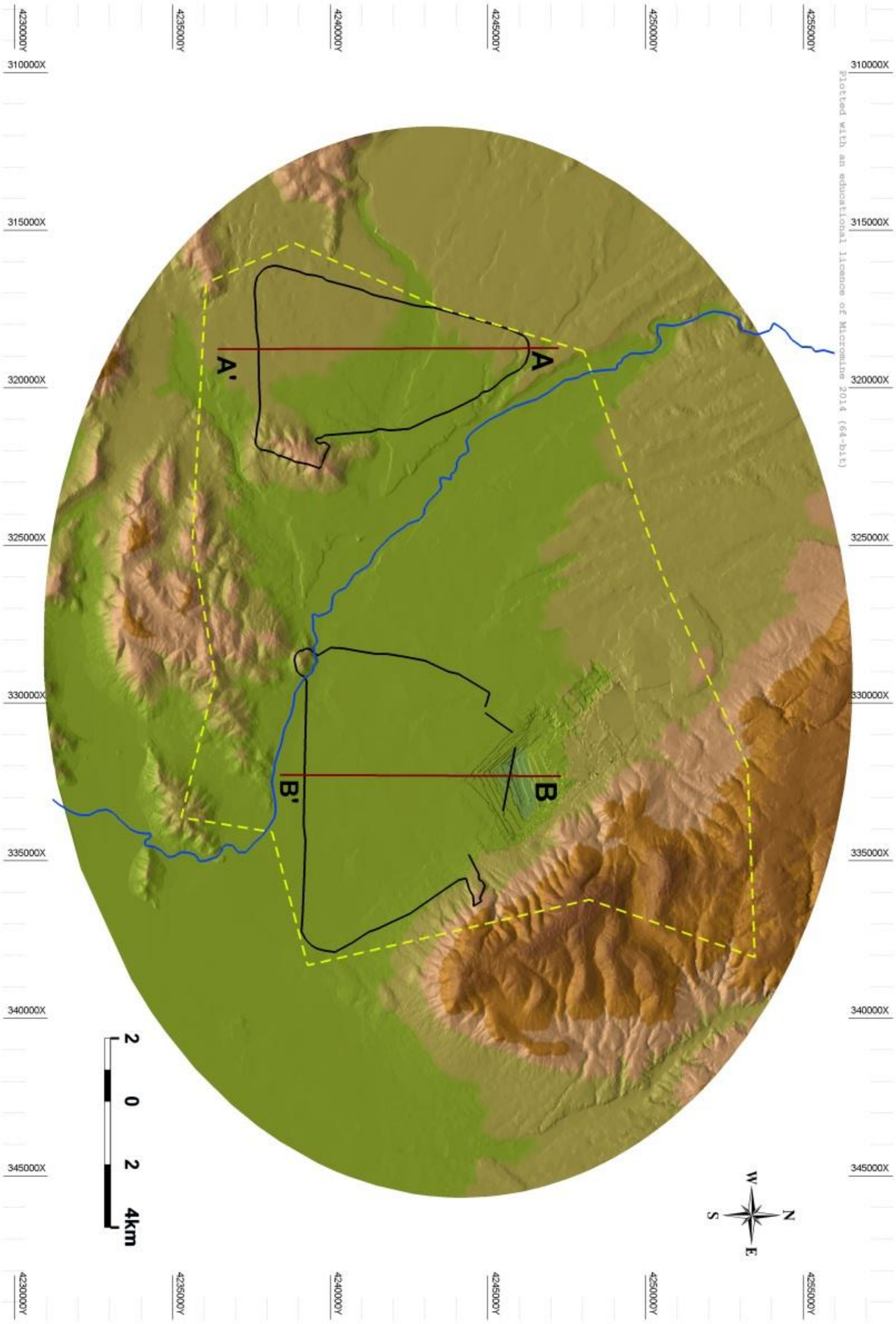

Figure I.6. Cross-sections of the Sector D and the Sector E in AECB

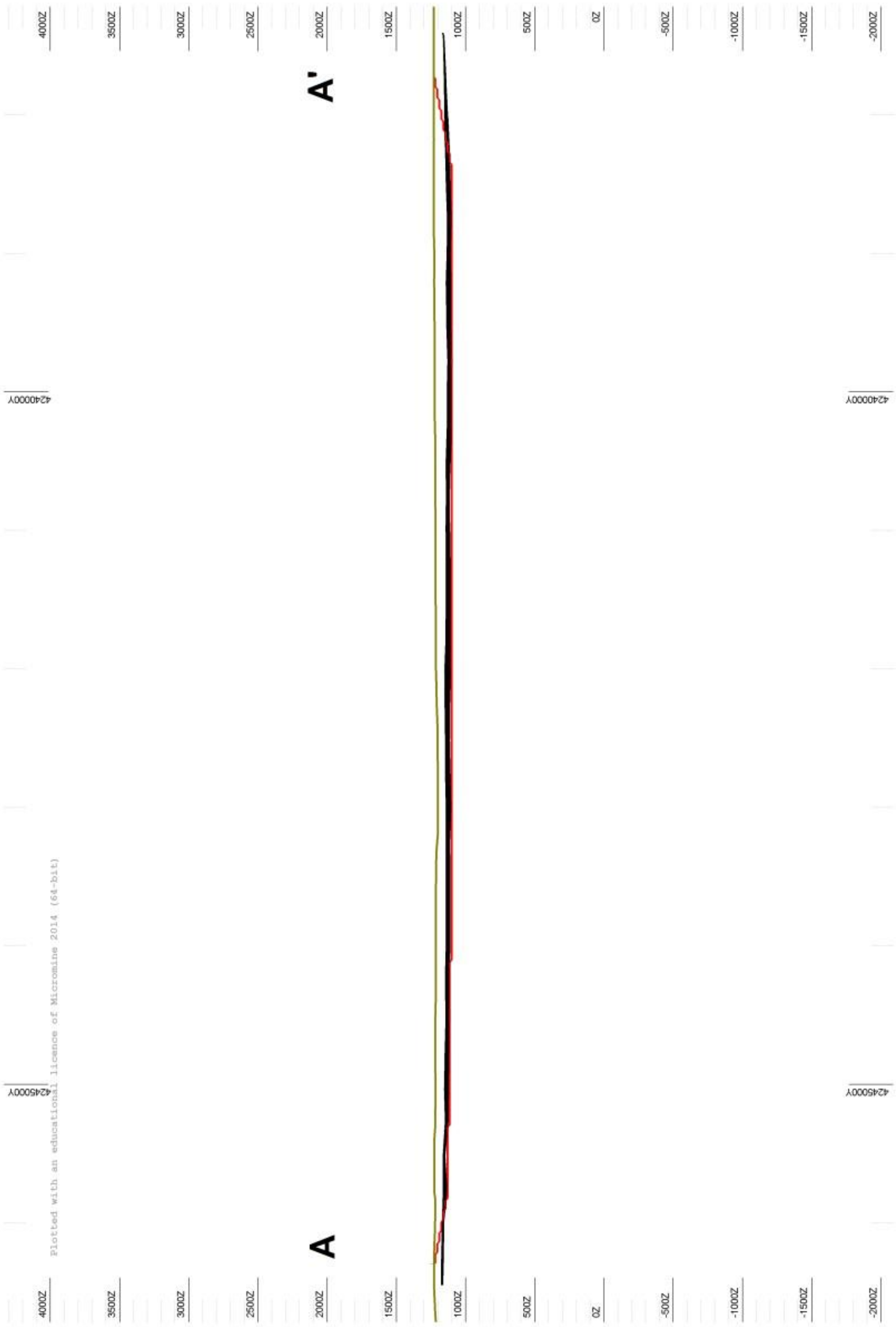

Figure I.7. A-A` Cross-section of the Sector D

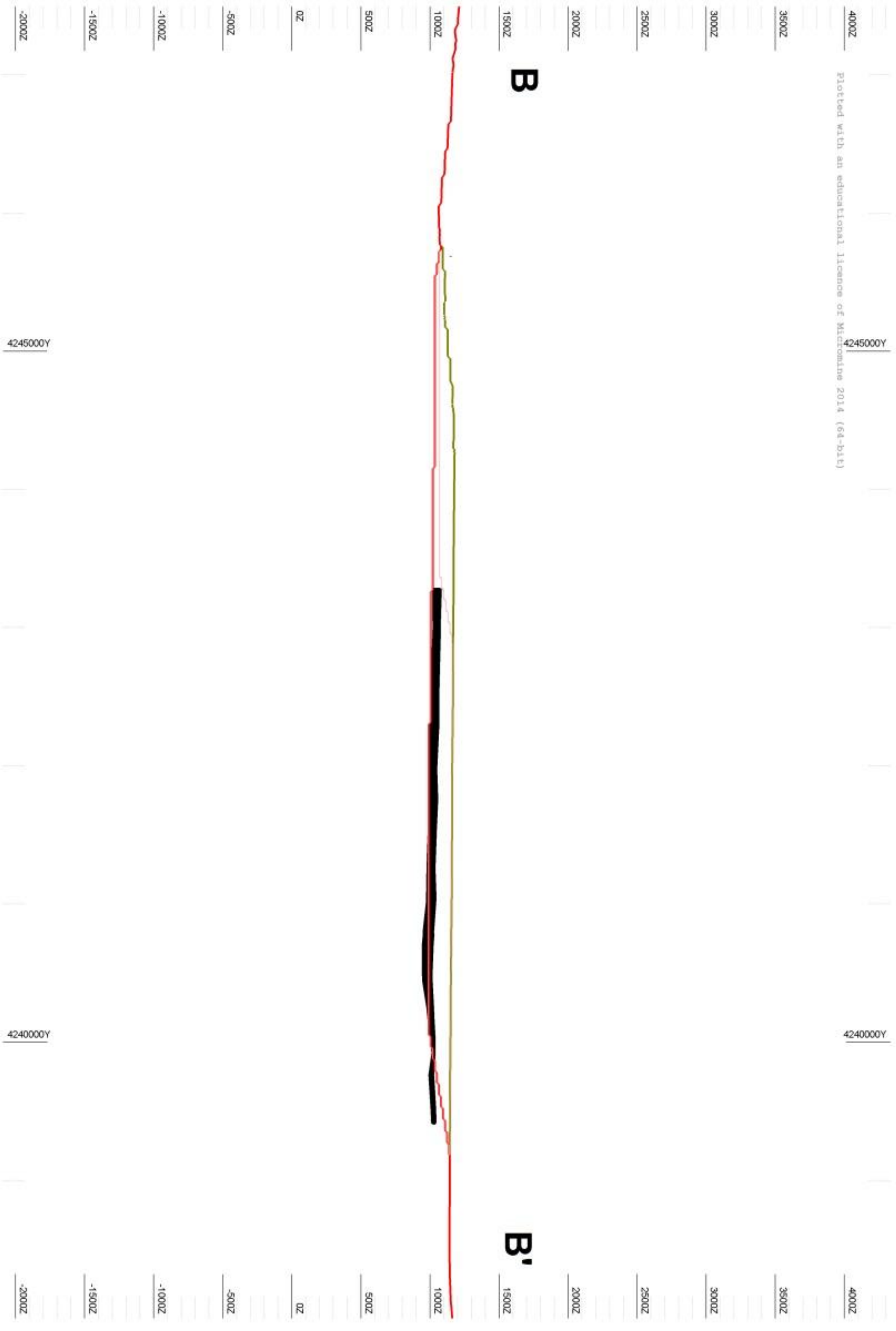

Figure I.8. B-B` Cross-section of the Sector E

APPENDIX J

Transformation Tables for Case 1

Table J.1. Transformation table of the environmental indicators

	Indicator	Original value				Transformed Value (Standardization)				Indicator's impact on environment
		Alternative 1 (A1)		Alternative 2 (A2)	Alternative 3 (A3)	A1		A2	A3	
		A Sector	B Sector			A Sector	B Sector			
E1	% of resource is left relative to the total amount of the permitted reserves of that resource	14.70	20.80	11.16	48.20	0.01	0.43	-0.23	2.31	-
E2	Total land area need to be rehabilitated	3560.03	2416.47	4399.02	4927.73	2.75	1.55	3.64	4.19	-
E3	Percentage of forest damaged by defoliation	0	0	0	0					-
E4	Amount of land (will be) disturbed due to mining operations	4480.26	2416.47	4399.02	4927.73	3.63	1.50	3.55	4.09	-
E5	Total area of permitted development (mines and all other facilities)	5334.60	2354.44	4225.93	2728.84	3.47	0.97	2.54	1.29	-

Table J.1. continued

E6	Total land area newly opened for extraction activities (including area for overburden storage and tailings)	1259.00	459.98	4399.02	4927.73	-0.35	-0.76	1.28	1.55	-
E7	Percentage of newly opened land area relative to total permitted development	0.24	0.20	1.04	1.81	-0.64	-0.70	0.57	1.74	-
E8	Number of sites on environmentally protected or sensitive areas, including both current and planned developments	0	0	0	0					-
E9	Loss of arable land	4480.26	2113.49	3243.82	3447.17	4.33	1.52	2.86	3.10	-
E10	Amount of land consumption	4480.26	2416.47	4399.02	4927.73	3.63	1.50	3.55	4.09	-
E11	Area change from greenfield to brownfield	3560.03	2113.49	3243.82	3447.17	5.18	2.67	4.63	4.99	-
E12	Total waste extracted (non-saleable material, including overburden)	768,061, 000.00	1,266,47 3,208.00	2,428,525, 648.98	4,292,318, 278.54	-0.43	-0.07	0.79	2.17	-

Table J2. Transformation table of the social indicators

	Indicator	Original value				Transformed Value (Standardization)				Indicator's impact on society
		Alternative 1 (A1)		Alternative 2 (A2)	Alternative 3 (A3)	A1		A2	A3	
		A Sector	B Sector			A Sector	B Sector			
S1	Number of proposed developments that require resettlement of communities	0	0	1	0	-1	-1	1.31	-1	-
S2	The number of households resettled due to proposed developments (Displaced population)	0	0	1368	0	-1	-1	1.31	-1	-
S3	Number of archaeological sites affecting from the strategy	0	1	2	1	-1	0.41	1.83	0.41	-
S4	Vehicle accessibility negatively affected settlements/population* **[m]**	0	2	3	5	-1.00	0.11	0.66	1.77	-
S5	Total new land acquisition** **[s]**	1259.00	459.98	4399.02	3447.17	-0.21	-0.71	1.76	1.16	-

Table J.2. continued

S6	Percentage of local population think/ observe the mining sector potential source of conflicts on the local level in terms of environmental issues, including land use and land acquisition **[s]**	70.25	30.40	30.40	2.74	0.62	0.62	-

*The indicator is needed to transform negative impact as all other selected indicators indicate negative impact conditions (the original version is given in Chapter 3 and Appendix G). This way the obtained index score will indicate that smaller score is more sustainable

**Contrary to economic indicator set, land acquisition is seen as a negative impact in the social set in this study because most of the purchased land is agricultural land and agriculture is the most important economic activity of the locals. This is determined based on the applied questionnaire that shows land acquisition is seen as a negative impact by the local communities.

S1: Bakraç

S4: B sector: Yazıbelen, İğdemlik; A2: Çobanbeyli, Yazıbelen, İğdemlik; A3: Berçenek, Çomudüz, Alemdar, Çoğulhan, Kuşkayası

Table J.3. Transformation table of the economic indicators

	Indicator	Original value				Transformed Value (Standardization)				Indicator's impact on economy
		Alternative 1 (A1)		Alternative 2 (A2)	Alternative 3 (A3)	A1		A2	A3	
		A Sector	B Sector			A Sector	B Sector			
Ec1	Amount of sellable product production	339,850,000.00	573,064,800.00	670,841,325.00	428,011,762.50	1.66	3.48	4.25	2.35	+
Ec2	Produced goods or services per land input	269936.46	237149.56	152497.90	86857.79	2.76	2.30	1.12	0.21	+
Ec3	Total cost of land acquisition *	1,259.00	459.98	3243.82	3447.17	-0.01	-0.64	1.54	1.70	+
Ec4	Recovery of reserve (ratio of alternative's tonnes / estimated tonnes)	85.30	79.20	88.84	51.80	4.86	4.44	5.11	2.56	+
Ec5	Number of families (individuals) need to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations**	1/ 1,259.00	1/459.98	1/3243.82	1/3447.17	0.03	1.83	-0.60	-0.62	+

Table J.3. continued

Ec6	Ratio of number of local families benefiting from the mining sector directly by employment in the mining company to number of families benefiting from the traditional economic activities on the mine operational area***	1259.00	459.98	3243.82	3447.17	-0.01	-0.64	1.54	1.70	+

* Cost of the land acquisition is negative indicator for investor but it has positive impact on land owners from the economic point of view. In this study's case, it is assumed that the public authority is the actor, proposing the strategy and evaluating sustainability, but it will not cover the cost of land acquisition. Therefore, the indicator can be accepted as positive because the public will benefit from the payment. Additionally, the total cost will be multiplier of the total land area as the price will be same and so the standardized result will be same for each alternative. Also cost difference between irrigated and not-irrigated land is accepted as 0 for the study.
**Changing the source of income from traditional local sectors to the industrial and service sectors needs improvement of the vocational qualifications and resettlement in some cases. Therefore, the indicator is indicating negative economic impact on the local people. However, considering the majority of the economic indicators in the index, in order to obtain a cumulative positive result from the economic index, the indicators need to indicate positive outcome. Therefore, the indicator value will be standardized as a dominator of 1.
***As a rule of thumb industrialized and regulated mining sector creates well paid and social security jobs for its employees compared to small scale and traditionally practiced local economic activities, such as fishery, agriculture, livestock and forestry. Therefore, higher the number of the employment from the locals higher the economic well-being of them during the mining operations. To evaluate this, it is assumed that one person from each family, who owns land within the mining area, will be employed in the operations.

APPENDIX K

Indicator Selection Matrices of Case 2

Scope Colum A & B: Evaluation based on the objectives of the energy policy fulfilment

- Colum A: Considering the environmental sensitivity in the energy and natural resources sector activities,
- Colum B: Increasing the contribution of the domestic natural resources in the country's economy

Relevance Colum: Evaluation based on the strategic target fulfilment

- Using the proven lignite and hard coal reserves in electricity generation

Score Scale:

- Score 1 for low fulfilment – slightly / very hardly related with /satisfying the issue highlighted
- Score 2 for medium fulfilment – partially / moderately related with /satisfying the issue highlighted
- Score 3 for high fulfilment – clearly / undoubtedly related with /satisfying the issue highlighted
- Score 0 is used for 'not applicable' or 'no idea' cases.

  [**s**] – means suggested by the author for this study
  [**m]** – means modified from the original indicator or unit of the indicator, given in Appendix B, by the author for this study

  Nbr: abbreviation used for 'number' in the matrixes
  Dscrptn: abbreviation used for 'description' in the matrixes
  m.u.: abbreviation used for 'monetary unit' in the matrixes

Table K.1. Case 2 indicator selection matrix for the environmental indicators

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A	B				
% of each resource extracted relative to the total amount of the permitted reserves of that resource*	%	1	3	3	3	3	13
% of expected solid loss and habitat loss compared to the current conditions (Mitigation measure in order to reduce the pressure favouring underground mining and not open pit) **[m]**	%	3	1	0	0	3	7
% of expected reduction of the landscape quality **[m]**	%	3	1	0	1	1	6
Total water withdrawal by source (expected)	m^3	3	1	0	2	3	9
Water sources significantly affected by withdrawal of water	Nbr	3	1	0	0	3	7
Decrease in the groundwater level	m^3	3	1	0	0	3	7
Shortage of water that sustains biodiversity sectors	Dscrptn	3	0	0	0	0	3
Total land area need to be rehabilitated **[m]**	ha	3	1	0	3	3	10
% of the land area rehabilitated relative to the total land area occupied by the closed mines/quarries awaiting rehabilitation	%	3	1	1	0	3	8
Net number of trees planted (after thinning and after subtracting any trees removed for the extraction activities)	Nbr	3	1	0	2	3	9

Table K.1. continued

Indicator \ Parameter	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A	B				
		3	0				
% of forest damaged by defoliation	%	3	2	0	3	3	11
The number and percentage of total site areas identified as requiring biodiversity management **[m]**	Nbr & %	3	1	0	0	3	7
Habitats protected or restored	Dscrptn	3	0	0	1	1	5
Loss of high mountain vegetation		3	0	0	1	1	5
Loss of wildlife habitat		3	0	0	1	1	5
Death and displacement of wildlife		3	0	0	1	1	5
Effected area of selected key ecosystems	ha	3	0	0	2	3	8
Size of land in/ on protected areas and areas of high biodiversity value outside protected areas **[m]**	ha	3	0	0	2	3	8
Amount of land disturbed or rehabilitated due to mining operations **[m]**	ha	3	1	0	3	3	10
Total area of permitted development (mines and all other facilities)	ha	3	1	2	3	3	12
Total land area newly opened for extraction activities (including area for overburden storage and tailings)	ha	3	2	2	3	3	13

Table K.1. continued

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
		3	2				
Total land area covered by ancient or rain forest that was cleared for the extraction activities	ha	3	1	0	0	3	7
Number of sites on environmentally protected or sensitive areas, including both current and planned developments **[m]**	Nbr	3	1	0	3	3	10
Loss of arable land	ha	3	3	0	3	3	12
Loss of arable land (power station and other infrastructure)	ha	3	3	1	0	3	10
Amount of land consumption	ha	3	1	0	3	3	10
Area change from greenfield to brownfield	ha	3	2	0	3	3	11
Land under erosion risk as due to mining operations **[m]**	ha	3	1	0	0	3	7
Land under salinization risk due to mining operations **[m]**	ha	3	1	0	0	3	7
Land under contamination threat due to mining operations **[m]**	ha	3	1	0	0	3	7
Total waste extracted (non-saleable material, including overburden) **[m]**	m^3	3	0	2	3	3	11

Table K.1. continued

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
		3	1				
Reduction of landscape value due to infrastructure problems caused by operations	%	3	2	0	0	1	6
Cutting the biological wildlife corridor due to mining sector operations	Nbr	3	1	0	0	1	5

* Natural resource recovery related indicators are considered as slightly related with the environmental sensitivity parameter in the environmental pillar because the recovery is directly related with the mining area and it has impacts on the environment.

Table K.2. Case 2 indicator selection matrix for the social indicators

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
% of indirect relative to direct jobs	%	0	2	0	1	3	6
Net employment creation expressed as percentage contribution to employment in a region or country	%	0	2	0	1	3	6
Total number of operations taking place in or adjacent to Indigenous Peoples' territories	Nbr	0	2	0	0	3	5
Number and percentage of operations or sites where there are formal agreements with Indigenous Peoples' communities	Nbr & %	0	2	0	0	3	5
Number of proposed developments that require resettlement of communities **[m]**	Nbr	0	1	1	3	3	8
% of employees sourced from local communities relative to the total number of employees	%	0	2	0	1	3	6
Reduction of basic services for the people (health, education, recreation, etc.)	%	0	0	0	2	3	5
The number of households resettled due to proposed developments **[m]** (Displaced population)	Nbr	0	0	0	3	3	6
Population growth rate change before after	%	0	0	0	1	3	4
Dependency of women and 18 older [before and after]	%	0	0	0	0	1	1

Table K.2. continued

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A	B				
Change in urban population	%	0	0	0	3	3	6
Net migration rate incomers/outgoing	%	0	0	0	3	3	6
Change in qualified population	%	0	0	0	1	3	4
Number of archaeological sites affecting from the strategy	Nbr	0	0	0	3	3	6
Percentage of migrated population to different city in displaced population	%	0	0	0	0	3	3
Infrastructure expenditure per capita	m.u.	0	0	0	1	3	4
Change in number of schools	Nbr	0	0	0	2	3	5
Change in number of health service points open to public	Nbr	0	0	0	2	3	5
Change in number of public buildings	Nbr	0	0	0	2	3	5
Vehicle accessibility affected settlements/population	Nbr	0	0	0	3	3	6
Information/Communication services accessibility	Dscrptn	0	0	0	2	1	3
Recreational area per capita	m^2	2	0	0	0	3	5
House price to income ratio	%	0	0	0	2	3	5
Net income change per capita	%	0	0	0	2	3	5

Table K.2. continued

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
Total new land acquisition **[s]***	ha	2	2	3	3	3	13
Change in recreational area after mining operations (due to mining operations) **[s]**	ha	2	1	0	0	3	6
Percentage of local population think/ observe change in recreational area after mining operations (due to mining operations) **[s]**	%	2	1	0	0	3	6
Percentage of local population observing/expecting positive change, sourced from current/planned mining operations in their region in terms of social background **[s]**	%	0	0	0	3	3	6
Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of employment **[s]**	%	0	1	0	3	3	7
Percentage of local population considering the mining sector investment as potentially positive contributor to overcome local problems in terms of infrastructure **[s]**	%	0	0	0	2	3	5
Percentage of local population think/ observe the mining sector as potential source of conflicts on the local level in terms of corruption, social instability**[s]**	%	0	0	0	1	3	4

Table K.2. continued

Parameter / Indicator	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A	B				
Percentage of local population think/ observe the mining sector as potential source of conflicts on the local level in terms of environmental issues, including land use and land acquisition **[s]****	%	2	1	1	2	3	9
Percentage of local population think/ observe improvement in information/communication among the mining sector actors and local public **[s]**	%	0	0	0	3	3	6
Percentage of local population think/ observe accessibility to information about land management, new mining plans etc. is in place **[s]**	%	0	0	0	0	3	3
Percentage of local population think/ observe ways of public consultation/participation are in place **[s]**	%	0	0	0	2	3	5
Percentage of local population think/ observe the mining sector as potential source of problems on the local level in terms of environmental pollution **[s]**	%	3	0	0	3	3	9
Percentage of local population think/ observe the mining sector as potential source of problems on the local level in terms of health and safety issues **[s]**	%	2	0	0	3	3	8

* Land acquisition indicator is considered as moderately related with the environmental sensitivity parameter because this area is directly affected from the mining operations negatively in terms of environment sensitivity.

**As the indicator is indicating negative impact, for the sake of the social index, the indicator needs to indicate positive outcome in order to obtain a cumulative positive result from the index. Therefore, the indicator value will be standardized as a dominator of 1.

Table K.3. Case 2 indicator selection matrix for the economic indicators

Parameter / Indicator	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
Amount of sellable product production **[modified]** *	tonnes	2	3	3	3	3	14
Earnings from all sellable products based on today's market price before interest and tax **[m]**	m.u.	0	3	2	3	3	11
Added value to primary resources by further processing to semi-manufactured and manufactured products **[m]**	m.u./tn	0	3	1	1	3	8
Value-added per unit value of extracted reserve **[m]**	m.u./tn	0	3	1	2	3	9
Ratio of lowest wage to national legal minimum **[m]**	%	0	2	0	3	3	8
Percentage of revenues that are redistributed to local communities from the relevant areas of operation, relative to the net sales	%	0	2	0	1	3	6
Investments into community projects (e.g. Schools, hospitals, infrastructure) as percentage of net sales	%	0	2	0	1	3	6
The total sum of all types of taxes and royalties paid/will be paid by extraction of the natural resource **[m]**	m.u./yr	0	3	2	3	3	11
Direct economic value generated and distributed	m.u./yr	0	3	1	1	3	8
Development and impact of infrastructure investments and services provided primarily for public benefit through commercial, in-kind, or pro bono engagement.	m.u./yr	0	2	0	1	2	5

Table K.3. continued

Indicator \ Parameter	Unit	Scope		Relevance	Data availability	Quanti-fication	Score
		A	B				
Understanding and describing significant indirect economic impacts, including the extent of impacts.	Dscrptn	0	2				
Tax payment of the mining operations **[m]**	m.u.	0	3	2	3	3	11
% of royalty payments to expected revenues from selling the extractable reserve	%	0	3	2	3	3	11
Produced goods or services per land input*	%	2	3	2	3	3	13
Total cost of land acquisition [s]	m.u.	0	3	2	3	3	11
Ratio of economic growth in the region before and after the mining sector investment [s]	%	0	3	0	1	3	7
Ratio of share of the region's contribution to national GDP before and after the mining sector investment [s]	%	0	3	0	1	3	7
Recovery of reserve (ratio of alternative's tonne / estimated tonne) [s] *	%	2	3	3	3	3	14
Change in total tax payments in the region before and after the mining operations [s]	%	0	3	1	1	3	8
Ratio tax payment of the mining operation to total local/traditional economic activities' tax payments specifically in the mining licence area [s]	%	0	3	1	1	3	8

Table K.3. continued

Indicator \ Parameter	Unit	Scope A	Scope B	Relevance	Data availability	Quanti-fication	Score
Number of families (individuals) need to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations. [s] **	Nbr	1	2	1	1	3	8
Ratio of number of local families benefiting from the mining sector directly by employment in the mining company to number of families benefiting from the traditional economic activities on the mine operational area [s]**	%	1	2	0	1	3	7
Ratio of number of families benefiting from the mining sector indirectly by employment in the auxiliary sectors of the mining sector to number of local families benefiting from the traditional economic activities on the mine operational area [s]**	%	1	2	0	0	3	6
Ratio of unit land value in the region before and during (after) the mining operations	%	0	2	3	0	3	8
Ratio of generated economic value on per unit land before and during (after) the mining operation	%	0	3	1	0	3	7

* Natural resource recovery, so the produced valuable material, related indicators are considered as moderately related with the environmental sensitivity parameter in the economic pillar because the recovery is directly related with the mine plan and it affects the environment.

** Change in traditional economic activities are related with the environmental conditions, however as these are considered under the economic pillar, the relation is considered as slightly

APPENDIX L

Transformation Tables for Case 2

Table L.1. Case 2 transformation table of the environmental indicators

	Indicator	Original value				Transformed Value (Standardization)				Indicator's impact on environment
		Alternative 1 (A1)		Alternative 2 (A2)	Alternative 3 (A3)	A1		A2	A3	
		A Sector	B Sector			A Sector	B Sector			
E1	% of resource is left relative to the total amount of the permitted reserves of that resource	14.70	20.80	11.16	48.20	0.01	0.43	-0.23	2.31	-
E2	Total area of permitted development (mines and all other facilities)	5334.60	2354.44	4225.93	2728.84	3.47	0.97	2.54	1.29	-
E3	Total land area newly opened for extraction activities (including area for overburden storage and tailings)	1259.00	459.98	4399.02	4927.73	-0.35	-0.76	1.28	1.55	-
E4	Percentage of newly opened land area relative to total permitted development	0.24	0.20	1.04	1.81	-0.64	-0.70	0.57	1.74	-

Table L.1. Case 2 transformation table of the social indicators

	Indicator	Original value				Transformed Value (Standardization)				Indicator's impact on society
		Alternative 1 (A1)		Alternative 2 (A2)	Alternative 3 (A3)	A1		A2	A3	
		A Sector	B Sector			A Sector	B Sector			
S1	Total new land acquisition* **[s]**	1259.00	459.98	4399.02	3447.17	-0.21	-0.71	1.76	1.16	+
S2	Percentage of local population think/ observe the mining sector potential source of conflicts on the local level in terms of environmental issues, including land use and land acquisition** **[s]**	1/70.25		1/30.40	1/30.40	0.62		2.74	2.74	+

* As the strategic action strongly stresses the use of all proven lignite resources for electricity generation and as the energy policy highlights that increasing the natural resources' contribution in country's economy, acquisition of land contributes to achievement of these two. Therefore, this indicator is accepted as positive.

**Hence the indicator is indicating negative impact. For the sake of the social index, the indicator needs to indicate positive outcome in order to obtain a cumulative positive result from the economic index. Therefore, the indicator value will be standardized as a dominator of 1.

Table L.1. Case 2 transformation table of the economic indicators

Indicator		Original value				Transformed Value (Standardization)				Indicator's impact on economy
		Alternative 1 (A1)		Alternative 2 (A2)	Alternative 3 (A3)	A1		A2	A3	
		A Sector	B Sector			A Sector	B Sector			
Ec1	Amount of sellable product production	339,850,000.00	573,064,800.00	670,841,325.00	428,011,762.50	1.66	3.48	4.25	2.35	+
Ec2	Produced goods or services per land input	269936.46	237149.56	152497.90	86857.79	2.76	2.30	1.12	0.21	+
Ec4	Recovery of reserve (ratio of alternative's tonnes / estimated tonnes)	85.30	79.20	88.84	51.80	4.86	4.44	5.11	2.56	+
Ec5	Number of families (individuals) need to change somehow their traditional source of income, i.e. forestry, fishery, farming etc. due to land acquisition and/or mining operations*	1/ 1,259.00	1/459.98	1/3243.82	1/3447.17	0.03	1.83	-0.60	-0.62	+

*As changing the source of income from traditional economic activities to employment in the industry and in the service sector, the vocational qualifications of the locals need to be improved as well as resettlement etc. is necessary. Hence the indicator is indicating negative economic impact. For the sake of the economic index, the indicator needs to indicate positive outcome in order to obtain a cumulative positive result from the economic index. Therefore, the indicator value will be standardized as a dominator of 1.

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name:	Yaylacı, Evren Deniz
Nationality:	Turkish
Date and Place of Birth:	03.04.1980, Ankara
E-mail:	evrenyaylaci@gmail.com

EDUCATION

PhD	Middle East Technical University, Mining Engineering, 2015
M.Sc.	Brandenburg University of Technology, Environmental and Resource Management, 2005
B.Sc	Middle East Technical University, Mining Engineering, 2003

WORK EXPERIENCE

2013-2015	METU, Dept. of Mining Eng.	TUBİTAK 113M463 no. project PhD scholar
2014-2015	UN, FAO	Natural Resource Expert
2005-2013	Kalkınma Proje Danş. Ltd.Şti.	Managing Partner

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

Yaylacı E.D., Ismaila, A.B., Uşkay, O., Düzgün, Ş., Spatial Analysis of Electricity Supply and Consumption of Turkey for Effective Energy Management and Policy-making In Schmidt, M., Onyango, V., Palekhov, D. eds. Implementing Environmental and Resource Management, Springer-Verlag, Berlin, pp. 153-168, 2011

Yaylacı E., Mining and SEA- An example from Turkey In Schmidt M, João E and Albrecht E (eds) (2005) Implementing Strategic Environmental Assessment, Springer-Verlag, Berlin, pp. 631-645, 2005

Yaylacı E.D., Towards a Sustainable Mining Industry: Actions and Tools In: The 19th International Mining Congress and Fair of Turkey (IMCET 2005), İzmir, Turkey, pp.41-58, 2005