

AHP Analysis in Terms of Sustainable Mining: Case in Turkey*

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Abstract: The wealth and poverty of countries have been the subject of research throughout history. In this context, underground riches, which are seen as the most important sources of wealth in the country, have been examined and seen as worth researching. It is seen that the same understanding may be behind Turkey's production of the first written norms on the mines in the Zonguldak basin during the Ottoman period. In this study, the combined version of two separate AHP analyzes made by the author in his Master's thesis will be analyzed. According to the findings obtained in the thesis, the criteria were recompiled and the economic and environmental sub-analyses on sustainability were examined at once. It has been stated once again that the most fundamental problem of the mining industry is the tax burden on the producers. It is a distinctive feature that two separate AHP analyzes are compiled and reanalyzed in the study.

Keywords: Mines, Mining, Sustainability, Industrial Policies, AHP

JEL Classification: L52

1. Introduction

"The white man treats his mother to earth and his brother to the sky as if he were a commodity that could be bought or plundered, as he treated sheep and shiny beads. His appetite and greed will one day devour the world and leave only a barren desert" (Wikipedia, 2021).

In the adventure, which is accepted as the beginning of the Industrial Revolutions and that steam machines will be used in different fields, especially in the textile sector, following the invention, Europe has entered a new period, especially England. The most important paradigms of this period were shaped by the writings and works of many economists such as Adam Smith, John Baptista Say, and David Ricardo. In the work called

* This study is derived from the author's thesis with the title of: "Assessment of Underground Richness: An AHP Analysis in Terms of Sustainable Mining" in 2021.

The Wealth of Nations, which is assumed to be the most important of these works, Adam Smith also associated the wealth of nation states with the geography on which the countries are located, and therefore with the underground riches. Essentially, it is for the same reason that Europe, since ancient times, wanted to establish hegemony, especially over African lands. When the colonial formation and slavery issues are examined, it is stated that underground mines and riches are very important (Yülek, 2019).

Mining takes its place among the most important sectors of the twenty-first century. It is seen that the use of underground riches in the most ideal way, keeping them in reserve and maintaining planned studies, especially as energy sources, are priority areas of development for every country in every period. For example, the planning of underground mining and energy reserves, which have a special section in the eleventh development plan for Turkey, their extraction processes and long-term plans are explained in detail (TC Ministry of Industry and Technology, 2020).

On the other hand, in its study titled "Sustainable Development Goals", which was published by the world development agency working with the United Nations, seventeen items were discussed for sustainability. Sustainable development goals numbered 3, 7, 8, 9, 11, 15 are directly related to the mining sector. However, although important steps have been taken for Turkey in line with the sustainable development goals numbered 3, 7 and 9, it is seen in the literature that the same success has not been achieved in other areas. Sustainable development goals determined by the development agency are listed below:

- 1) End of poverty
- 2) Solving the hunger problem
- 3) Raising healthy individuals
- 4) Education based on quality rather than quantity
- 5) Social gender equality
- 6) Access to clean water and sanitary conditions
- 7) Accessible and clean energy
- 8) Decent jobs and economic growth
- 9) Industry infrastructure and innovation support
- 10) Reducing inequalities
- 11) Establishment of sustainable cities and living spaces
- 12) Responsible consumption and production
- 13) Climate action
- 14) Conservation of aquatic life and diversity

- 15) Terrestrial life
- 16) Peace and justice
- 17) Establishment of partnerships for all these goals. (Karapınar, 2021)

In this study, a literature analysis was made about mining in the world and Turkey in general, and then an interview was conducted with A*K, who has more than 15 years (17 years) experience in the field, in accordance with the phenomenology method, and the factors affecting sustainability in the mining issue were determined. The factors were supported and then, by making binary evaluations in accordance with the AHP analysis from nine businessmen who are experts in their fields, the "Time consistency" test was performed and finally the factors were ranked according to their importance. The factors were evaluated through the two perspectives discussed in the AHP analysis, and based on this, the views were recompiled for each perspective, and the efficiency levels of the factors were revealed by ranking the factors separately from both perspectives.

2. Literature and Methodology

Although the literature review of the study was made in the thesis of the author, a new analysis was provided by evaluating the results of the thesis in this study (Kolçak, 2021). In the thesis, the analysis on two separate sustainability concepts for sustainability will be combined here. Details are given below.

2.1. Literature

Local governments in Finland, Denmark and Norway were examined and the issues mentioned on mining in smart cities were taken into consideration. (Akarçay, 2017). For a sustainable structuring, within the scope of central administration and decentralization discussions, the evaluations about the law numbered 6360 have been examined (Anbarlı, Kızılkaya, 2016).

To be able to understand the international applications in the studies subject, in addition to the current understanding of local government in Turkey, the existing structures, legislations and functioning in France have been examined (Arsenault, 2005; Attali, 2008; Auby, Auby, Noguella, 2008; Batı, 2018; Kayıkçı, 2003). The evaluations on the current system in the United States of America were examined (Göymen, 2004; Ayhan, 2008; Hull, Leask, 2000; Şengül 2012; Turan, 2017).

The structures in the metropolitan municipalities of Ankara, Çankırı, Trabzon, Izmir and Antalya, Konya, especially in Istanbul, were evaluated (Belge,2002; Bensghir, 2000;

Bensghir, 2001a; Bensghir, 2001b; Bensghir, 2001c; Bozatay, 2016; Ceren, 2011; Çobanoğulları, 2013; Eryılmaz, 2011; Eryılmaz, 2013; Gözler, Kaplan, 2011; Topaloğlu, 2019; Nadaroğlu, 1998; Şahin, 2007).

Reports and literature on the general course of the mining industry in the world and in Turkey, its problems and solution proposals have been examined (ICMM, 2021; Çelebi, Nazmi, 2020; Öztürk, Gezgin 2020, ÇTSO, 2021; TMMOB, 2017; TMMOB, 2021; Yiğit, 2008, Enerji Atlası, 2021; İstanbul Ticaret Odası, 2003; Kalkan, Alparslan, 2009; Karapınar, 2019; Karapınar, Nuray, 2021; Oz, 2019; MTA, 2021; Pekdemir, 2018; WCED,1987).

A wide literature review was conducted within the framework of sustainability and on-site management. Applications and examples based on a sustainable management approach and the use of technological developments in this sense have been examined (Davis, Olson, 1985; UN Development Agency, 2018; Ekonomik Yaklaşım Derneği, 2018; Emini, Kocaoğlu, 2011; Karakaya, Gaytancıoğlu, 2017; Gün, 2012; Kattz, 2003; Oz, 2018; Ozalp, 2011; Özmehmet, 2008; Senge, 2000; Soygüzel, 2015; Seyidoğlu, 1996; TC Sanayi ve Teknoloji Bakanlığı, 2018; TC Dış İşleri Bakanlığı, 2021; Torunoğlu, 1997; Yanık, 2010; Yayla, 2015; Tonta, Ünal, 2005; Yıldırım, Öner, 2004).

The Python Program used in the thesis for the AHP analysis after the main problems and criteria on sustainability were obtained, and case studies on the subject were examined (Alonso, Lamata 2006; Tuncer, 2021; Oz, Başar, 2021)

2.2. Methodology

In the conducted and approved thesis, there are two separate analyzes. The first of these is on the economic aspect of sustainability, while the second is on the environmental aspect. In this study, based on the results of the AHP analysis for both areas, a single and holistic analysis was performed instead of two different analyzes. For a sustainable mining, all of the criteria stated to be effective above 0.10 in the first study were combined for a single analysis.

For a sustainable mining, the environmental factors obtained and their efficiency percentages are listed below (Kolçak, 2021):

Professional Reputation	(2%)
Waste Management	(15%)
Social Living Areas Planning	(4%)
Social License	(22%)

Dust and Noise Pollution	(21%)
OHS Susceptibility of Employees	(24%)
Transparent Management	(12%)

The economic factors and their efficiency percentage relatively obtained for a sustainable mining are listed below (Kolçak, 2021):

Legislation	(15%)
Tax Burden on the Producer	(37%)
Labor Costs	(11%)
Occupational Health and Worker Safety	(4%)
Certification	(3%)
Unregistered Expenses	(3%)
Professional Reputation	(27%)

For a union group for total sustainability, Professional Reputation has been combined and taken into consideration. Also, the issue on Occupational Health System (OHS) could be also combined under one criteria. After these two criteria, Waste Management, Social License, Dust and Noise Pollution, Transparency in Management, Legislation, Tax Burden on Miner and Labor Costs which are greater than 10 percent have been included to the combined analysis.

The combination of these tables need to calculate the new pair comparisons of the criteria. Since the AHP as a specific method needs to compare the pairs of the whole criteria. This calculation for each pair, would be made by using the first consistent outcomes obtained as in the thesis.

As an example, when the Labor Costs and Transparent Management are compared, the efficiency rate of Labor Costs which is 0,11 is compared with the Transparent Management which is 0,12. So the comparison is concluded as the Transparent in Management is more important than Labor Costs with the ratio of 12/11.

When the comparison would make any one of the criteria by Professional Reputation, it should be combined as if two different outcomes are coming from two different side; hence this kind of combination needs a geometric average calculation on both outcomes which are coming from the thesis.

2.3. Criteria for Sustainability

The selected criteria for the whole sustainability issue is mentioned in part 2.2. The criteria could be defined simply as follows:

2.3.1. Legislation

One of the most amended legislation in the history of the Republic is the mining law. Not many changes were made until the mining law numbered 3213 was reached. However, especially in the last 10 years, the changes made 24 times as of 2010 have presented a very problematic situation economically for the producers and sector representatives. For this reason, the role of legislation and its continuous change is important among the sustainability factors that affect the subject economically.

2.3.2. Tax Burden on the Producer

The tax burden is generally concise, corporate tax, state right has a significant economic impact in terms of mining, and while there is no issue of state rights in other sectors, it is stated that a 5% share of state right on invoice is an important factor in mining. Therefore, economic factors should be included in the sustainability of the sector.

2.3.3. Labor Costs

It can be stated that there is a labor cost corresponding to 3–5% of the monthly total turnover in the mining sector, especially in the quarries. This value is the net amount paid. It is one of the main problems of all entrepreneurs engaged in production in this sector. On top of the net payment, SSI and other expenses also have a negative impact on the profit margin of the sector.

2.3.4. Professional Reputation

Professional reputation is a factor that affects sustainability both economically and socially. On the economic side, the credibility of mining and the fact that it is seen as a profitable sector by the banking sector bring positive and negative elements. According to the supplier companies, the location of the mining quarry is clear and mining has a respectable aspect due to the perception of wealth, which can also be expressed as a positive factor.

2.3.5. Waste Management

It is known that waste management is at the forefront of the problems of enterprises engaged in metal mining with chemical content. In quarrying and mineral-containing mining operations, the presence of chemicals is generally negligible. However, what is meant by waste is not only the chemicals contained in the mines. Waste oils of a mining

operation and tires that have become unusable are also waste materials. In accordance with the legislation, these waste oils and rubber etc. It is collected and generally collected in municipal waste-containing garbage.

2.3.6. Social License

It can be stated that certification affects sustainability in two ways. On the one hand, it has bureaucratic intensity and tedious procedures, on the other hand, it is a fact that the profitability of the economy is negatively affected.

The concept of social license is a concept that has entered the literature in recent decades. In the process from the industrial era to the last decades, the health problems caused by the environmental impact on people were not fully known. In our country and in the world, there are hardly any examples where a sanction was applied against the negative effects of many mining activities on human health over the past long years.

In today's world, they should create a platform where they can act together with the local people during the exploration and discovery work in the region where a mining activity will be carried out.

2.3.7. Dust and Noise Pollution

It is a fact that a number of measures taken regarding dust and noise pollution, which is one of the biggest problems of open pit operation, cannot prevent dust and noise.

2.3.8. Occupational Health System

One of the most important issues of the mining industry is the sensitivity of the employees about OHS and occupational diseases are a very big problem. On the other hand, labor courts are mostly on the side of the workers and it is a common problem that has been expressed for years that they have a negative attitude towards the employer. In fact, it is a known fact that the issue of compensation is an industry.

Many of the accidents encountered in the mine sites are caused by the employees leaving the field from time to time without taking the necessary precautions. When employers and permanent supervisors constantly control field workers, it is seen that many of these personnel do not comply with the physical conditions of the mine site. Especially in summer, it is a very common situation for the personnel in the field to prefer to wear slippers instead of steel-toed shoes, and to say "the weather is very hot, we are sweating" when asked why they are not wearing hard hats.

Although they have been repeatedly warned and warned by the employer that especially hard hats and steel-toed shoes are very important for the life safety of the personnel, it is seen that they still do not comply with these rules.

It is an undeniable fact that most of the accidents that occur in a mining company are caused by the personnel's non-compliance with the site rules. For example, one of the personnel had cut his hand in the crushing and screening facility and was immediately taken to the state hospital. After the doctor at the state hospital said that there was no way we could save his finger, the employer sought had the accident-stricken staff done the operation in a hospital where there was a microsurgeon specialist, saying "calm down, we will save your finger". When the employer, who came to the hospital while the injured personnel was in surgery, asked how the accident happened, he received an answer saying, "While the facility was working, while trying to replace the broken tape, the helmet slipped and he lost his balance". The employer, who was not at all surprised by this, witnessed many times that the personnel did not fasten their helmets when they put them on their heads and acted as if they had caps on their heads. The purpose of the employer, who entered the staff's room after the surgery was over, was to check if the staff were well. During this visit, examples such as the personnel saying "the one who made me wear that hard hat.....!" while getting sober, is a typical case of inviting an accident encountered by many companies operating in the mining field.

No matter how much the personnel is trained in a mining company, the invoices of the accidents encountered while acting in the field according to their own knowledge are usually paid to the employer before the labor courts.

2.3.9. Transparent Management

Mining companies should share all the planned stages of the mining site with the local people, from the planning stage of the mining area to the rehabilitation stage, and act in a way that clears the question mark in their minds.

3. AHP Analysis

According to the outputs of consistent calculations, the criteria for minin sector sustainability are listed as below, in Table 1.

Table 1. Criteria and its Codes in Program

Criteria	Code in Python
Legislation	et1

Tax Burden on the Producer	et2
Labor Costs	et3
Professional Reputation	et4
Waste Management	et5
Social Licence	et6
Dust and Noise Pollution	et7
Occupational Health System	et8
Transparent Management	et9

Source: Created by the Authors

When the pair comparison made, the table 2 is obtained from the program which is used as AHP analysis.

Table 2. The Pairwise Comparison of the Criteria

X	Y	Choose Criteria [X,Y]	Importance Index [1-9]
et1: Legislation	et2: Tax Burden on the Producer	y	2,467
et1: Legislation	et3: Labor Costs	x	1,364
et1: Legislation	et4: Professional Reputation	x	2,041
et1: Legislation	et5: Waste Management	x	1,000
et1: Legislation	et6: Social License	y	1,467
et1: Legislation	et7: Dust and Noise Pollution	y	1,400
et1: Legislation	et8: OHS Susceptibility of Employees	y	1,600
et1: Legislation	et9: Transparent Management	x	1,250
et2: Tax Burden on the Producer	et3: Labor Costs	x	3,364
et2: Tax Burden on the Producer	et4: Professional Reputation	x	5,340
et2: Tax Burden on the Producer	et5: Waste Management	x	2,467
et2: Tax Burden on the Producer	et6: Social License	x	1,682
et2: Tax Burden on the Producer	et7: Dust and Noise Pollution	x	1,542
et2: Tax Burden on the Producer	et8: OHS Susceptibility of Employees	x	1,542
et2: Tax Burden on the Producer	et9: Transparent Management	x	3,083
et3: Labor Costs	et4: Professional Reputation	x	1,588
et3: Labor Costs	et5: Waste Management	y	1,364
et3: Labor Costs	et6: Social License	y	2,000
et3: Labor Costs	et7: Dust and Noise Pollution	y	1,909
et3: Labor Costs	et8: OHS Susceptibility of Employees	y	2,182
et3: Labor Costs	et9: Transparent Management	y	1,091
et4: Professional Reputation	et5: Waste Management	y	2,165
et4: Professional Reputation	et6: Social License	y	3,175
et4: Professional Reputation	et7: Dust and Noise Pollution	y	9,000
et4: Professional Reputation	et8: OHS Susceptibility of Employees	x	1,342
et4: Professional Reputation	et9: Transparent Management	x	1,633
et5: Waste Management	et6: Social License	y	1,467
et5: Waste Management	et7: Dust and Noise Pollution	y	1,400
et5: Waste Management	et8: OHS Susceptibility of Employees	y	1,600
et5: Waste Management	et9: Transparent Management	x	1,250
et6: Social License	et7: Dust and Noise Pollution	x	1,048
et6: Social License	et8: OHS Susceptibility of Employees	y	1,091
et6: Social License	et9: Transparent Management	x	1,833
et7: Dust and Noise Pollution	et8: OHS Susceptibility of Employees	y	1,143
et7: Dust and Noise Pollution	et9: Transparent Management	x	1,750
et8: OHS Susceptibility of Employees	et9: Transparent Management	y	1,225

Source: Created by the Authors

The following entrance matrix (Table 3) and normalized (Table 4) matrixes are obtained by using the Table 2 information.

Table 3. Main Matrix as an input value for the program

Main Matrix

	et1	et2	et3	et4	et5	et6	et7	et8	et9
et1	1,000	0,405	1,364	2,041	1,000	0,682	0,714	0,625	1,250
et2	2,467	1,000	3,364	5,340	2,467	1,682	1,542	1,542	3,083
et3	0,733	0,297	1,000	1,588	0,733	0,500	0,524	0,458	0,917
et4	0,490	0,187	0,630	1,000	0,462	0,315	0,111	1,342	1,633
et5	1,000	0,405	1,364	2,165	1,000	0,682	0,714	0,625	1,250
et6	1,467	0,595	2,000	3,175	1,467	1,000	1,048	0,917	1,833
et7	1,400	0,649	1,909	9,000	1,400	0,955	1,000	0,875	1,750
et8	1,600	0,649	2,182	0,745	1,600	1,091	1,143	1,000	0,816
et9	0,800	0,324	1,091	0,612	0,800	0,545	0,571	1,225	1,000
tp	10,957	4,512	14,903	25,668	10,929	7,451	7,367	8,608	13,533

Source: Created by the Authors

Table 4. The Normalized Matrix of Table 3.

Normalized Matrix

	et1	et2	et3	et4	et5	et6	et7	et8	et9	ort
et1	0,091	0,090	0,092	0,080	0,092	0,092	0,097	0,073	0,092	0,089
et2	0,225	0,222	0,226	0,208	0,226	0,226	0,209	0,179	0,228	0,216
et3	0,067	0,066	0,067	0,062	0,067	0,067	0,071	0,053	0,068	0,065
et4	0,045	0,042	0,042	0,039	0,042	0,042	0,015	0,156	0,121	0,060
et5	0,091	0,090	0,092	0,084	0,092	0,092	0,097	0,073	0,092	0,089
et6	0,134	0,132	0,134	0,124	0,134	0,134	0,142	0,106	0,135	0,131
et7	0,128	0,144	0,128	0,351	0,128	0,128	0,136	0,102	0,129	0,153
et8	0,146	0,144	0,146	0,029	0,146	0,146	0,155	0,116	0,060	0,121
et9	0,073	0,072	0,073	0,024	0,073	0,073	0,078	0,142	0,074	0,076
tp	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Source: Created by the Authors

If the analysis is consistent, the result would be as in the last column which gives the weights for every parameter respectively. To make the

Table 5. Testing the Consistency of the Weights, Obtained at Table 4.

Weight Testing for Consistency

	et1	et2	et3	et4	et5	et6	et7	et8	et9	sum	sum/ort
et1	0,089	0,088	0,089	0,123	0,089	0,089	0,109	0,076	0,095	0,846	9,556
et2	0,218	0,216	0,220	0,323	0,220	0,220	0,235	0,187	0,234	2,072	9,574
et3	0,065	0,064	0,065	0,096	0,065	0,065	0,080	0,055	0,069	0,626	9,582
et4	0,043	0,041	0,041	0,060	0,041	0,041	0,017	0,162	0,124	0,571	9,453
et5	0,089	0,088	0,089	0,131	0,089	0,089	0,109	0,076	0,095	0,854	9,582
et6	0,130	0,129	0,131	0,192	0,131	0,131	0,160	0,111	0,139	1,252	9,582
et7	0,124	0,140	0,125	0,544	0,125	0,125	0,153	0,106	0,133	1,573	10,312
et8	0,142	0,140	0,143	0,045	0,143	0,143	0,174	0,121	0,062	1,112	9,186
et9	0,071	0,070	0,071	0,037	0,071	0,071	0,087	0,148	0,076	0,703	9,278
Ort											9,567
CI											0,071
CI/RI9											0,049

Source: Created by the Authors

Since the CI/RI_9 is less than 0,10, ($=0,049 < 0,10$) the analysis is consistent. At the end, it can be stated that, tax burden on the producer (with 22%) is the most effective parameter for sustainability whereas the second one is the dust and noise pollution (with 15%)

4. Conclusion

The main output table is shown in the table 6. According to this table, the most important factor for sustainability on mining sector is shown as the taxation system. Tax burden on the miner is seen as a great challenge. The efficiency ratio is 22% with rank 1. The second important parameter for the mining sector sustainability is shown as dust and noise pollution with the 15% effect. The third one Social License and the fourth one OHS.

Table 6. Output of the Analysis

Number of Crite	9	Consistency Index	0,071
Result	Consistent	Related Random Inde	1,452
	Comparisons Consistency		0,05
Code	Criteria	Weight	
et1	Legislation	0,09	
et2	Tax Burden on the Producer	0,22	
et3	Labor Costs	0,07	
et4	Professional Reputation	0,06	
et5	Waste Management	0,09	
et6	Social License	0,13	
et7	Dust and Noise Pollution	0,15	
et8	OHS Susceptibility of Employees	0,12	
et9	Transperant Management	0,08	
		-	

Source: Created by the Authors

By means of this result, both government and reel sector have to take into account that they have to plan on tax and pollution respectively. When the results are analyzed, the mining sector entrepreneurs and invest owners has the same ratio responsibility as government almost 50%-50%. So they have to collaborate on sustainability. Academy in the country should also support the sector and this may be studied in any academic paper.

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