How To Select The Most Appropriate Indicators For Sustainable Mining –

A Case Study Of Sangan Iron Ore Mines (SIOM)In Iran

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Sustainable Development in Mining

- *Mining, minerals and metals are important to the economic and social development of many countries. Minerals are essential for modern living. Enhancing the contribution of mining minerals and metals to sustainable development includes actions at all levels (UN,2002).*

- *Minerals community will contribute to a sustainable future through the use of our scientific, technical, educational, and research skills in minerals, metals, and fuels (SDIMI,2003).*

Sustainable Development Indicators

- Chapter 40 of the Agenda 21 calls on countries and the international community to develop indicators of sustainable development.
- Indicators:
  - to decisions and actions by simplifying, clarifying and aggregating information to decision-makers.
  - help incorporate physical and social science knowledge into decision-making processes.
  - help to measure and calibrate the progress towards sustainable development goals.
  - provide information to build an early warning system to prevent economic, social and environmental setbacks.
  - are useful tools to communicate ideas, thoughts and values .

Sustainable Development in Iranian Mining Sector

- 20th World Mining Congress (2005) in Tehran ,"Mining and Sustainable Development" as a milestone in Iranian Mining Industry and Academia

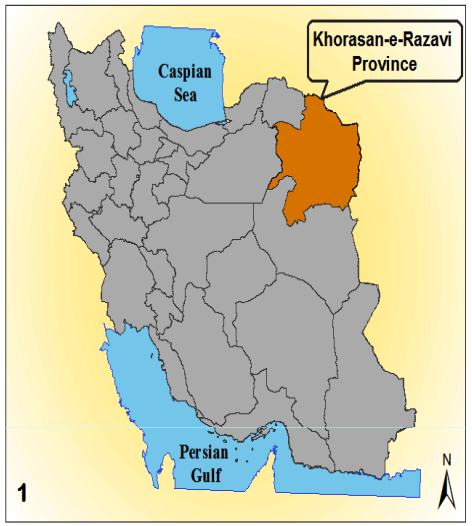
- Iranian Mines and Mining Industries Development and Renovation Organization (IMIDRO) defines itself in its long-term strategies as:

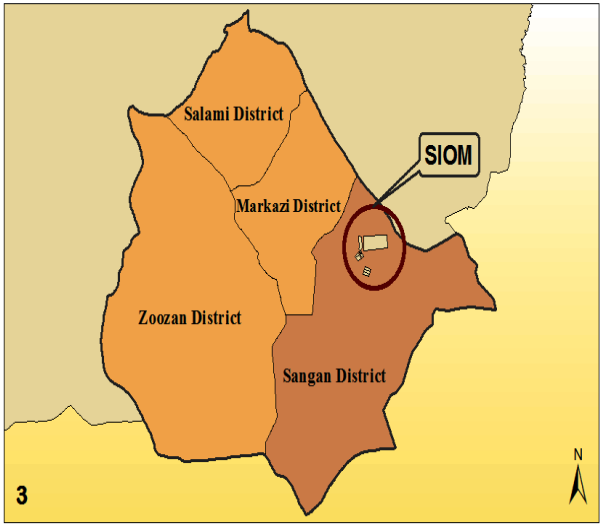
"Leader and pioneer in the sustainable development and evolution of mine and mineral *industries sector and competitiveness in the world value chains"*

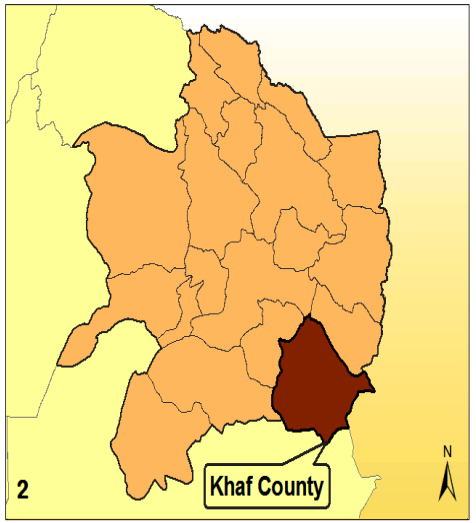
Study Area: Sangan Iron Ore Mines (1)

- Located 300 km southeast of capital of Khorasan-e-Razavi Province.
- Located 30 km west of Afghanistan border.
- Located 18 km Northeast of Sangan Town- Khaf County.
- SIOM: one of the largest iron ore deposits in Iran.

1- Location of Khorasan-e-Razavi Province in Iran (I.R.O.)
2- Location of Khaf County in Khorasan-e-Razavi Province
3- Location of Sangan District and Sangan Iron Ore Mines in Khaf County







Study Area: Sangan Iron Ore Mines (2)

- SIOM is the **biggest national project** in the eastern part of Iran.
- The total mineral resources (Sangan iron ore deposits) are estimated to be **1200 Mt**.
- The total production of Sangan is planned **20 million tons per year** (MTPY) till the end of the project.

Study Area: Sangan Iron Ore Mines (3)

Phases	Performance Duration														
	Before	2012		2013		2014		2015		2016		2017		2018	
One															
Two															
Three															
Four															

- IMIDRO is intending to develop an open pit mine complex and supporting facilities for production of iron oxide concentrate and pellets in 4 phases.
- At the first phase, five MTPY iron ore concentrate and pellet will be produced.
- Phases two and three are under negotiation with some investors for implementation of the same plants as phase one in parallel by IMIDRO.
- The fourth phase of development for producing 5 MTPY iron ore concentrate and pellet is directly depending on the exploration results of Eastern anomalies.

Status of Sustainable Development in SIOM

2002

2006

2015

Progress of road construction (Khaf-Taybad Road)

2008

2009

2010

Progress of railway construction.

High School for Girls

Technical School for Boys

Water Reuse System in Sangan Concentrate Plant

Selection of Sustainable Development Indicators (1)

Goal: Sustainable Development Indicators of CSD Applicable to SIOM

↓

Defining the criteria (Availability, authenticity etc.)

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Selecting the first set of indicators and preparing the questionnaire

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Selecting the Delphi panel of experts

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Distributing the questionnaires (Rating the indicators in a 1-9 scale)

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Analyzing the responses by FDM

↓

SDIs applicable to SIOM
(the 5 indicators with the highest rank in each aspect)

Selection of Sustainable Development Indicators (2)

Stage 1

- Selecting the most appropriate indicators for SIOM from the indicators` set of UN Commission of sustainable Development (CSD), on the basis of:

  ** availability, *authenticity, *possibility of quantification, *application in the study area, *possibility of detecting along term trend, and *citation in relevant scientific literature.*

- Distributing questionnaires among local experts, authorities and community to rate the importance of selected indicators on a "very low" to "very high" scale.

Selection of Sustainable Development Indicators (3)

Stage 1

Economic Indicators	Importance				
	Very Low	Low	Moderate	High	Very High
Length of Roads					
Length of Railway					
Increase in family`s income (per capita)					
Farmers` income					
Employment- population ratio					
Share of women in wage direct employment in the mining sector					
Ratio of annual Electricity consumption in mining sector to total energy consumption in Khaf County					

Selection of Sustainable Development Indicators (4)

Stage 1

Social Indicators	Importance				
	Very Low	Low	Moderate	High	Very High
Access to primary sanitary facilities					
Access to potable water					
Access to electricity and other energy sources					
Under-five mortality rate					
Nutrition status of residents					
Immunization against infectious childhood diseases					
Net enrolment rate in primary education					
Women net enrolment rate in high school					
Adult illiteracy rate					
Population growth rate					
Emigration rate					
Dependency rate					
Telephone and internet users					
Number of drug users					
Life expectancy					

Selection of Sustainable Development Indicators (5)

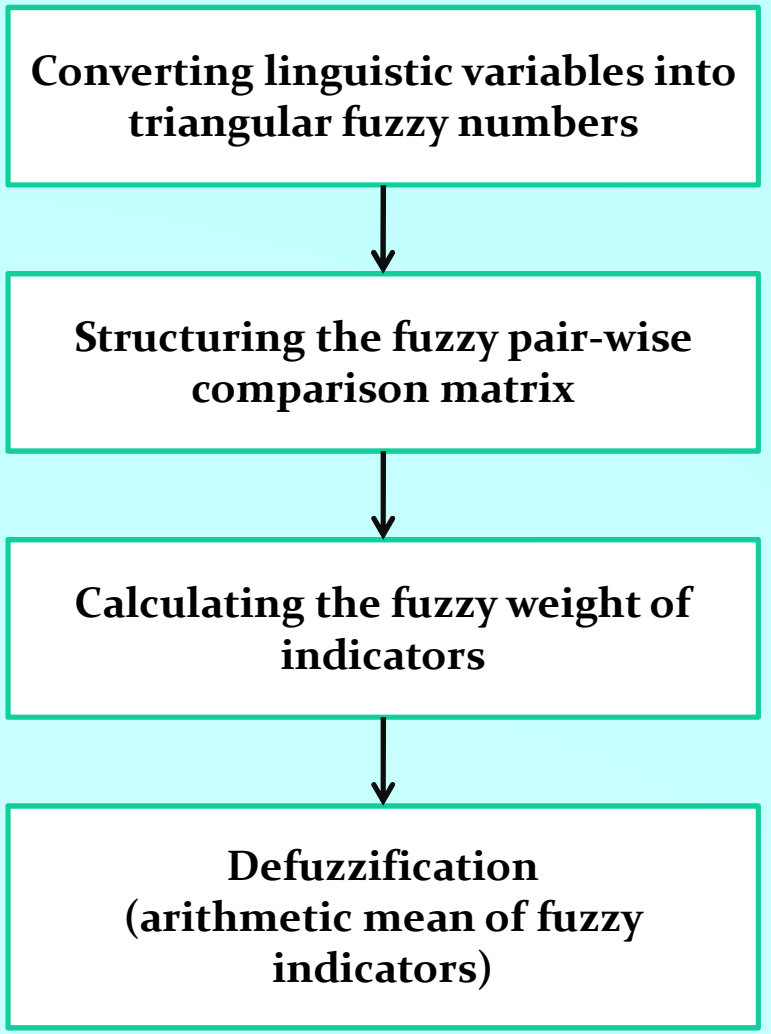
Stage 1

Environmental Indicators	Importance				
	Very Low	Low	Moderate	High	Very High
Water Quality					
Average depth of aquifers					
Water consumption in Sangan Mining Complex					
Wastewater production					
Air quality					
Solid waste production					
Ratio of sanitary disposed solid waste to total solid waste produced					
Protected areas					
Endangered species					
Area of land assigned to mining activities					

Selection of Sustainable Development Indicators (6)

Stage 2

- Fuzzy Delphi Method: an analytical method founded upon the Delphi Method and the Fuzzy Theory.
- It is based on a similarity function to assess the level of agreement between experts.
- The FDM assures no misinterpretation of expert opinions since it considers the fuzziness that every survey process has to deal with.



Results

Applying the FDM to questionnaires and analyzing them according to the process, results can be tabulated as follows:

Group	Indicators	Rank
Ranking of economic indicators according to FD weights	Length of railway	1
	Ratio of annual electricity consumption in mining sector to total energy consumption in Khaf County	2
	Increase in family`s income (per capita)	3
	Length of roads	4
	Employment- population ratio	5
	Farmers' income	6
	Share of women in wage direct employment in the mining sector	7

Results

Group	Indicators	Rank
Ranking of social indicators according to FD weights	Life expectancy	1
	Net enrolment rate in primary education	2
	Nutrition status of residents	3
	Access to primary sanitary facilities	4
	Access to electricity and other energy sources	5
	Telephone and internet users	6
	Population growth rate	7
	Number of drug users	8
	Women net enrolment rate in high school	9
	Access to potable water	10
	Dependency rate	11
	Immunization against infectious childhood diseases	12
	Adult illiteracy rate	13
	Under-five mortality rate	14
	Emigration rate	15

Results

Group	Indicators	Rank
Ranking of environmental indicators according to FD weights	Water consumption in Sangan mining complex	1
	Area of land assigned to mining activities	2
	Ratio of sanitary disposed solid waste to total solid waste produced	3
	Solid waste production	4
	Wastewater production	5
	Average depth of aquifers	6
	Endangered species	7
	Air quality	8
	Protected areas	9
	Water Quality	10

Conclusion

- The application of FDM enables SIOM managers to choose sustainable development indicators which are assessed as the most relevant and important in this mining area.
- Since experts were chosen from different stakeholders such as governmental, non – governmental organizations, academic institutions or local groups the results are quite valid.
- As the next step to these fifteen indicators need to be calculated, measured and reported in different time courses to assess the progress of SIOM projects and operation activities to achieve its sustainability goals.

Thanks For Your Kind Attention