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Environmental and social sustainability assessment of the mining industry

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Is mining industry satisfied with those photos?

- **Talvivaara Mining Company** is a Finnish-based nickel mining business operating in Finland. Its mining business went bankrupt **in November 2014**, and it is bound for liquidation. The mine had suffered several leaks of toxic metal-contaminated tailings, which had threatened local waterways.
- Demonstration against Talvivaara on November 14th, 2012

- The **Mount Polley copper and gold mine disaster** is an environmental disaster in the region of central British Columbia, that began on **August 2014** with a breach of the tailings pond, releasing water and slurry into Polley Lake. The spill flooded Polley Lake, its outflow Hazeltine Creek, and continued into nearby Quesnel Lake and Cariboo Creek. Few days later the 4 Km^2 sized tailings pond was empty. The mine operator, Imperial Metals, had a history of operating the pond beyond capacity since at least 2011.

Is mining industry satisfied in Greece ?

No !

#Skouries among five of the most contrcontroversial mining projects of 2013

March 11, 2014 | Filed under: Eldorado Gold, Greece, mining, Skouries, Uncategorized

‘Civil war’ brewing over disputed Greek goldmine

April 12, 2015 | Filed under: Eldorado Gold, Greece, mining, Skouries, Uncategorized

© AFP/File / by Vassilis Kyriakoulis | A police bus blocks a road as gold mine workers protest against the government’s plan to scrap a gold mine project in the Halkidiki peninsula, northern Greece, in Skouries on February 15, 2015 THESSALONIKI (GREECE) (AFP) – Scrawled on the homes of the …

Yes !

Why ?

- **Environmental issues** (often magnified and/or falsified) appear in the forefront
  - to sensitize the public
  - To justify opposition
  - to cover social and/or political issues

- **The environmental and social arguments mix** and are hard to divorce even in legal terms, when a judicial dispute is taking place (*Kazakidis, Gaidajis and Angelakoglou, 2013)*

- Mining industries tend to **focus on the common identified issues** (e.g. tailings and water management, reagents utilization), **neglecting issues** of regional and local importance (biodiversity, social license to operate etc.)

Need for the mining industry

To prove the sustainability of its activities

Why ?

Because the achievement of sustainability has been set as a primary goal of modern society

Need for the industry

To be able to assess the whether it moves towards **sustainability**

A simple **definition** of **sustainability assessment** is:
"a process that guides decision making towards sustainability" *(Hacking and Guthrie, 2008)*

The **special characteristics** of the **mining industries** such as:

✓Large amounts of incoming/outgoing materials

✓Significant area of coverage of their facilities

✓Need to cope with issues such as biodiversity, restoration etc.

further hinder the application of evaluation frameworks for assessing their sustainability

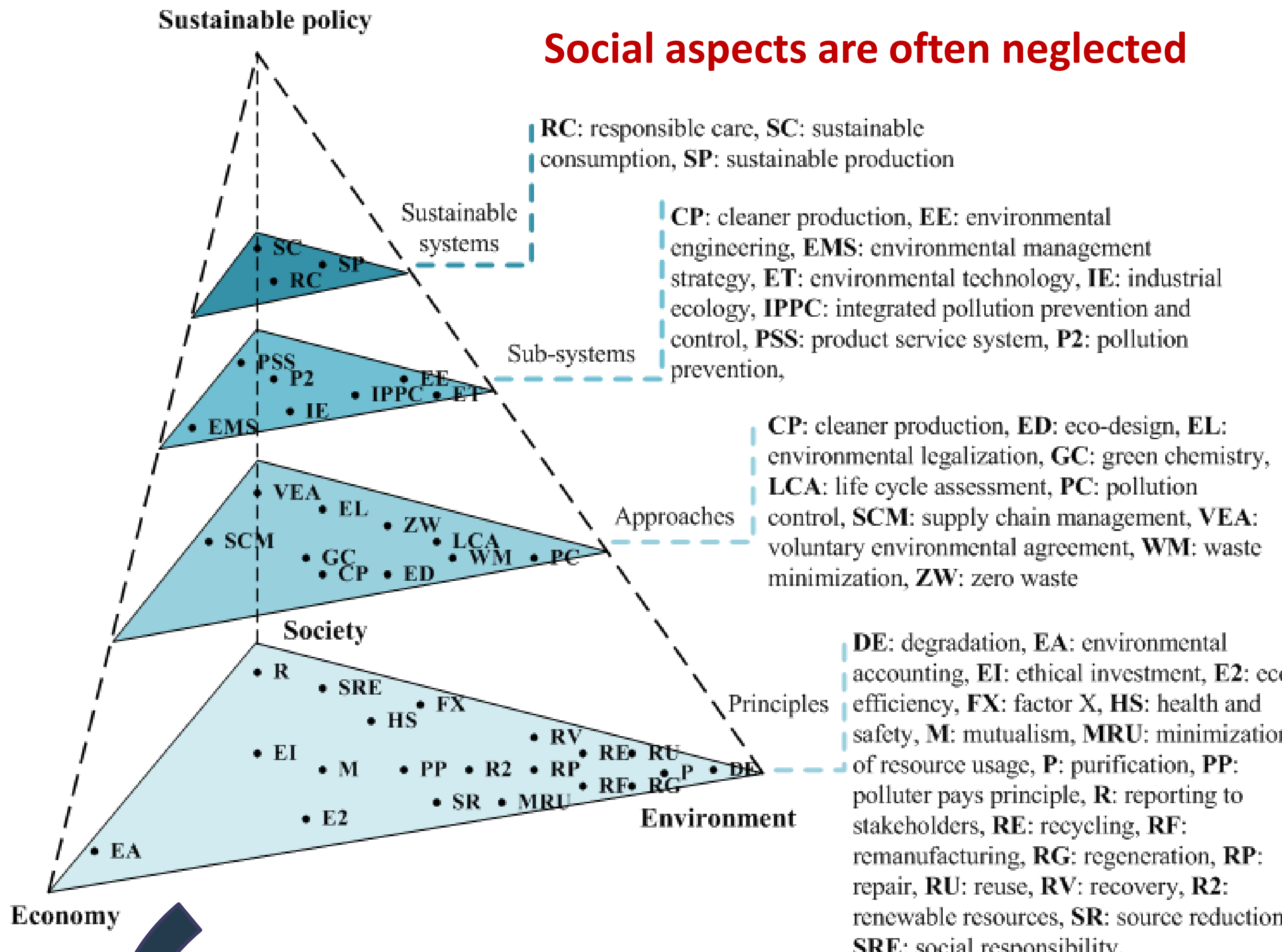
The concept of "Sustainability"

Environmental protection is at the forefront of sustainable development
(Collin and Collin, 2010)

Environmental sustainability is defined as *"**the situation in which vital environmental functions are safeguard for future generations**"*
(Hueting, 2010)

Environmental sustainability should not be confused with the environmental performance.
They vary in the extent of the assessment, the time scale and the width of topics covered
(Wehrmeyer and Tyteca, 1998)

Social aspects are often neglected



*Most of the terms related to sustainability are **focusing** mainly on its **environmental aspect***

Our work

➢Are **current practices and metrics for assessing the sustainability** of industrial systems **truly promote sustainable development**, and if not, what can be done to improve them?

State of the art analysis (**Is there a problem?**)

Angelakoglou K., Gaidajis G., (2015)
"A review of methods contributing to the assessment of the environmental sustainability of industrial systems"
***Journal of Cleaner Production**, 108, pp. 725-747*

Identification and analysis of **48 methods** that can be utilized to assess the environmental sustainability of industrial systems (analysis of more than **300 scientific papers and technical documents)**

Provide specific ideas and methodological steps to cope with the problems identified (**How can the assessment be improved?**)

Our work

Methods contributing to the assessment of the environmental sustainability

Individual/Set of Indicators

- IChemE Sustainable Development Progress Metrics (IChemE)
- Indicators of Sustainable Development for Industry (ISDI)
- Indicators of Sustainable Production (ISP)
- Sustainability Assessment Framework for Industries (SAFI)
- Sustainability Reporting Guidelines (GRI)
- Wuppertal Sustainability Indicators (WSI)

Socially Responsible Investment Indices

- Dow Jones Sustainability Index (DJSI)
- FTSE4Good Index (FTSE)
- OEKOM Corporate Rating (OEKOM)

Composite Indices

- AIChE Sustainability Index (AIChE SI)
- BASF Method (BASF)
- Compass Index of Sustainability (COMPASS)
- Compliment Index (COMPLIMENT)
- Composite Sustainability Performance Index (CSPI)
- Composite Sustainable Development Index (I_{CSD})
- Index of Sustainable Performance (SP Index)
- Life Cycle iNdeX (LInX)
- Organizational Sustainability Performance Index (OSPI)
- Quantitative Assessment of Sustainability Indices (QASI)
- Sustainable Environmental Performance Index (SEPI)
- Σwesh Plot (ΣWESH)

Material and Energy Flow Analysis

Material Flow

- Ecological Footprint (EF)
- Material Inputs per Service and Ecological Rucksack (MIPS)
- Substance Flow Analysis (SFA)
- Sustainable Process Index (SPI)
- Water Footprint (WF)

Energy Flow

- Cumulative Energy/ Exergy Demand (CED/ CExD)
- Embodied Energy (EE)
- Emergy Analysis (EA)
- Exergy Analysis (EXA)

Environmental Accounting

- Cost-Benefit Analysis (CBA)
- Contingent Valuation Method (CVM)
- Environmental Management Accounting (EMA)
- Material Flow Cost Accounting (MFCA)
- Total Cost Assessment (TCA)

Life Cycle Analysis

Single Aspects/Generic framework

- Bridges to Sustainability Framework (BRIDGES)
- Carbon Footprint (CF)
- EDP (EDP)
- Life Cycle Sustainability Dashboard (LCSD)
- USES-LCA

Multiple Impacts Assessment

- CML 2001
- Eco-Indicator 99 (EI99)
- EDIP 2003
- EPS 2000
- IMPACT 2002+
- LIME
- ReCiPe
- TRACI

Sustainability assessment domain | Environmental assessment domain

6 categories

The specific classification was selected over other approaches since :

- it is **applied by many companies in practice** (OECD, 2009)
- is expected to be more **easily understood** and **accepted** by industries and interested agents

Is there a problem? – Our work

Evaluation criteria and relevant questions	Checklist
Criterion 1: Ability to promote actions of improvement	
Q.1.1: Can methods* promote actions that reduce environmental impact?	*Y/N*
Q.1.2: Can methods promote the development of environmentally sustainable products?	*Y/N*
Q.1.3: Can methods promote corporate image and communication strategies?	*Y/N*
Q.1.4: Can methods promote energy and resource efficiency?	*Y/N*
Criterion 2: Ability to help decision making	
Q.2.1: Do methods assess an adequate number of environmental issues?	*Y/N*
Q.2.2: Do methods include specific thresholds/targets of sustainable performance?	*Y/N*
Q.2.3: Can methods identify specific environmental "hot spots" of the industry?	*Y/N*
Q.2.4: Can methods support the achievement of environmental regulations?	*Y/N*
Criterion 3: Potential for benchmarking	
Q.3.1: Can methods aggregate the results into single scores?	*Y/N*
Q.3.2: Are methods able to evaluate progress over time?	*Y/N*
Q.3.3: Can results be applied for cross-comparisons among different industries/products?	*Y/N*
Q.3.4: Can methods be applied/updated to compare overall sustainability performance?	*Y/N*
Criterion 4: Applicability and ease of use	
Q.4.1: Can methods be easily applied by non-experts?	*Y/N*
Q.4.2: Can methods be easily applied by small-medium industries (data/cost involved)?	*Y/N*
Q.4.3: Do methods include clear guidelines of implementation (freely available)?	*Y/N*
Q.4.4: Are there supporting tools/software to help implementation?	*Y/N*
Criterion 5: *Integration of wider spatial and temporal characteristics*	
Q.5.1: Do methods integrate wider spatial characteristics/concerns in the assessment?	*Y/N*
Q.5.2: Do methods integrate special sectoral characteristics/concerns in the assessment?	*Y/N*
Q.5.3: Do methods assess environmental impacts at wider levels (e.g. national, global)?	*Y/N*
Q.5.4: Do methods integrate long-term concerns in the assessment?	*Y/N*

Our work

Key findings:

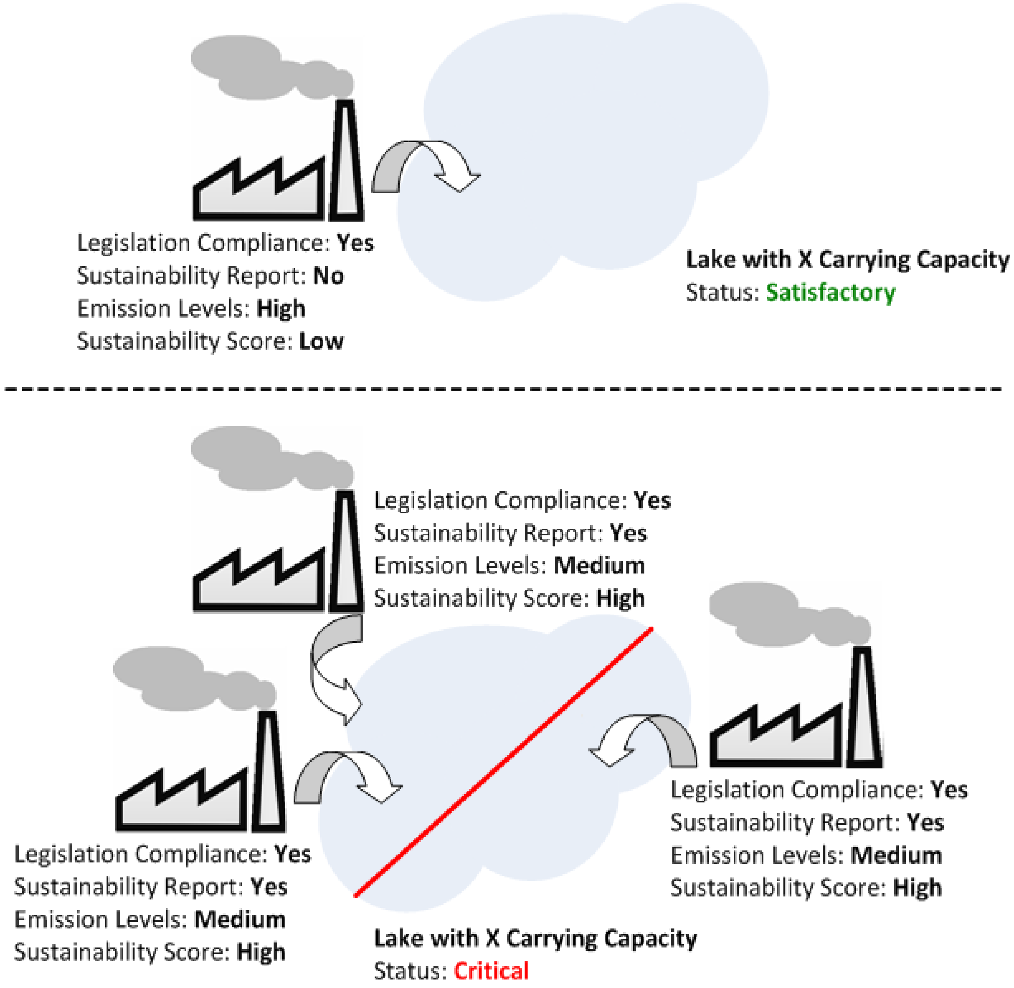
- Focus on industrial processes and products, not to the industry at a corporate or facility level
- Vast variety of environmental issues covered (143 different environmental categories were identified)
- Examples of applications were hard to be found (with the exception of GRI method)
- Industries tend to choose methods that allow them to select the information and indicators to be assessed !!

Is there a problem? – Our work

Key findings:

Lack of integration of spatial and temporal characteristics

- The environmental performance of a facility is highly related with its geographical region and its spatial characteristics
- Not all industries should be enforced to exhibit similar performance since they operate at locations with different background conditions
- Sustainability assessment tools should assess not only the **performance / accountability** of the examined industry, but also the **concern / impact** in regional, national and international level



Our work

Key findings:

Basic shortcoming identified

an indicator itself cannot efficiently quantify sustainability if not a **threshold value / sustainability reference point** is given.

Most of the methodologies examined **do not provide a threshold value** or simply examine the increase/reduction of the value of the examined indicator over consecutive years

- **Indicative example,** Global Reporting Initiative (GRI) methodological framework applied by most industries:
  - rates the industry according to the number of indicators assessed
  - thus focusing merely on disclosure of information
  - rather than the evaluation of actual performance.

The solution – steps towards efficient assessment

An integrated toolkit (**Environmental Sustainability Assessment of Industries - ENSAI toolkit**) that will provide the means to guide, assess and monitor the progress of mining industries towards predefined sustainability goals.

The toolkit consists of **three (3) interrelated tools**:

a) The **ENSAI Index**

An innovative methodological framework that is able to assess the environmental sustainability of mining industrial facilities and quantify the temporal variation of the facility's sustainability performance over time (**available**).

b) The **Responsible-Mining Guide**

A manual for providing information (e.g. sustainability theories, best practices, symbiotic relationships, etc.) to mining industries that can help them enhance sustainability - related strategies. (**under development**)

c) The **ENSAI Eco-label**

An eco-labeling scheme that rewards mining facilities meeting a defined set of sustainability criteria.
(**under development**)

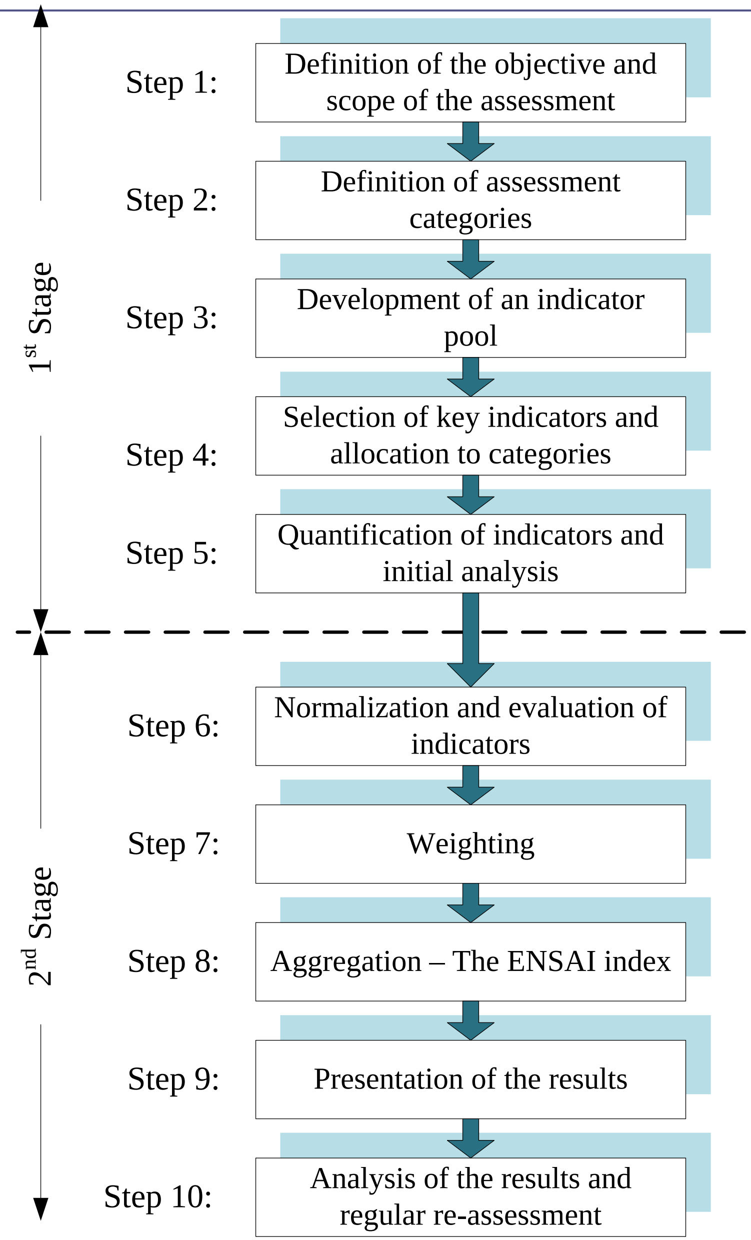
Capitalization of the results produced during the last five years

output indicators:

- one (1) PhD thesis,
- over twenty (20) scientific publications,
- three (3) research projects by LEMIE in the field of environmental sustainability assessment of industrial and technical systems

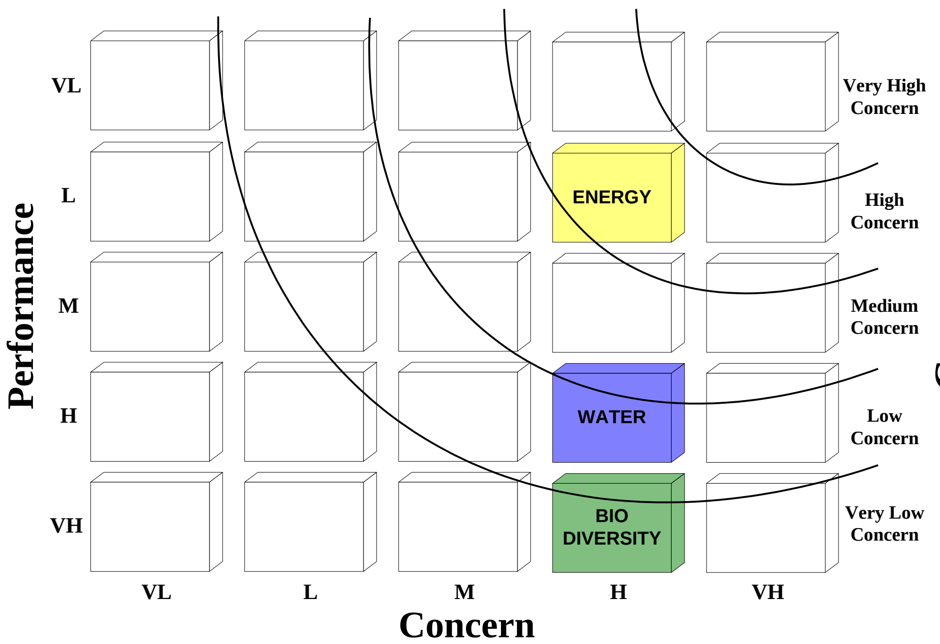
The ENSAI Index

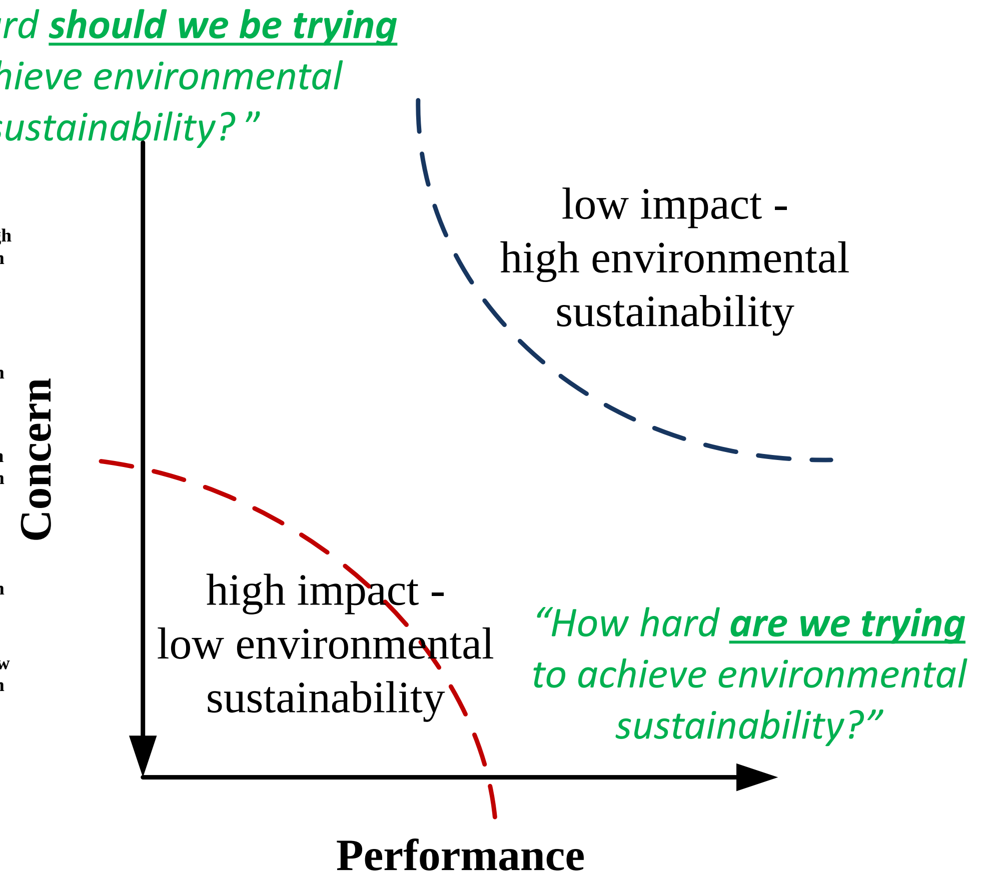
- **10** well defined **implementation steps**.
- **8 assessment categories** covering the vast majority of the issues that need to be included in the assessment.
- **35 core indicators** including specific sustainability thresholds / targets for every indicator.
- A **unique hybrid normalization procedure** based on the distance to sustainable reference values.
- **10 composite indices** and **1 final innovative index** of environmental sustainability.



The ENSAI Index - Highlights

Assessment of both performance and concern issues





The ENSAI Index - Highlights

Eight assessment categories based on the principles of Industrial Ecology

	Assessment category *(what we want to achieve)*	Objectives *(how to achieve it)*
1	**Sustainable consumption of materials and resources**	✓ Reduce material and resources utilization. ✓ Increase utilization of materials and resources of low scarcity. ✓ Increase material reuse and recycling. ✓ Increase utilization of materials derive from recycling.
2	**Waste and emissions minimization**	✓ Reduce waste and emission levels. ✓ Apply efficient waste management and disposal technologies – best available practices.
3	**Sustainable use/management of energy**	✓ Reduce energy consumption. ✓ Increase the utilization of renewable and cleaner forms of energy. ✓ Apply efficient energy management and saving technologies – best available practices.
4	**Sustainable use/management of water**	✓ Reduce water consumption. ✓ Increase water reuse. ✓ Apply efficient water management and disposal technologies – best available practices.
5	**Sustainable transportations and locality**	✓ Reduce total mileage required for the supply of the necessary raw materials and equipment. ✓ Utilize environmentally friendlier technologies for transportations (i.e. > Euro 4 vehicles).
6	**Environmental equity and synergy**	✓ Develop synergies for exchanging waste/materials with other industries and waste management firms. ✓ Develop synergies with various agents (i.e. universities) to promote innovation. ✓ Obtain environmental certifications by independent bodies and adopt an environmental management system.
7	**Conservation of ecological heath and biodiversity**	✓ Selection and utilization of materials and processes with zero or minimal risk to ecological health and biodiversity.
8	**Conservation of human health**	✓ Selection and utilization of materials and processes with zero or minimal risk to human health.

The **comparison** of the proposed categories with the respective categories of other existing sustainability assessment frameworks indicated that **the specific eight (8) categories cover the vast majority of the issues that need to be included in the assessment**

The ENSAI Index - Highlights

35 final core indicators (18 performance and 17 concern) of environmental sustainability

P.1-1: Total consumption of resources/materials (in absolute and relative units) P.1-2: Percentage of raw materials from recyclable/reusable materials	C.1-1: Depletion time of resources/materials utilized in production C.1-2: Percentage of products that can be reused/recycled at their end of life
Category 2: Waste and emissions minimization	
P.2-1: Air emissions by type and total (in absolute and relative units) P.2-2: Liquid waste by type and total (in absolute and relative units) P.2-3: Solid waste by type and total (in absolute and relative units)	C.2-1: Air emissions of the industrial sector C.2-2: Liquid waste of the industrial sector C.2-3: Solid waste of the industrial sector
Category 3: Sustainable use/management of energy	
P.3-1: Total energy consumption (in absolute and relative units P.3-2: Percentage of energy from renewable sources P.3-3: Integration of energy efficient technologies	C.3-1: Energy self-sufficiency at national level C.3-2: Energy needs of the industrial sector
Category 4: Sustainable use/management of water	
P.4-1: Total water consumption (in absolute and relative units) P.4-2: Percentage of water that is recycled/reused P.4-3: Integration of water efficient technologies	C.4-1: Water risk at national level C.4-2: Annual rainfall in the industrial area C.4-3: Water needs of the industrial sector
Category 5: Sustainable transportations and locality	
P.5-1: Total distance of the suppliers P.5-2: Initiatives to improve the environmental performance of the industrial fleet	C.5-1: Environmental assessment of suppliers C.5-2: Adequacy of the transportation network in the area of the industrial facility
Category 6: Environmental equity and synergy	
P.6-1: Initiatives to promote environmental accountability and equity P.6-2: Synergies developed to enhance the environmental performance of the industrial facility	C.6-1: Compliance with environmental laws and regulations
Category 7: Conservation of ecological health and biodiversity	
P.7-1: Global warming potential (GWP) P.7-2: Ozone depletion potential (ODP)	C.7-1: Distance of industrial facility from protected areas and/or areas of high biodiversity C.7-2: Land use designation of the area of the industrial facility
Category 8: Conservation of human health	
P.8-1: Risk to human health	C.8-1: Extent of impact of potential accident from residential areas C.8-2: Air quality in the area of the industrial facility

The ENSAI Index - Highlights

Unique normalization and evaluation of indicators

- A <u>hybrid normalization procedure</u> is proposed, combining the categorical scale and the distance to a reference approaches

   Distance to a reference compares the value of a given indicator to a reference point

   Categorical scale assigns a score to every indicator using a numerical or qualitative scale

- The **reference point** serves as <u>a starting criterion</u> in order **to assign** <u>sustainability scores</u> using a 5-point semi-qualitative scale (Very High (5), High (4), Medium (3), Low (2), and Very Low (1))
- The **reference point** can be a **background value** (i.e. air quality before the operation of the plant) or a **threshold value** (i.e. something causing irreversibility of the system)
- Additionally, reference points can be extracted from **best available techniques** (BAT), **relative regulations**, **commonly accepted standards** and/or **goals and expert judgements**

Ranking $I_{qc}^{t} = Rank(x_{qc}^{t})$

Standardisation (or z-scores) $I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc=\bar{c}}^{t}}{\sigma_{qc=\bar{c}}^{t}}$

Min-Max $I_{qc}^{t} = \frac{x_{qc}^{t} - \min_c(x_q^{t_0})}{\max_c(x_q^{t_0}) - \min_c(x_q^{t_0})}$.

Percentage of annual differences over consecutive years $I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc}^{t-1}}{x_{qc}^{t}}$

Distance to a reference $I_{qc}^{t} = \frac{x_{qc}^{t}}{x_{qc=\bar{c}}^{t_0}}$ or $I_{qc}^{t} = \frac{x_{qc}^{t} - x_{qc=\bar{c}}^{t_0}}{x_{qc=\bar{c}}^{t_0}}$

Categorical scales

$$I_{qc}^{t} = \begin{cases} 0 & \text{if } x_{qc}^{t} < P^{15} \\ 20 & \text{if } P^{15} \le x_{qc}^{t} < P^{25} \\ 40 & \text{if } P^{25} \le x_{qc}^{t} < P^{65} \\ 60 & \text{if } P^{65} \le x_{qc}^{t} < P^{85} \\ 80 & \text{if } P^{85} \le x_{qc}^{t} < P^{95} \\ 100 & \text{if } P^{95} \le x_{qc}^{t} \end{cases}$$

The ENSAI Index - Highlights

Real Example : Mining Industry in Greece

- ✓ Inreased water consumption per average daily production by 3.1% (**2 Points**)
- ✓ Low levels of water reuse (<25%) (**2 Points**)
- ✓ High level of water management technologies (**5 Points**)
- ✓ Low to medium water risk concern of the examined area according to WRI (**4 Points**)
- ✓ Annual precipitation ≈550mm (**3 Points**)
- ✓ Sector with high water related concerns and needs (**2 Points**)

Category	Assessment level				Final Score
	Performance [P]		Concern [C]		
	Indicator	Score	Indicator	Score	
Sustainable use/management of water	*P.4-1*	*2*	*C.4-1*	*4*	$I_S = 3{,}0$
	P.4-2	*2*	*C.4-2*	*3*	
	P.4-3	*5*	*C.4-3*	*2*	
	I_P	**3,0**	I_C	**3,0**	

- ✓ Industry needs to identify **ways to reuse water**
- ✓ Issues were raised regarding the **efficiency** of water management practices

The ENSAI Index - Highlights

Extraction of various sub-indices

Per assessment category – (8) sub-indices:

- I_1: Sustainable consumption of materials and resources index
- I_2: Waste and emissions minimization index
- I_3: Sustainable use/management of energy index
- I_4: Sustainable use/management of water index
- I_5: Sustainable transportations and locality index
- I_6: Environmental equity and synergy index
- I_7: Conservation of ecological heath and biodiversity index
- I_8: Conservation of human health index

Per assessment level – (2) sub-indices:

- I_P: Total performance index
- I_C: Total concern index

Total – (1) final index of environmental sustainability:

- I_{ENSAI}: **EN**vironmental **S**ustainability **A**ssessment of **I**ndustries index

The ENSAI Index - Highlights

Effective presentation of the results

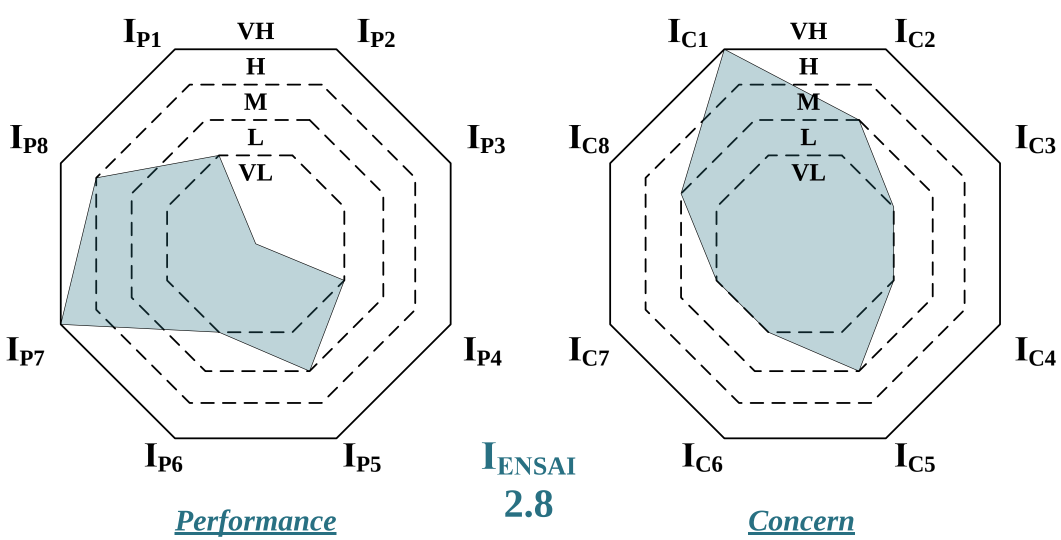
Utilization to:

✓sustainability reports,
✓corporate social responsibility reports,
✓environmental impact studies
✓presentation at meeting and conferences

Environmental Sustainability
ENSAI Score

Indicative example of the Eco-label to be awarded to industrial facilities

An evaluation/rewarding scheme can be developed specialized for mining industries



Indicative presentation of the results with the application of the ENSAI index

Benefits

- Improvement of the **image** of the mining industry.
- Identification of **hot spots** where the examined industrial facility should focus to improve its sustainability performance.
- More efficient and direct **adaptation** to current and future **legislation**.
- **Cost reductions**, due to the adoption of more efficient processes and techniques that result in the minimization of energy consumption, raw materials and other fuels.
- **Access to funding sources** (e.g. loans from banks, government grants, international programs).
- **Market advantages** due to the increasing demand of green products.
- More **transparent** and **efficient** external evaluations.

Social Sustainability in Mining

Is Sustainable Mining an oxymoron ?

Opinions of Stakeholders

Companies say their business is sustainable since:

i. Depletion of mineral resources are compensated by **new wealth**, which, in the form of useful lasting capital, can benefit present and future generations''
ii. Mineral depletion is not an issue due to the possibility of **recycling** many metals and minerals
iii. Discovery of new deposits, and the advancement of technology for improved **recovery** of minerals from previously unprofitable deposits

Investors are beginning to examine companies' levels of **social responsibility** in an effort to reduce their financial risks

Customers prefer products from sources that have demonstrated **good social** and environmental practices.

Governments show concern as poor environmental or social performance translate to economic and political problems.

General public, pressure groups, NGOs draw international attention to **environmental incidents**.

Local communities protest, impede or even shut down mines.

Social Sustainability in Mining

Technical-Economic parameters of a mining project : **8Ds**

1. Detection of geological anomalies;
2. Discovery of the mineral deposit;
3. Definition of the ore body to be mined;
4. Design of the mine;
5. Decision to go ahead with the project;
6. Development of the mine;
7. Depletion of the ore body;
8. Decommissioning of the mine.

1 missing D - Deception: caused by the lack of understanding and/or falsification of environmental / social issues

The **lack of social license to operate** has been recently stressed as one of the **major hurdles** for the mining companies to start a project *(Moffat, K., and Zhang, A. 2014)*

Social Sustainability in Mining

The Deception with environmental issues to justify the opposition

Social Sustainability in Mining

Do not use facts – understand source of perception

- Technical mining personnel **use facts** to explain their actions to local communities.
- Different stakeholders come with different **levels of understanding** on mining issues.
- These differences produce radically **different perceptions** on mining issues.
- The perceptions of the communities **cannot be resolved** with a list of facts not clear for the public.
- Facts create a hierarchy in the debate and **imply the superiority** of the company.
- The best way to deal with perceptions is to understand and attend to the **sources of perceptions**.

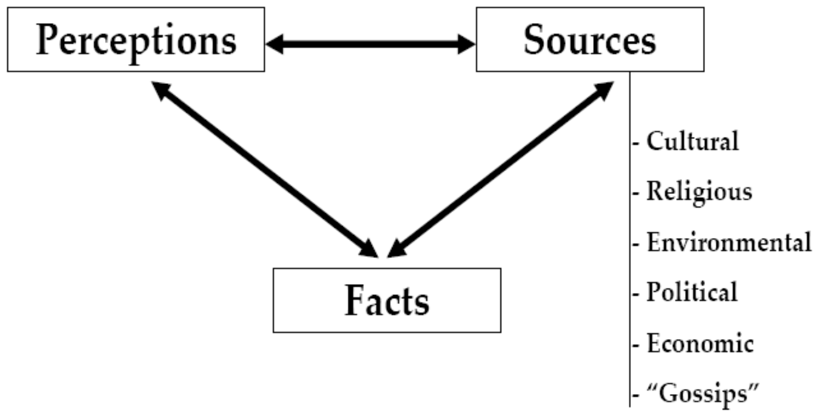
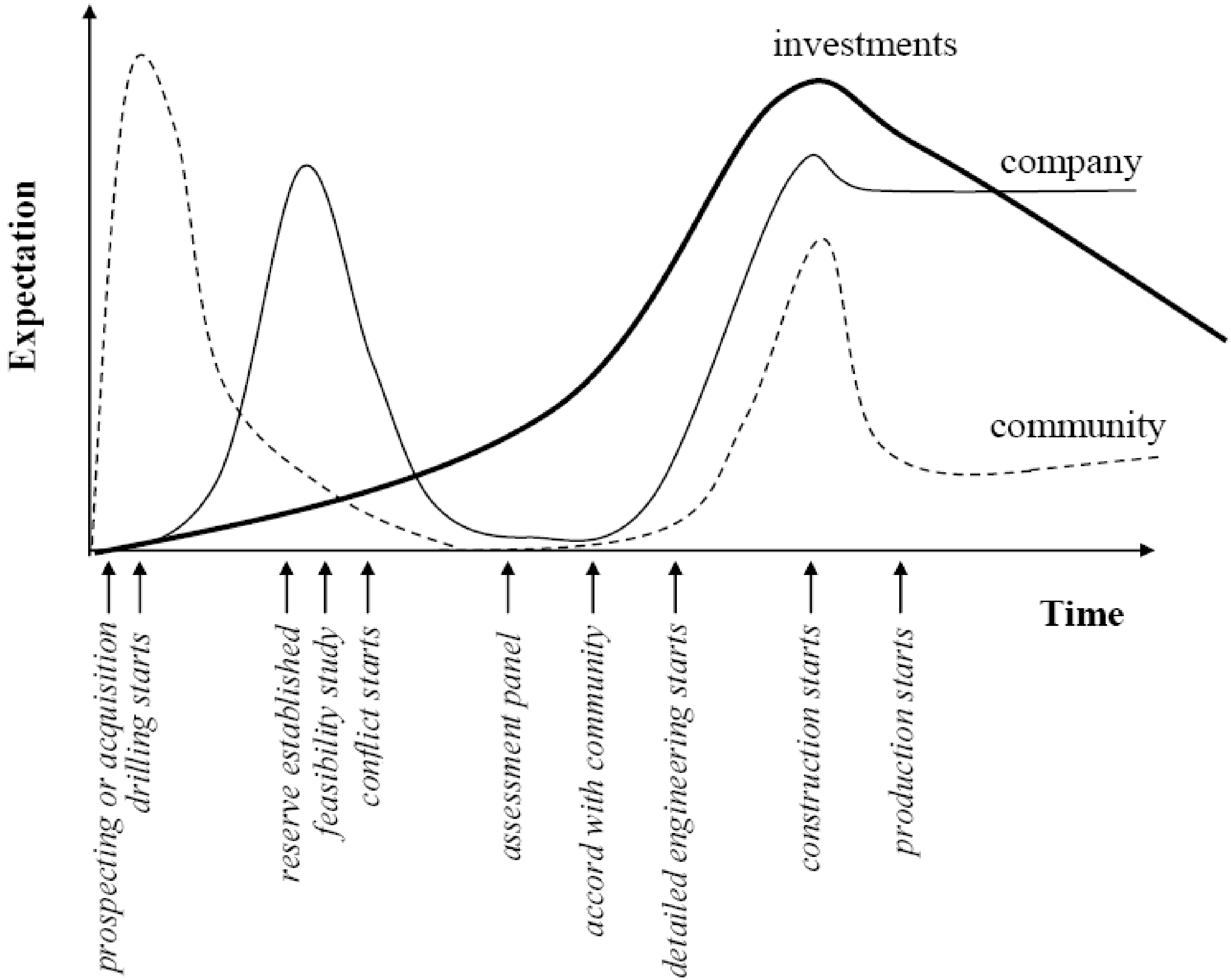


Figure. Knowing the sources of perceptions is more important than facts.

Social Sustainability in Mining

During the project phases the community expectations **fluctuate** and can create conflicts with the company expectations *(Veiga and Tucker, 2015).*



Social Sustainability in Mining

What to do ?

- ✓ Mining projects represent an opportunity to **add value** to local communities.
- ✓ The traditional benefits **are not sustainable**
- ✓ Those benefits are not in the direction of helping communities in their **economic diversification** (i.e., to find alternatives after mining)
- ✓ Develop **human infrastructure or social capital** for lasting value from mineral development

Human Values	Benefits
Friendship	Employment
Solidarity	Schools
Family	Hospitals
Culture & Traditions	Paved roads
Respect	Clean water

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Thank you for your attention

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