Sustainability analysis in the mining sector: a case study on new recycling technologies for sulphidic mine residues valorisation

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MINE TAILINGS

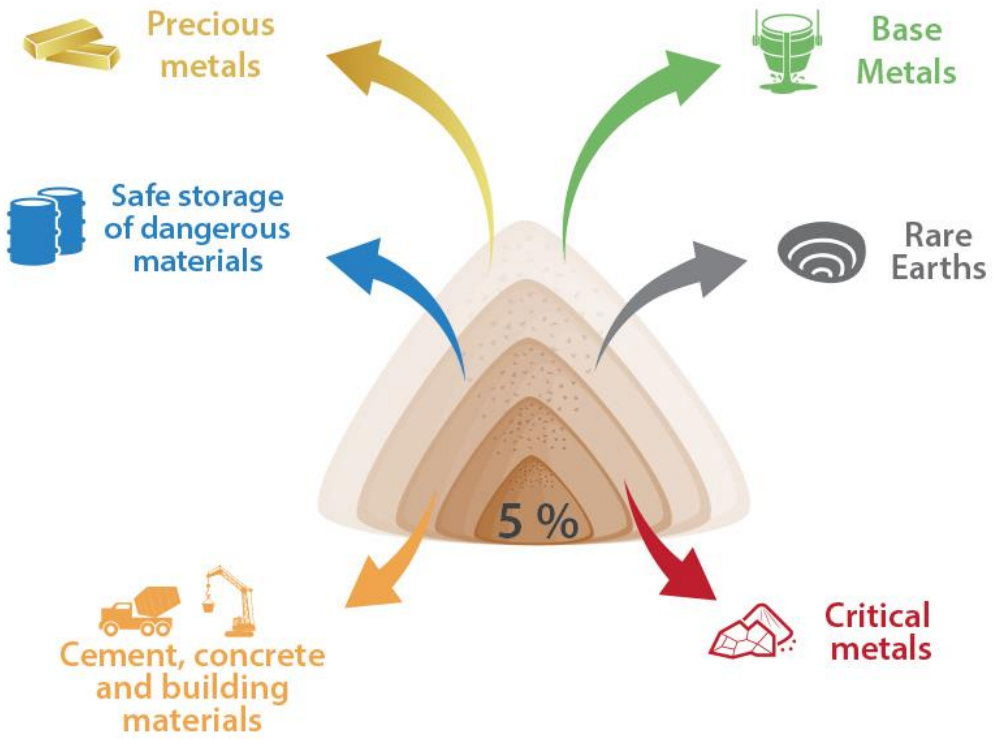
- Residues from mining activities
- Composed by:
  - low grade minerals (pyrite, pyrrhotite)
  - water
  - residual chemicals
- Usually stored in big ponds
- Mine activities benefits…
  - Contribute to the creation of new jobs
  - Create income local communities and businesses

  and costs:
  - Tailings may be source of environmental issues, due to leaching of metals
  - Consequential remediation costs are high
  - Compete with other businesses that may be affected by the contaminations (agricolture, fishery)

The opportunity of mine tailings

- Mine tailings can be a potential source for valuable and critical metals
- Benefits derived from the metal recovery can be many:
  - Reduction of environmental impacts
  - Economic profitability
  - Avoided remediation costs

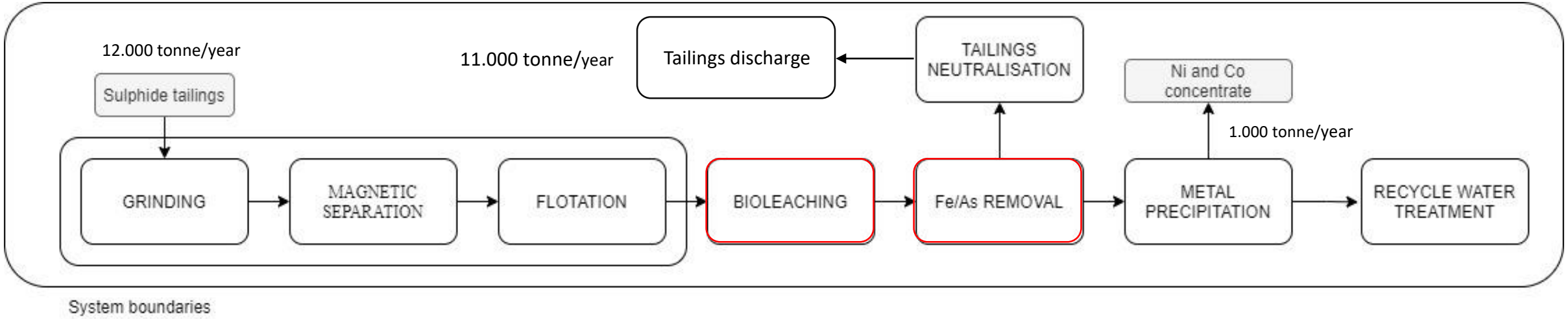
The context



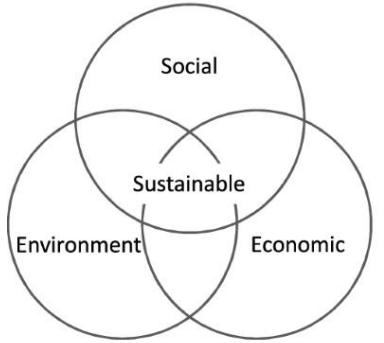
- **NEMO H2020 EC project**
- Aim:implement new technologies for the recovery of valuable and critical metals from sulphidic mine residues.

Mondo Minerals bioleaching project

- Recovery of valuable metals (**Ni** and **Co**) from sulfidic residues from Sotkamo and Vuonos talc production
- Main processes: **BIOLEACHING** and **Fe/As REMOVAL**



GOAL → provide a preliminary sustainability analysis of the environmental, economic and social costs and benefits of a new technique for sulphidic mine residues valorisation.



METHODS → Life Cycle Thinking approach

FIRST INDICATION OF THE TRADE-OFFS

Environmental LCA

Environmental impacts of the technology

Benefits derived from:
metals recovery
avoided landfilling of sulphidic mine residues

Social LCA

Identify potential social hotspots linked to the implementation of the technology

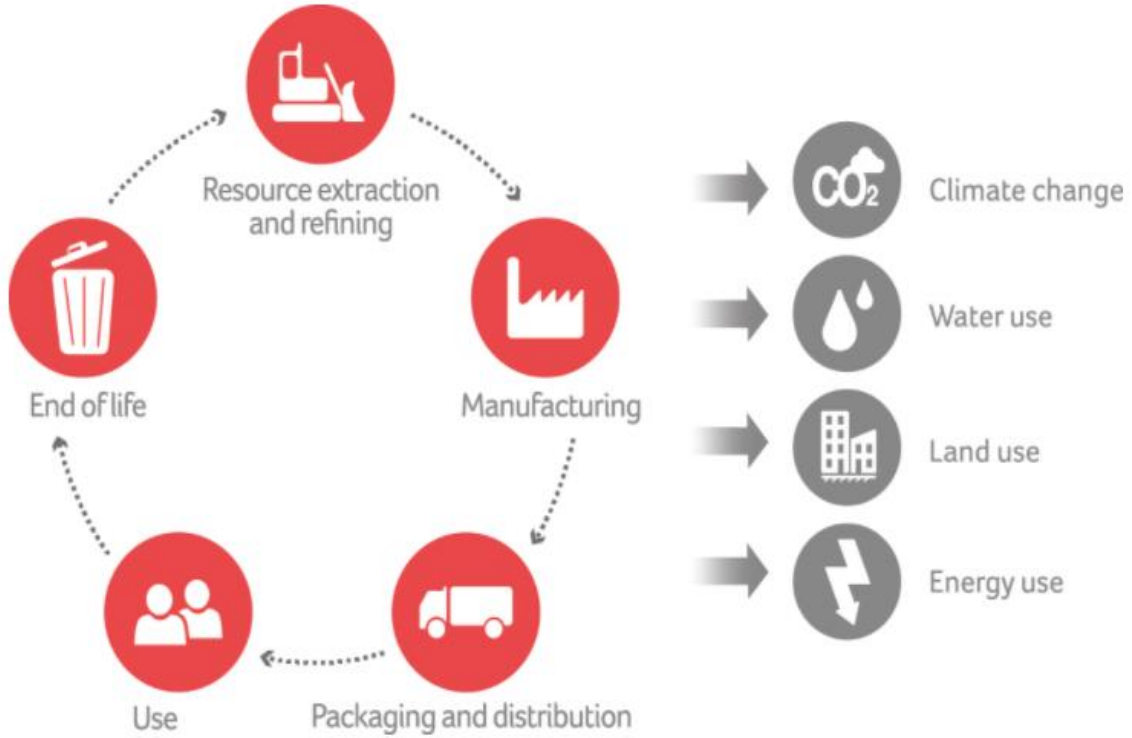
- workers
- local communities
- society

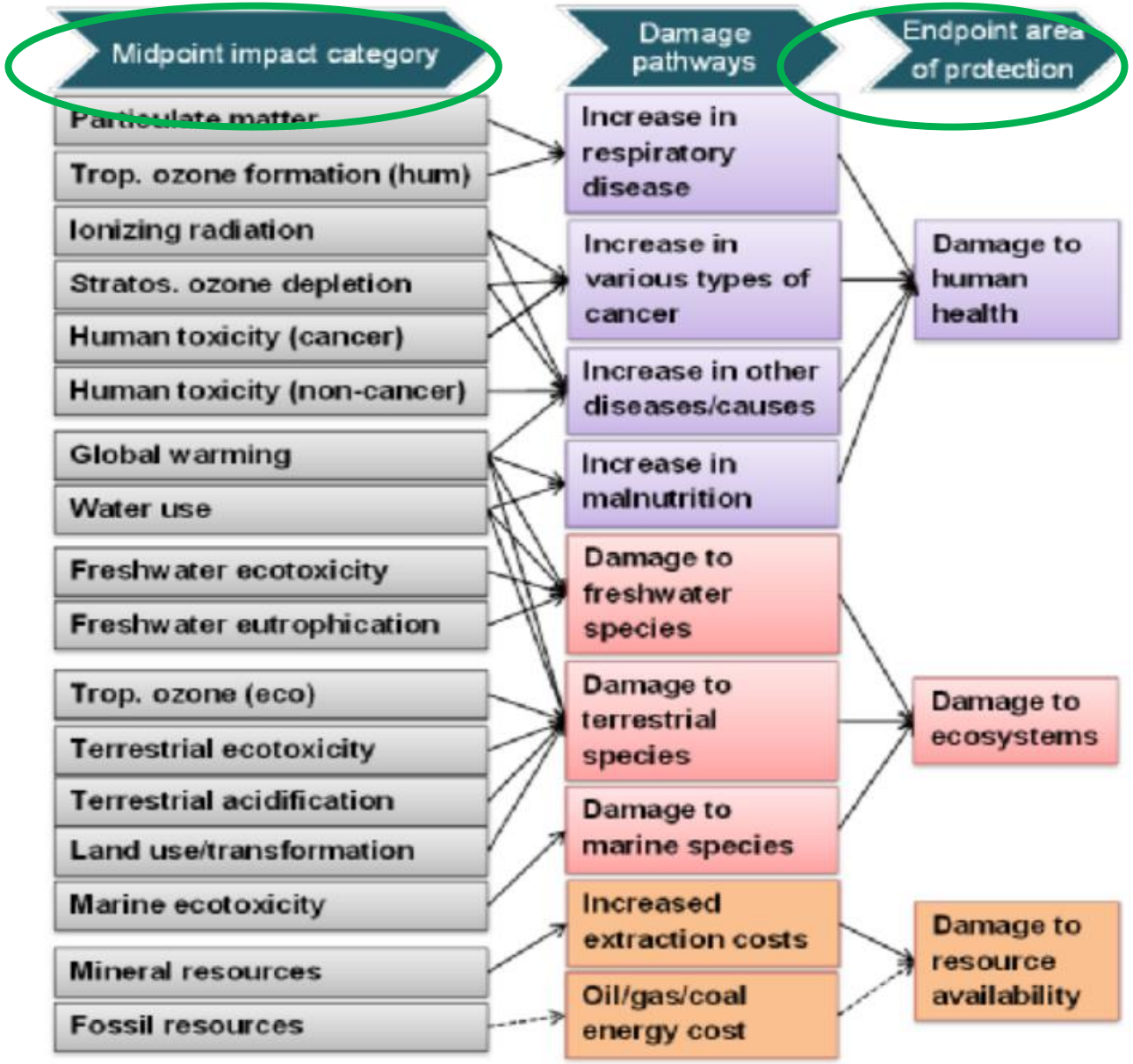
LCC

Identify the economic flows that are expected to be involved

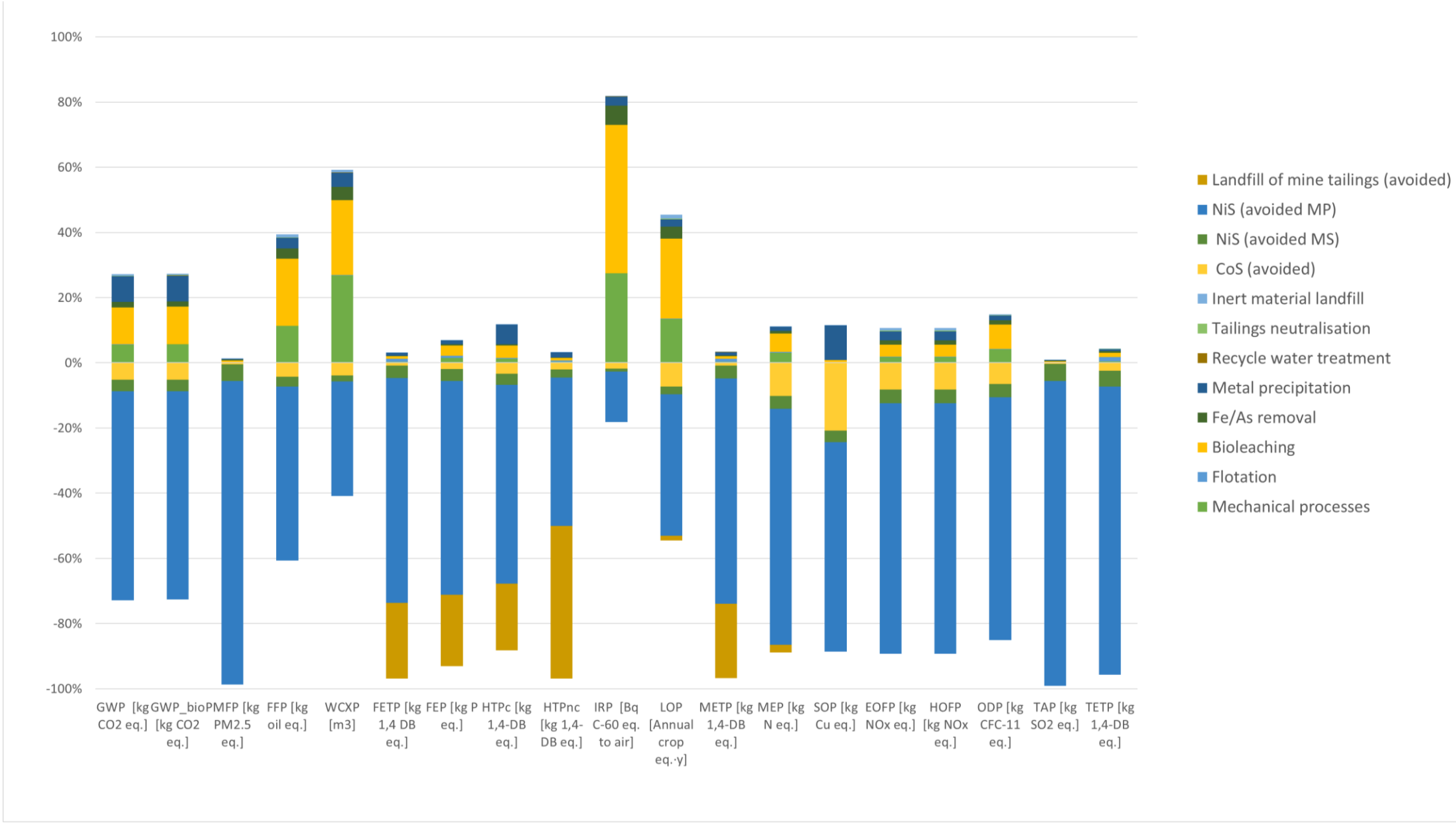
Life Cycle Assessment

- Aims at assessing the environmental impacts of the entire life cycle of the project
- Impacts assessed at midpoint and endpoint levels

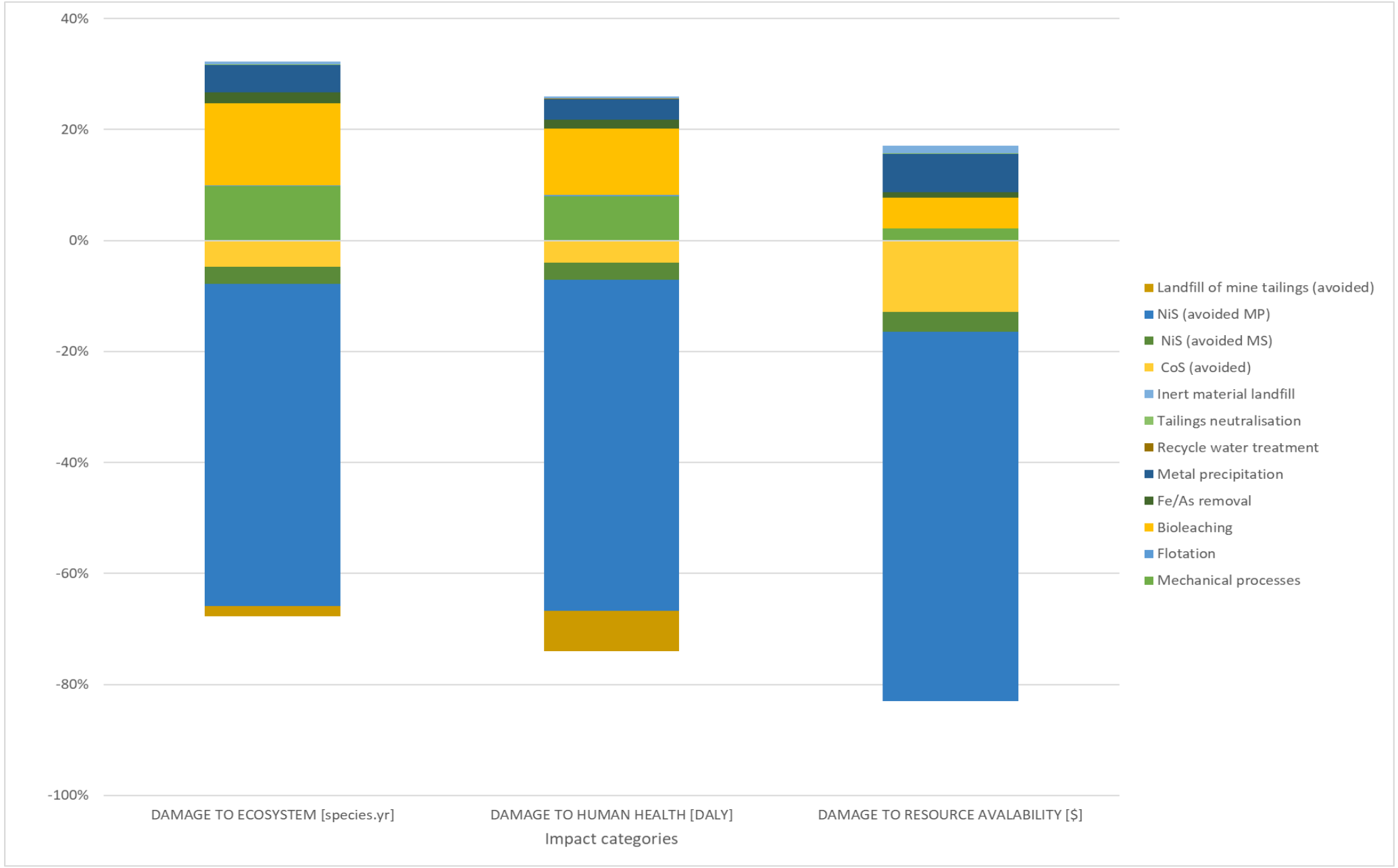



Midpoint impact category
Damage pathways
Endpoint area of protection
Particulate matter
Trop. ozone formation (hum)
Ionizing radiation
Stratos. ozone depletion
Human toxicity (cancer)
Human toxicity (non-cancer)
Global warming
Water use
Freshwater ecotoxicity
Freshwater eutrophication
Trop. ozone (eco)
Terrestrial ecotoxicity
Terrestrial acidification
Land use/transformation
Marine ecotoxicity
Mineral resources
Fossil resources
Increase in respiratory disease
Increase in various types of cancer
Increase in other diseases/causes
Increase in malnutrition
Damage to freshwater species
Damage to terrestrial species
Damage to marine species
Increased extraction costs
Oil/gas/coal energy cost
Damage to human health
Damage to ecosystems
Damage to resource availability

Midpoint results



Endpoint results



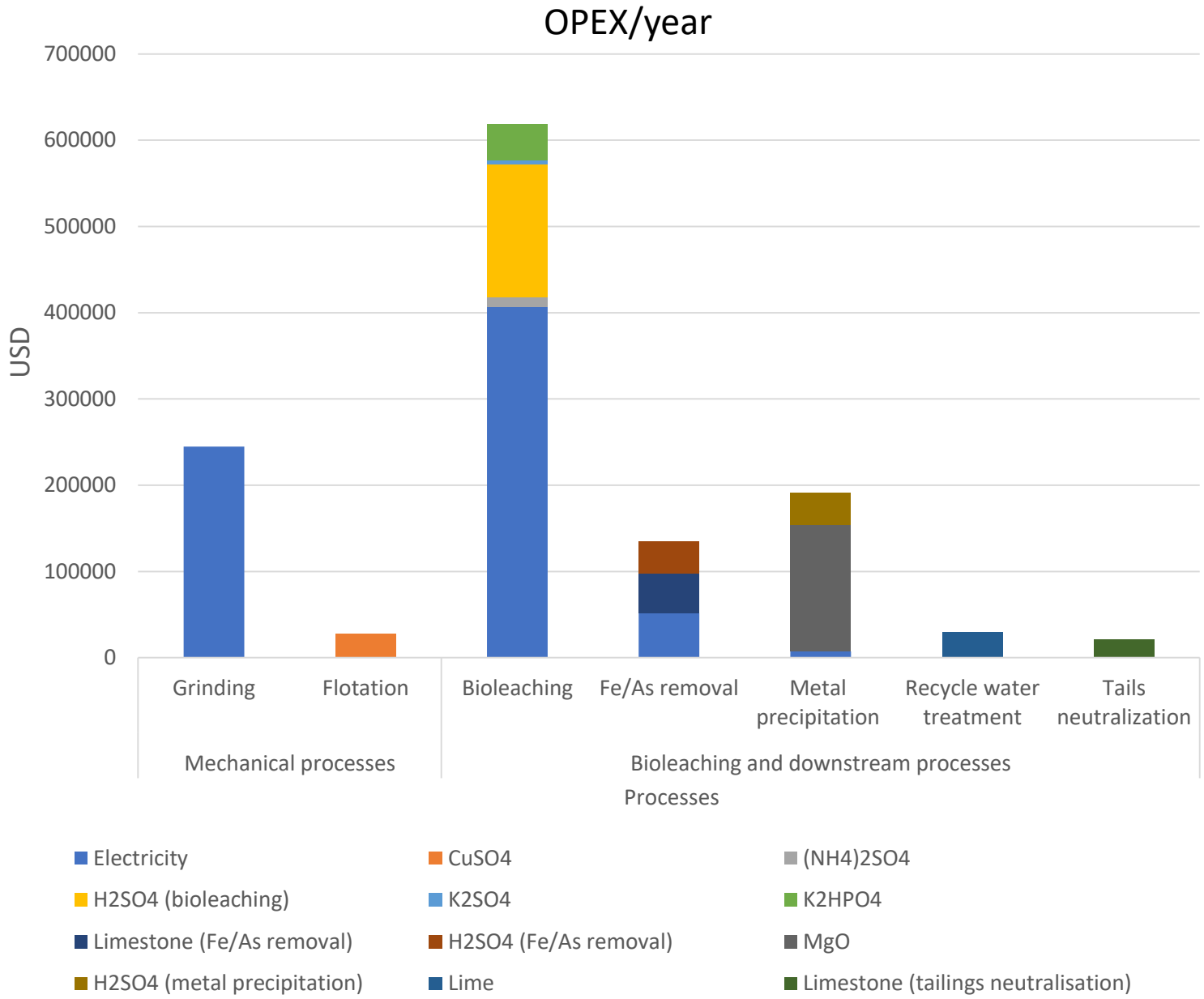
Life Cycle Costing

- Compilation and assessment of all costs related to the project, over its entire life cycle
- Operational costs (OPEX) are included and calculated for each process
- Revenues are calculated from the selling of the recovered metals
- The profitability of the project is assessed through the calculation of NPV:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$$

C_t= profit(revenues-costs)
r=discount rate
C_0= CAPEX
t=time

LCC results



NPV>0 → PROFITABLE

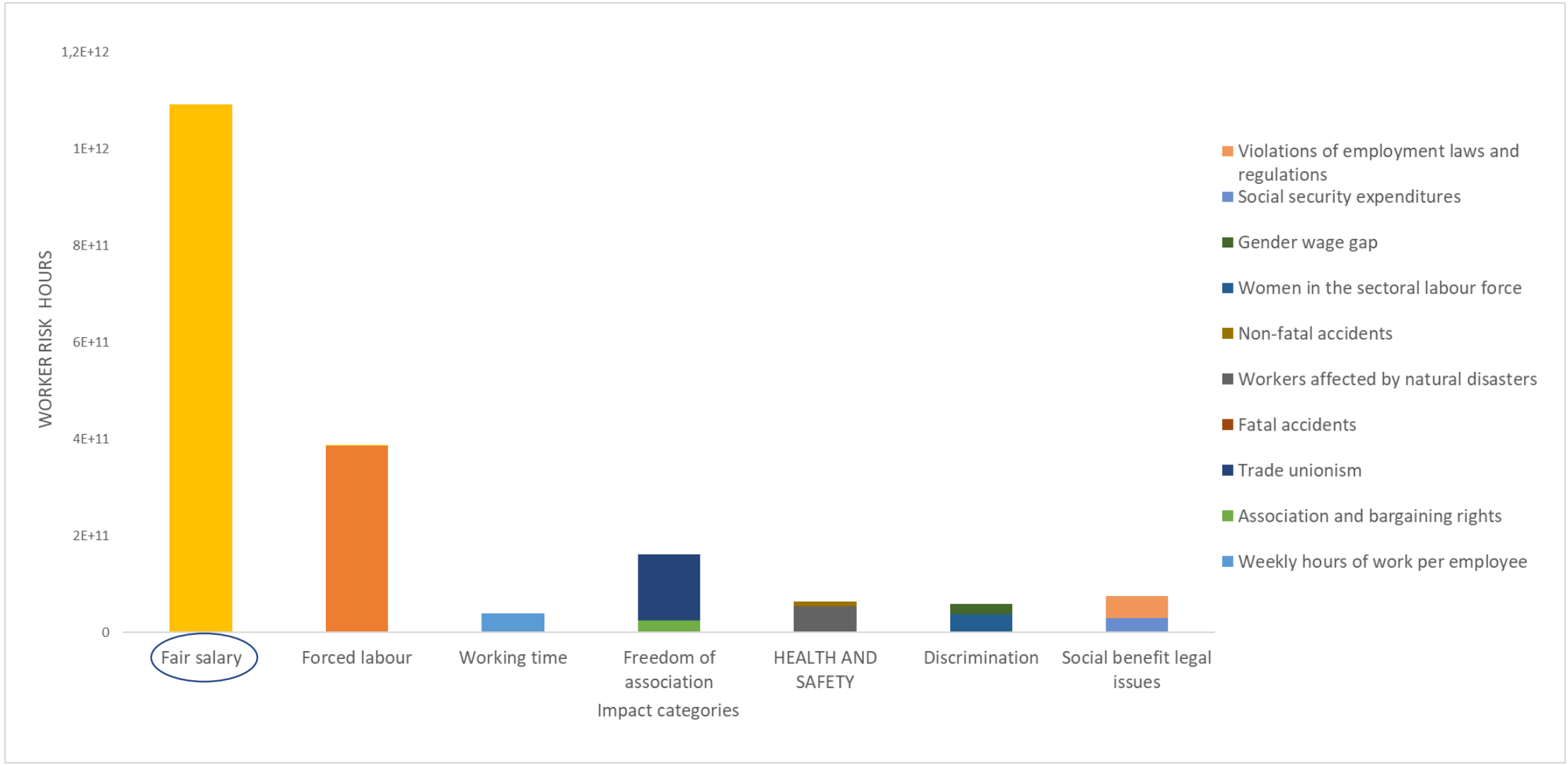
NPV=84.912.565 USD

Social Life Cycle Assessment

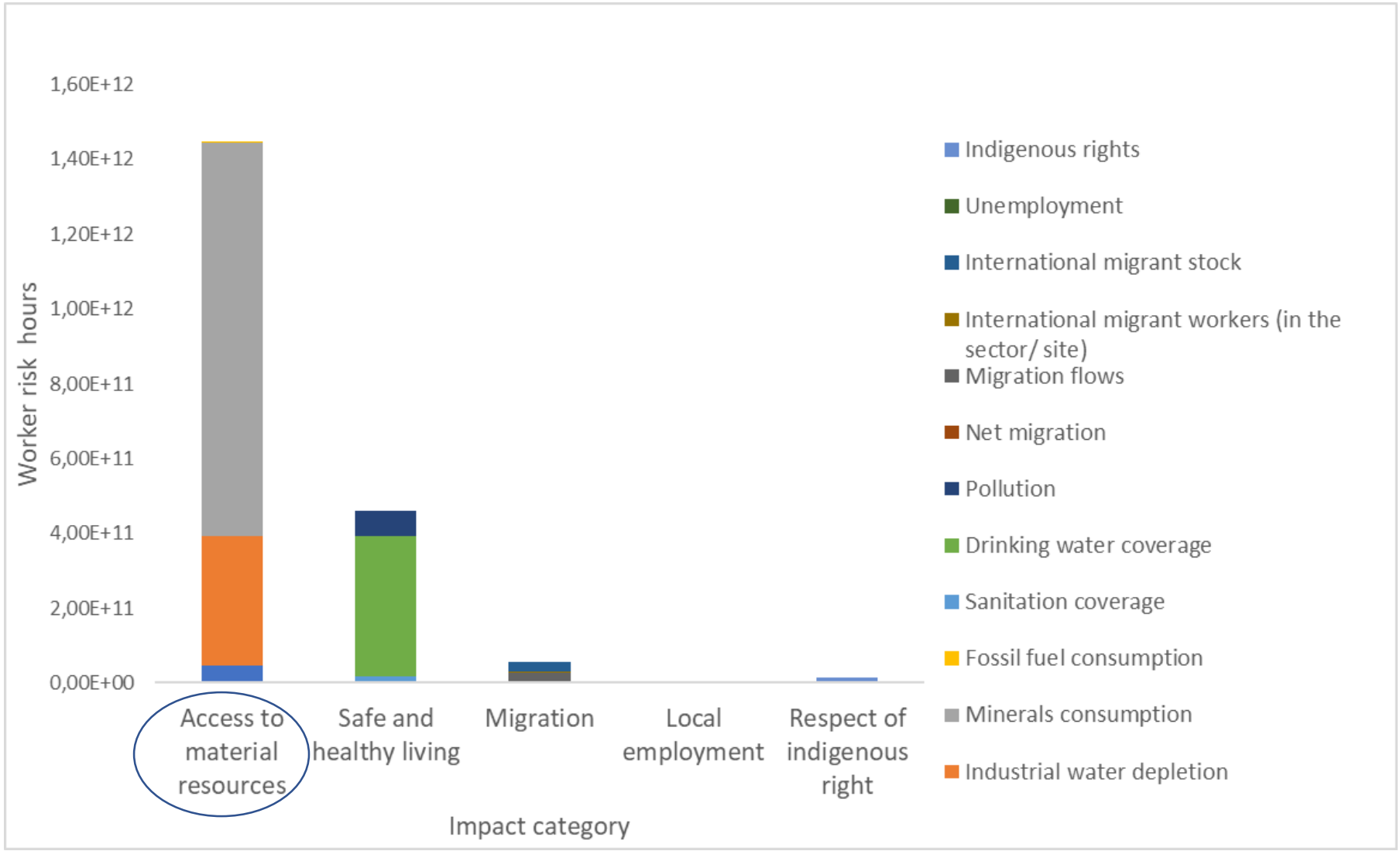
Aims at assessing the social impacts of the project

Stakeholder categories	Worker	Local community	Value chain actors (not including consumers)	Consumer	Society	Children
Subcategories	1. Freedom of association and collective barganing 2. Child lbor 3. Fair salary 4. Working hours 5. Forced labor 6. Equal opportunities / discrimination 7. Health and safety 8. Social benefits / social security 9. Employment relationship 10. Sexual harassment 11. Smallholders including farmers	1. Access to material resources 2. Access to immaterial resources 3. Delocalization and migration 4. Cultural heritage 5. Safe and healthy living conditions 6. Respect of indigenous rights 7. Community engagement 8. Local employment 9. Secure living conditions	1. Fair competition 2. Promoting social responsibility 3. Supplier relationships 4. Respect of intellectual property rights 5. Wealth distribution	1. Health and safety 2. Feedback mechanism 3. Consumer privacy 4. Transparency 5. End-of-life responsibility	1. Public commitments to sustainability issues 2. Contribution to economic development 3. Prevention and mitigation of armed conflicts 4. Technology development 5. Corruption 6. Ethical treatment of animals 7. Poverty alleviation	1. Education provided in the local community 2. Health issues for children as consumers 3. Children concerns regarding marketing practices

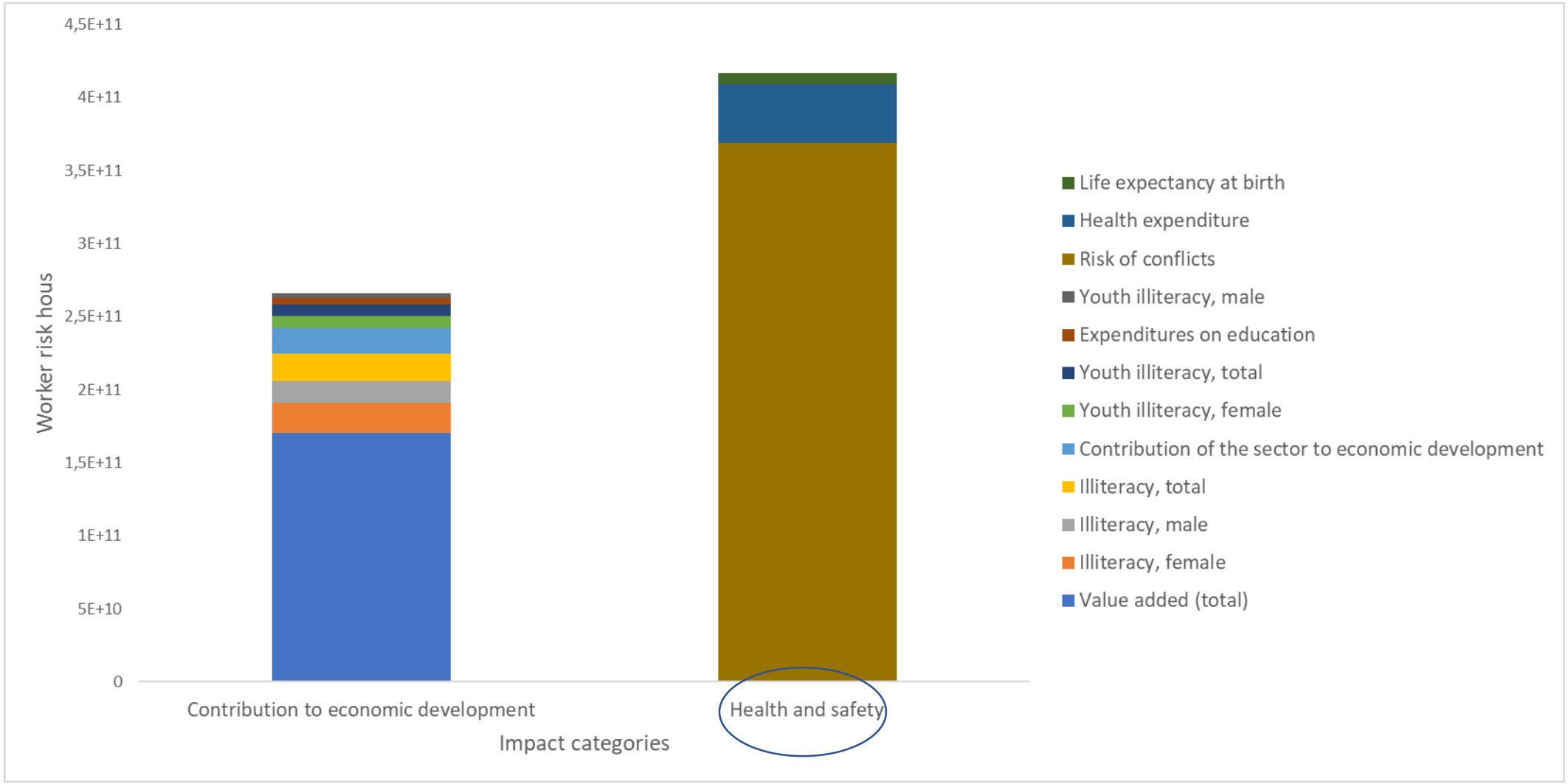
Workers


1,2E+12
1E+12
8E+11
6E+11
4E+11
2E+11
0
WORKER RISK HOURS
Fair salary
Forced labour
Working time
Freedom of association
HEALTH AND SAFETY
Discrimination
Social benefit legal issues
Impact categories
Violations of employment laws and regulations
Social security expenditures
Gender wage gap
Women in the sectoral labour force
Non-fatal accidents
Workers affected by natural disasters
Fatal accidents
Trade unionism
Association and bargaining rights
Weekly hours of work per employee

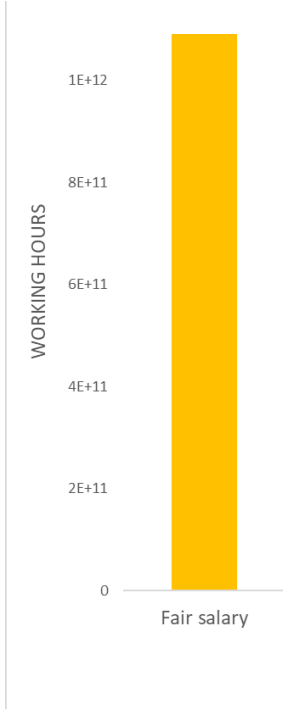
Local community



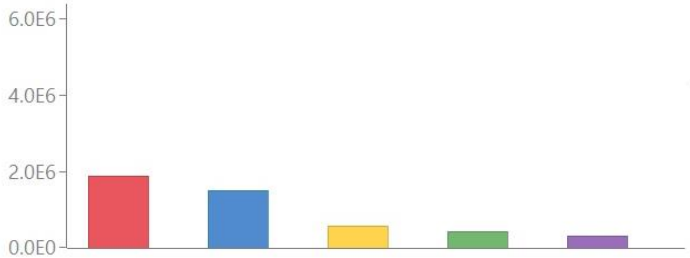
SOCIETY

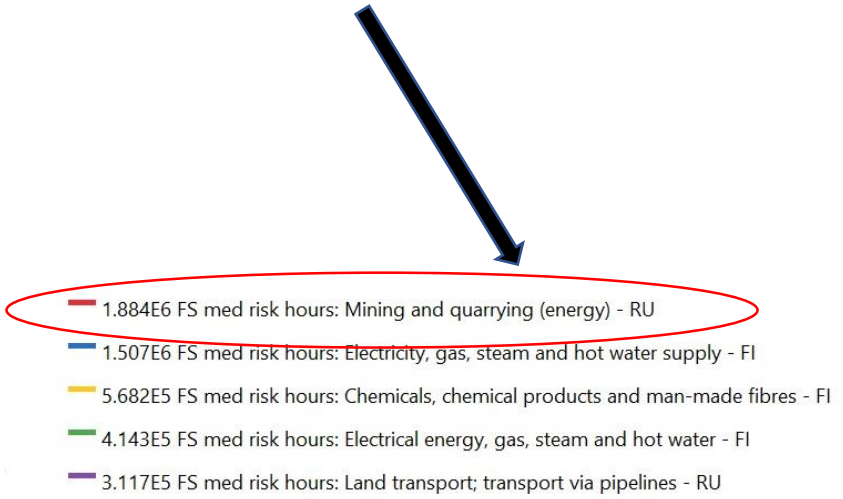

4,5E+11
4E+11
3,5E+11
3E+11
2,5E+11
2E+11
1,5E+11
1E+11
5E+10
0
Worker risk hous
Contribution to economic development
Health and safety
Impact categories
Life expectancy at birth
Health expenditure
Risk of conflicts
Youth illiteracy, male
Expenditures on education
Youth illiteracy, total
Youth illiteracy, female
Contribution of the sector to economic development
Illiteracy, total
Illiteracy, male
Illiteracy, female
Value added (total)

What does this mean?



- Results provide a first **screening** of the social hotspots
- Further investigations can be done:
  - Why?
  - Where are the impacts located?





Results summary

LCA

- Bioleaching contributes the most to the overall caused impacts
- The project contributes to the reduction of the production of Ni and Co concentrate from new resources
- Overall, the avoided impacts are greater than the caused ones

LCC

- The project is profitable
- Bioleaching contributes the most to the overall costs

S-LCA

- Analysis on the stakeholders
- Workers→ fair salary
- Local communities→access to material resources
- Society→ Health and safety

CONCLUSIONS

- First complete sustainability analysis for mine tailings recovery
- The analyses demonstrate that the recovery of mine tailings can be an opportunity to:
  - reduce the environmental impacts of metals extraction
  - increase the profitability of mine companies
- The S-LCA identified the social hotspots of the project
- The conduction of the three analyses can be useful for decision makers
  - the comparison allows to easily identify the common hotspots between the environmental, social and economic impacts of the project
- Further improvement can be done to:
  - Harmonize the three different analyses
  - Better develop the S-LCA to make site-specific considerations

THANK YOU FOR THE ATTENTION