An application of a pollution index and multicriteria decision tool in quantifying the hazards of historic mine sites for their repurposing

ZM Dzegere, I Watson, SE Mhlongo

ESG in the Minerals Industry Challenges and Opportunities
16-17 October 2024

SAIMM
THE SOUTHERN AFRICAN INSTITUTE OF MINING AND METALLURGY

Introduction

- Abandoned mines in South Africa.
- Negative impacts.
- Potential for other uses.
- Clear objectives for rehabilitation.

Objective

- To identify and quantify hazards of a selected study area
- Effectiveness of the methods

Study Site

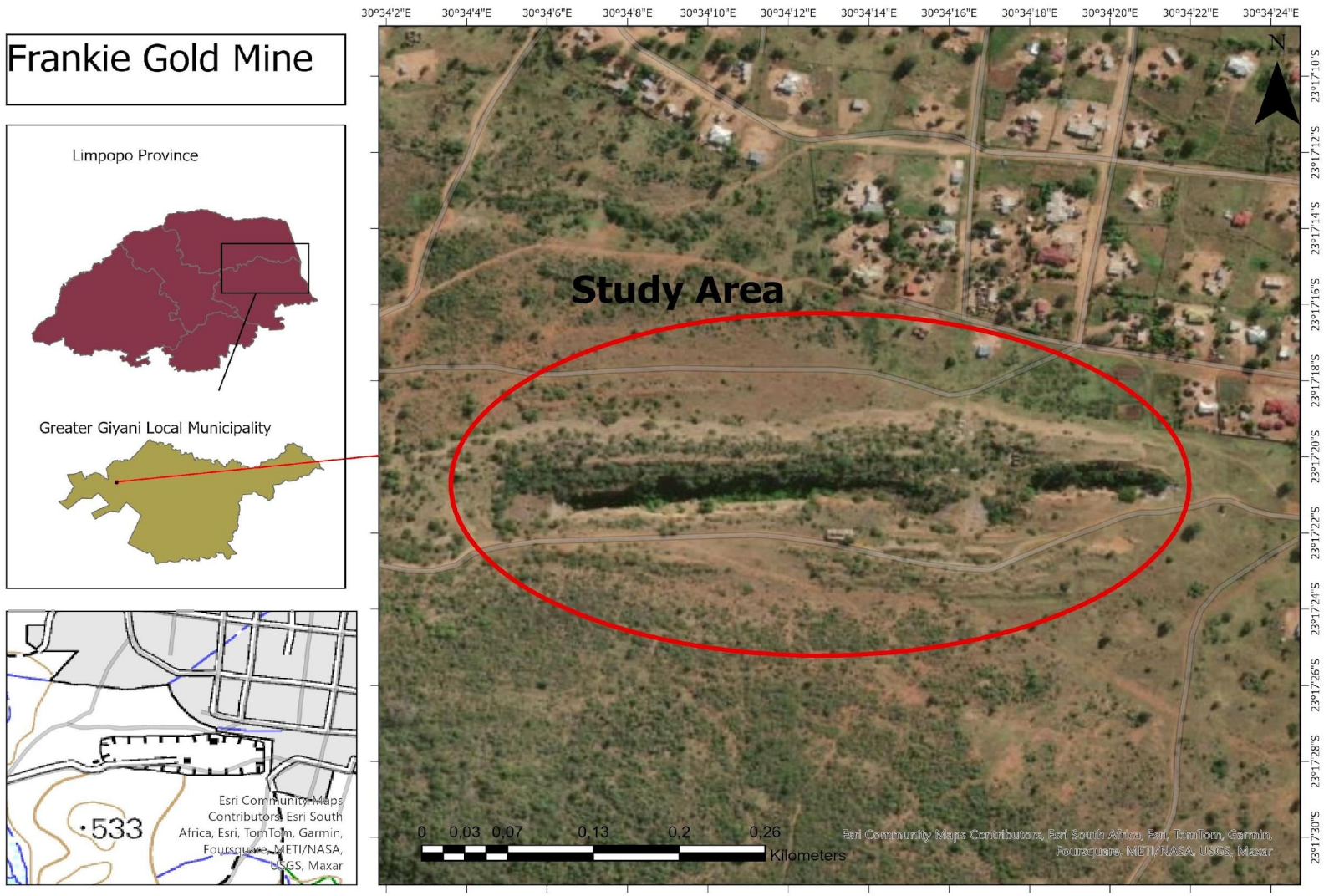
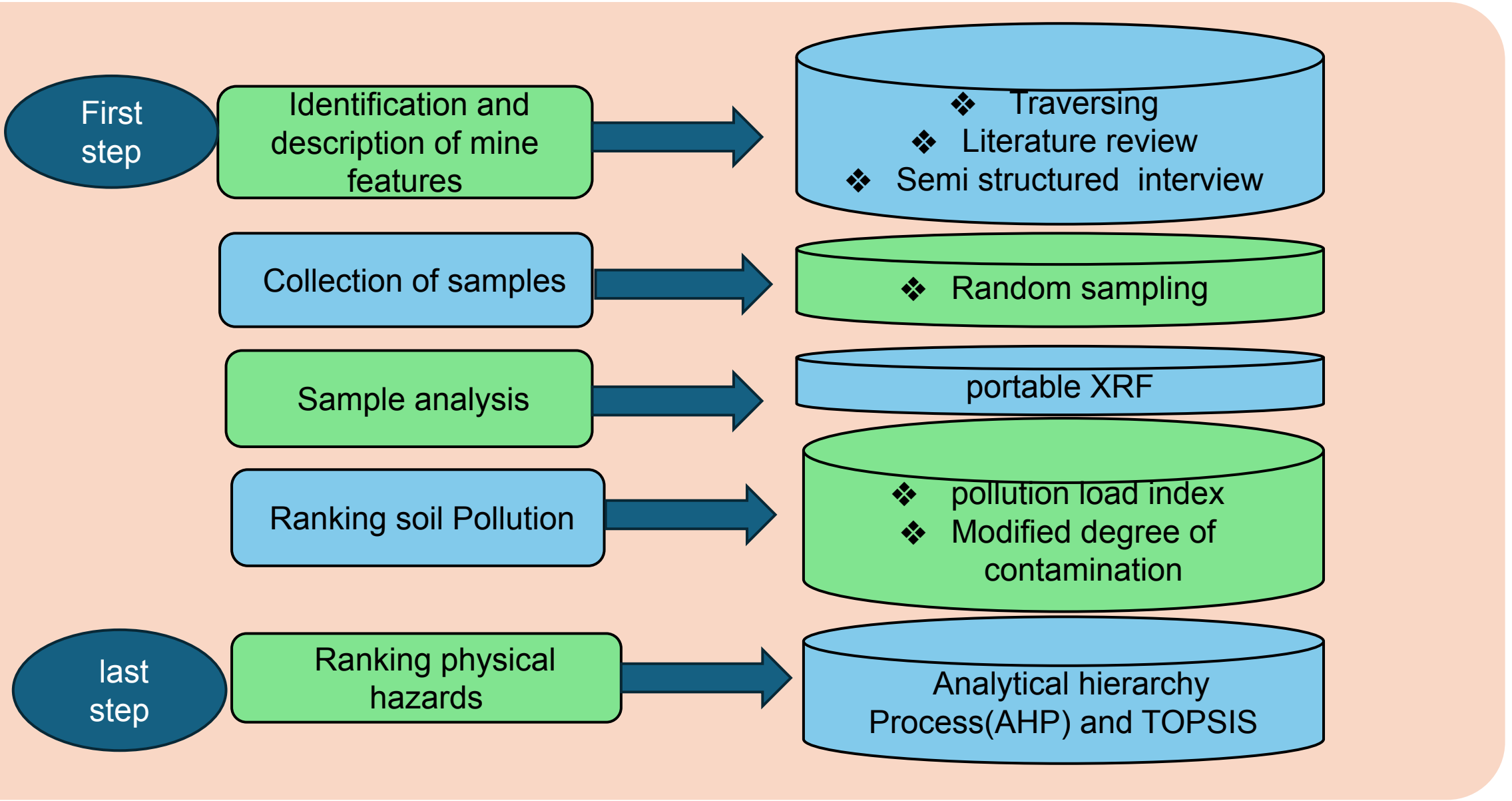


Figure 1 Locality map of Franke mine

- Found at Ka Mapuve Village in Limpopo.
- A gold mine characterized by deep excavations.
- 23º17’20”S; 30º 34’9” E

Study Approach



Soil pollution ranking using pollution indices

- Contamination factor for each heavy metal

$$\mathbf{Cf} = \frac{C}{P}$$

- Pollution load index

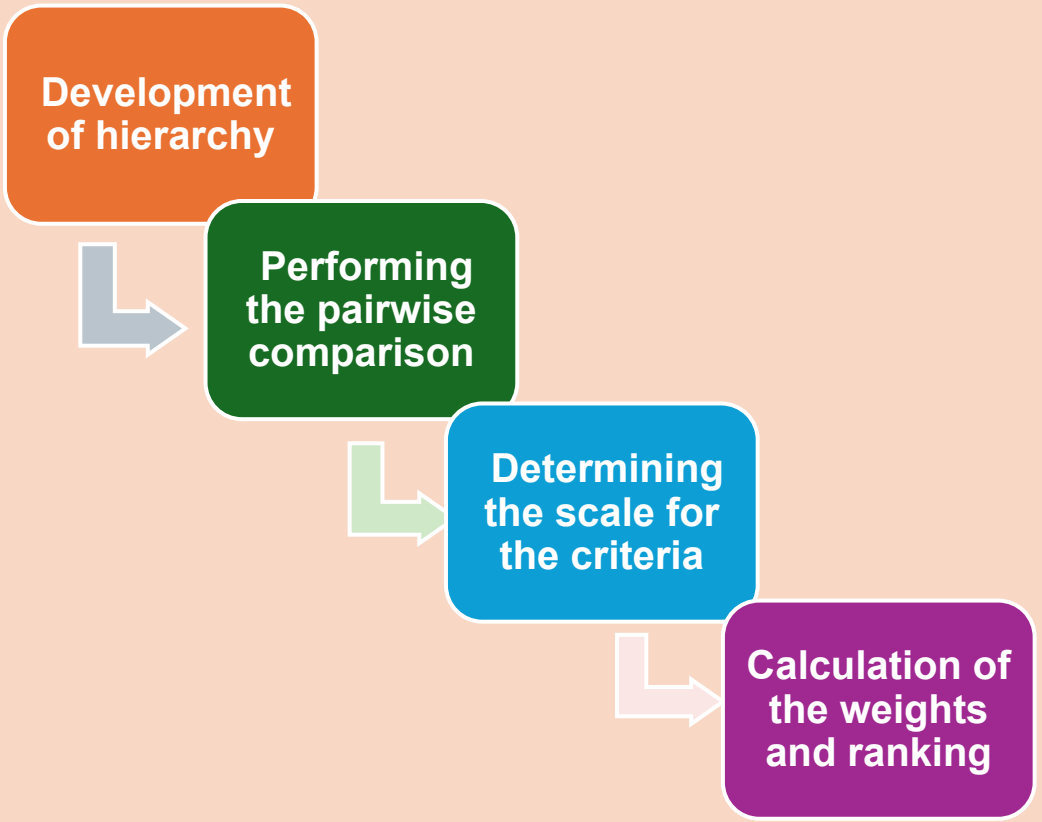
$$\mathbf{PLI} = (Cf1 \times Cf2 \ldots Cfn)^{(1/n)}$$

- Modified degree of contamination

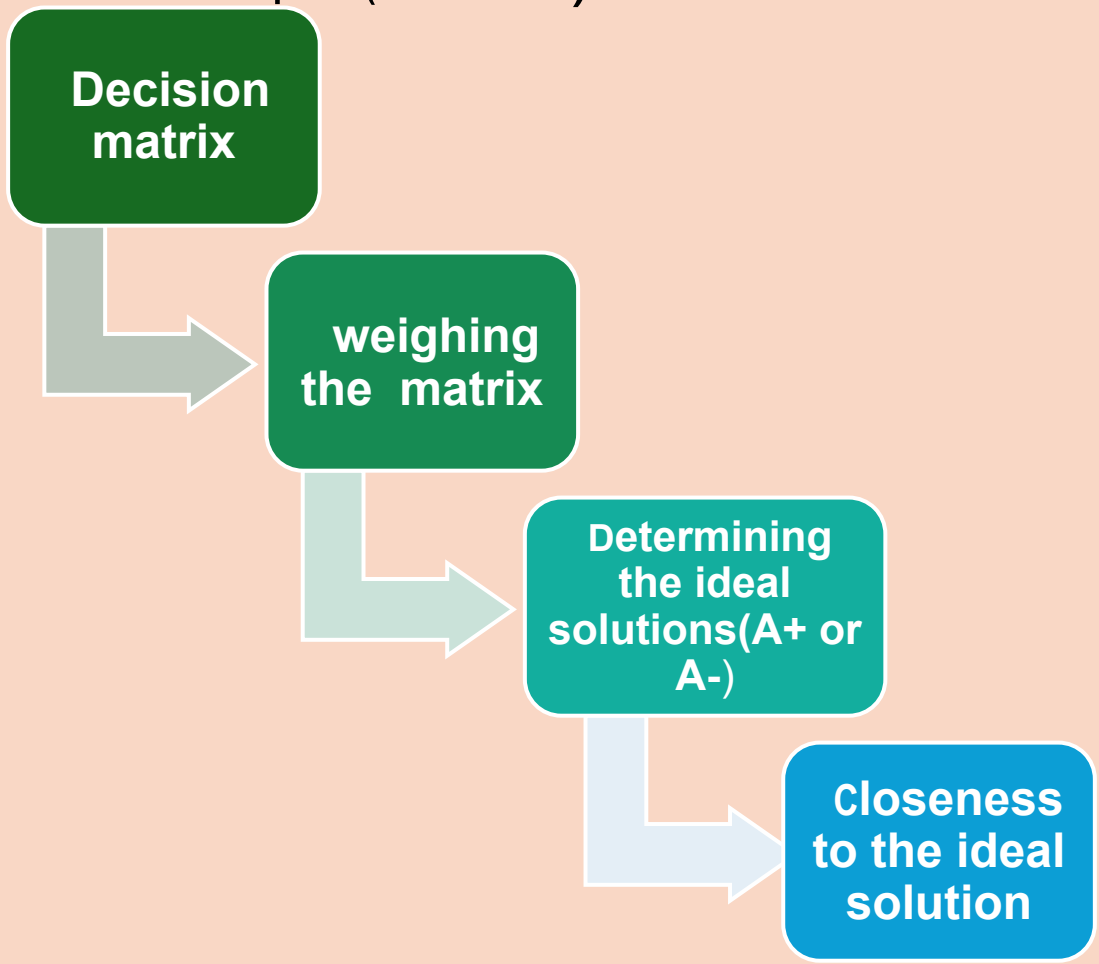
$$mCd = \frac{Cd}{n}$$

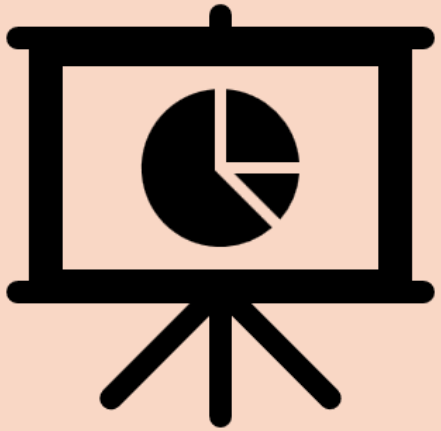
Physical hazards ranking using AHP and TOPSIS

- Super decision software (AHP)



- Online-output (TOPSIS)





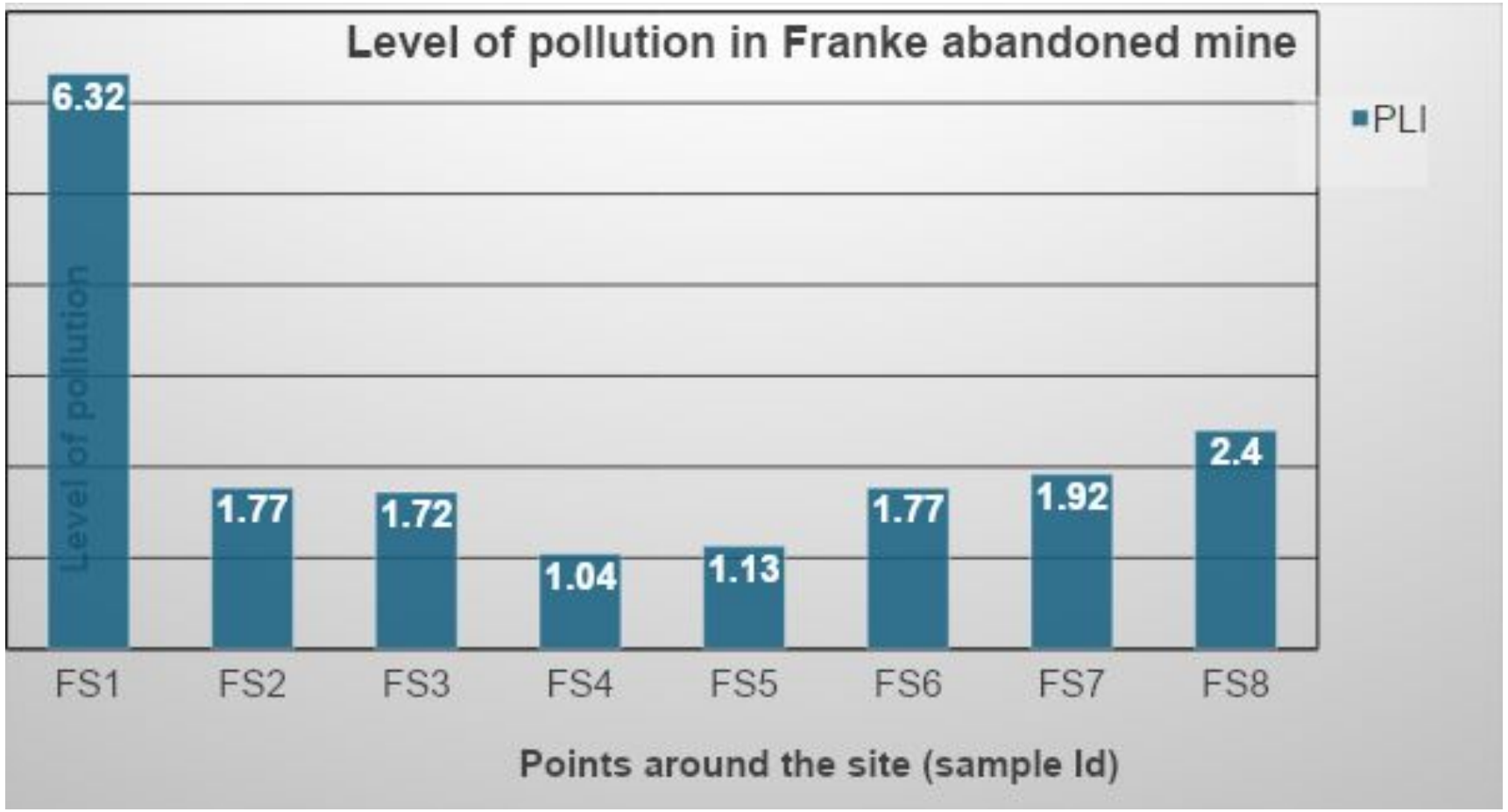
RESULTS AND DISCUSSION

Contamination factor

ID	Pb	Ni	Co	Cd	As	Zn	Cu	Cr
fS1	0,875	280	0,129	1,666	1,777	0,45	65,265	924
fS2	0,533	3,344	0,328	0,666	9,195	0,39	8,604	8,072
fS3	0,733	2,564	0,016	0,666	3,160	0,532	11,00	9,652
fS4	0,833	1,930	0,016	0,667	5,632	0,363	5,290	5,971
FS5	0,800	2,945	0,016	0,667	5,229	0,392	5,290	12,101
FS6	0,417	2,703	0,016	0,667	5,287	0,167	3,479	20,080
FS7	15,133	4,611	0,016	0,667	11,379	0,275	3,196	20,072
FS8	9,850	4,513	0,016	0,449	11,839	0,286	4,208	19,123

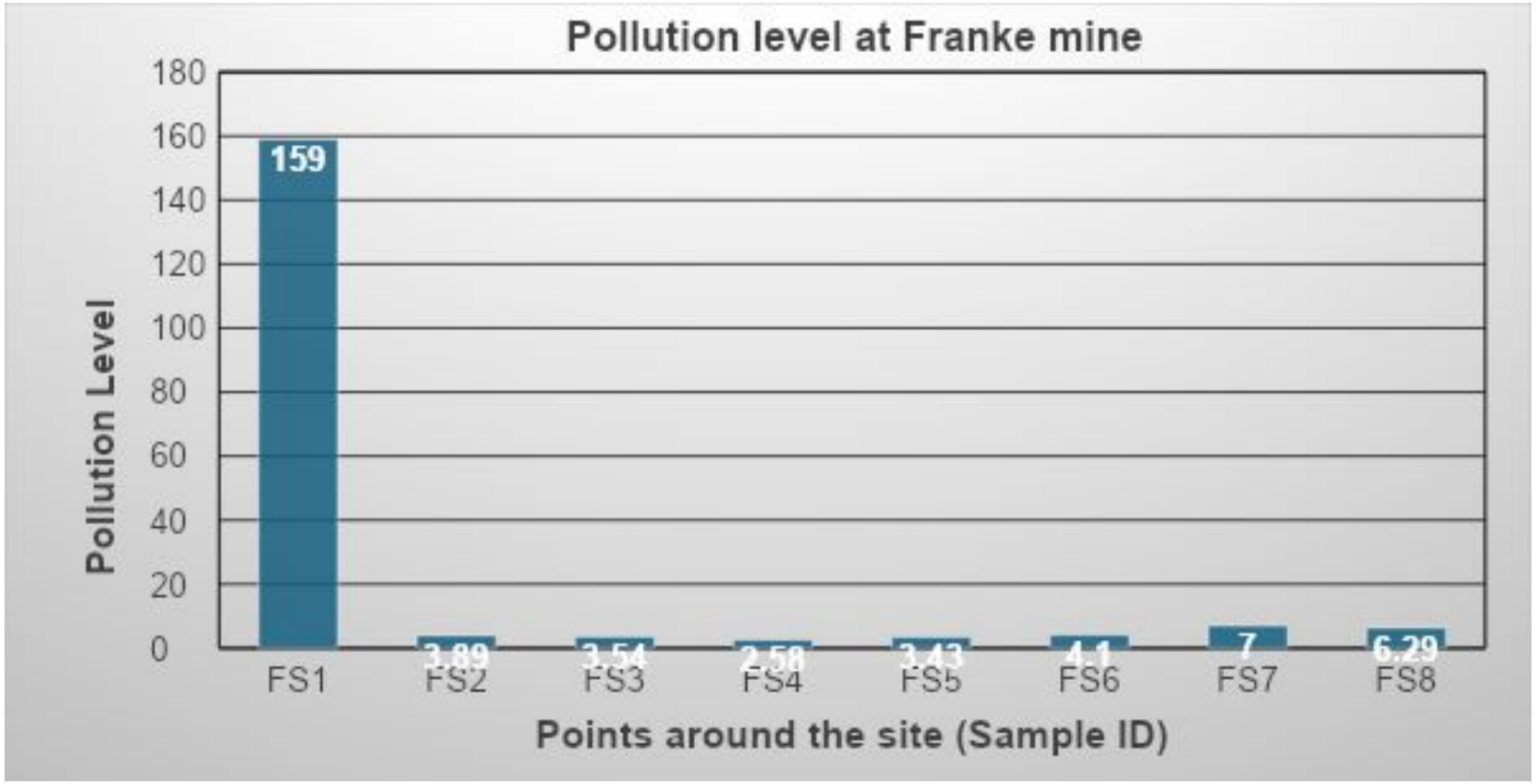
- 1<CF<3 moderate
- 3<CF<6 high
- Cf>6 very high

Pollution Level of a site per point (PLI)



- Pollution >1 mean the site is contaminated.
- The site is contaminated (low level of contamination – high level contamination).

Pollution Level (MCD)



- All the sampling points suggests moderate to extremely high contamination.

Physical features

1

2

3

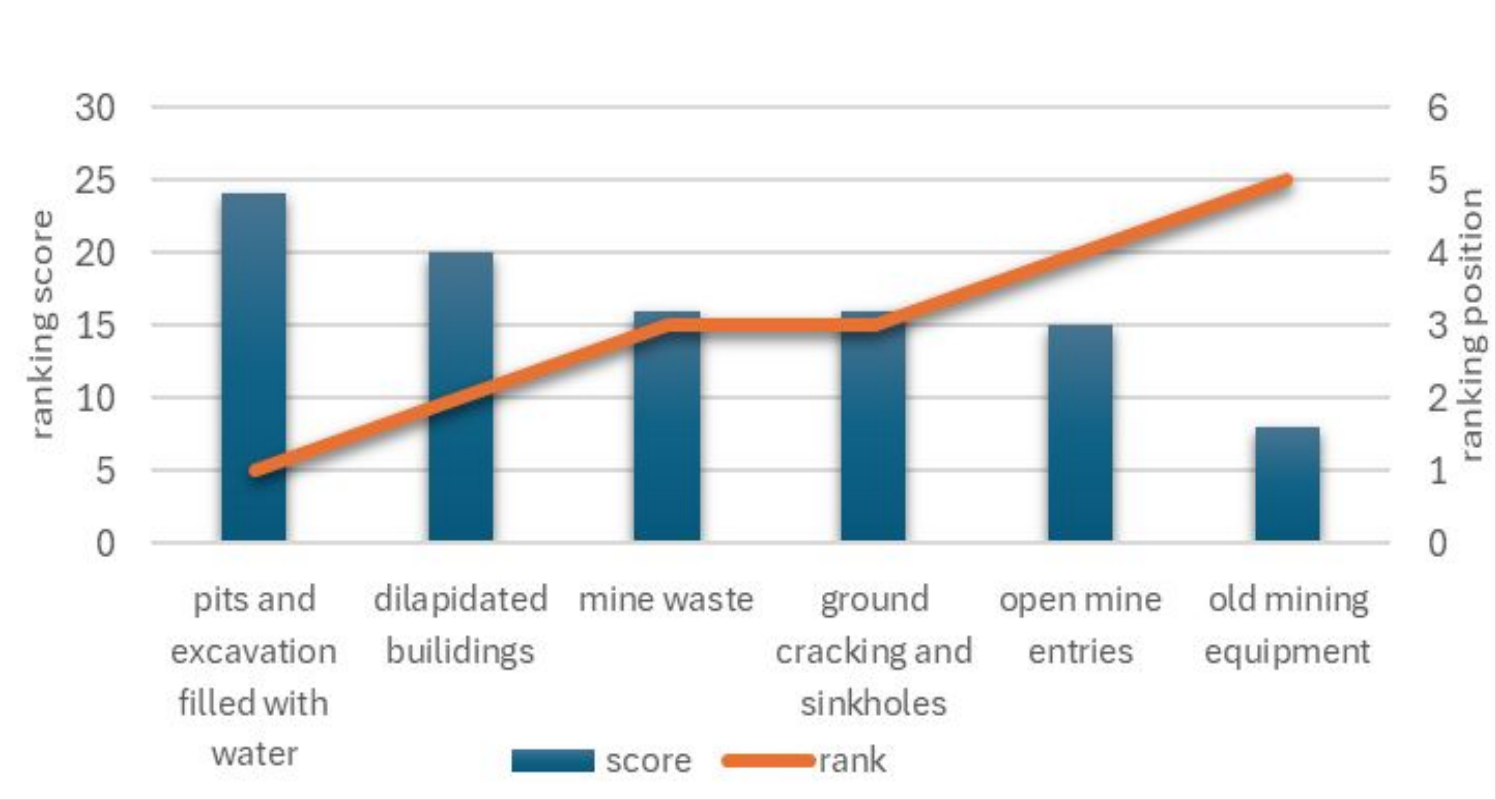
4

Ranking of physical hazards using AHP

❖ Results after synthesing the model.

Features	Ideals	Normals	Raw
Dilapidated buildings	0.839837	0.201190	0.201190
Ground cracking and sinkholes	0.682610	0.163525	0.163525
Mine wastes	0.682610	0.163525	0.163525
Old mining equipment	0.344113	0.082435	0.082435
Open mine entries	0.625177	0.149766	0.149767
Pits and excavation filled with water	1.000000	0.239558	0.239559

Ranking of physical hazards using AHP

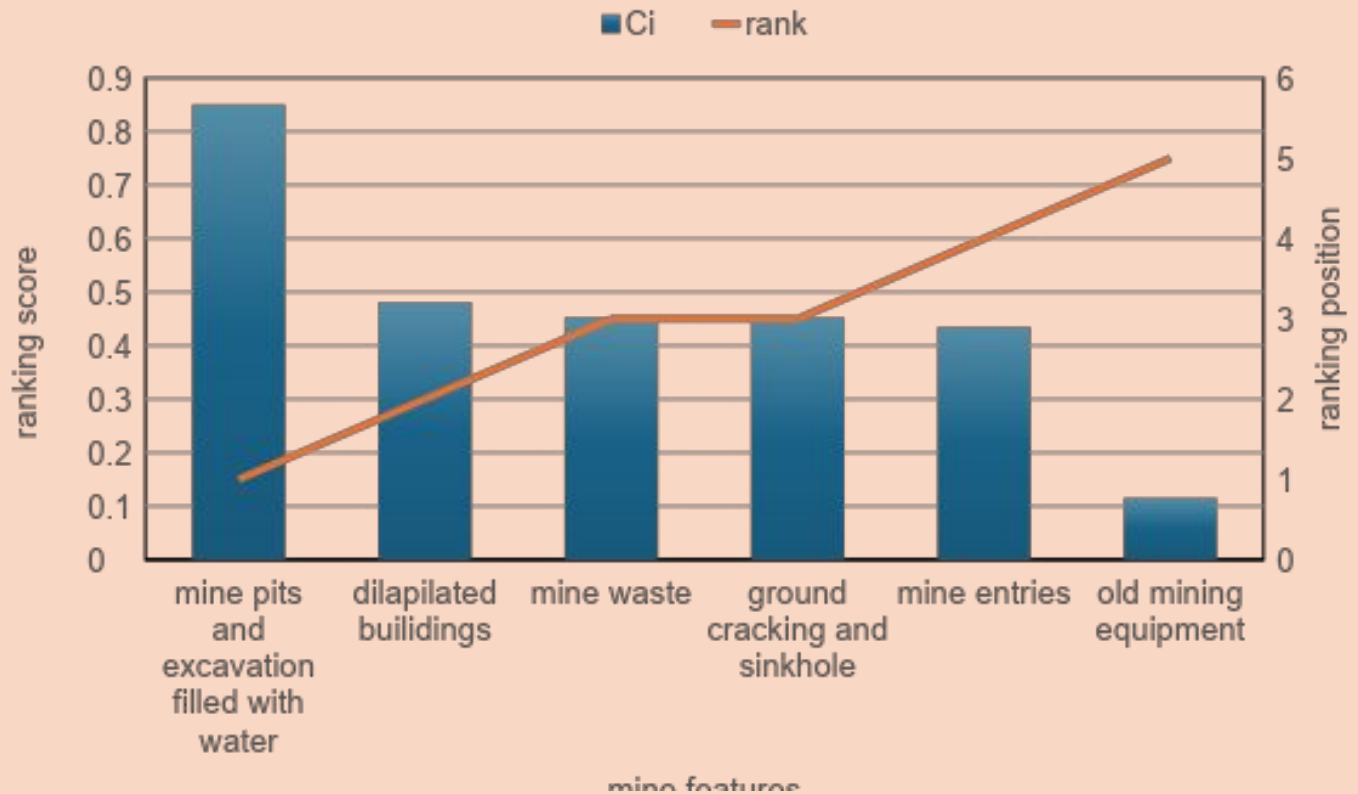


- pits and excavation filled with water is ranked number 1 hazard.

Closeness to the ideal solution

Features	Distance to ideal solution	Distance to ideal negative solution
dilapidated building	0,109	0,101
ground cracking and sinkhole	0,112	0,093
mine waste	0,112	0,093
old mining equipment	0,145	0,019
mine entries	0,118	0,091
mine pits and excavation filled with water	0,025	0,144

Ranking of the hazards using Topsis



- Based on the ideal positive solution mine pits and excavation were still ranked number one.
- Although they use different algorithms , if the parameters are not changed the results are likely to remain the same.

Conclusion

- For accuracy and best judgement, it is crucial to use two different approaches.
- Difference in contamination factor for each metal per point has to be taken into consideration when repurposing.
- Both Topsis and AHP can be applied in quantifying problems of abandoned mines.

THANK YOU!

WITS MINING INSTITUTE

MANDELA MINING PRECINCT
MINDS FOR MINES

WITS UNIVERSITY

100 1922 2022

Appendix

Parameter	Units	SSV1 All Land-Uses Protective of the Water Resource	SSV2 Informal Residential	SSV2 Standard Residential	SSV2 Commercial/ Industrial	Protection of Ecosystem Health
Metals and metalloids						
Arsenic	mg/kg	5.8	23	47	150	580
Cadmium	mg/kg	7.5	15	32	260	37
Chromium (III)	mg/kg	46,000	46,000	96,000	790,000	n/a
Chromium (VI)	mg/kg	6.5	6.5	13	40	260
Cobalt	mg/kg	300	300	630	5,000	22,000
Copper	mg/kg	16	1,100	2,300	19,000	16
Lead	mg/kg	20	110	230	1,900	100
Manganese	mg/kg	740	740	1,500	12,000	36,000
Mercury	mg/kg	1.0	1.0	1.0	6.5	4.1
Nickel	mg/kg	91	620	1,200	10,000	1,400
Vanadium	mg/kg	150	150	320	2,600	-
Zinc	mg/kg	240	9,200	19,000	150,000	240

Department of Environmental Affairs (2013)