THE USE OF MULTI-CRITERIA ANALYSIS IN THE EXTRACTIVE INDUSTRY

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Abstract

Multi-criteria decision analysis is an approach that provides for the systematic evaluation of project alternatives. Golder Associates have developed a multi-criteria decision analysis tool, GoldSET that allows for the unbiased comparison of quarry closure options based on the principals not only of technical risk but also sustainability. The approach benefits from the use of both qualitative and quantitative indicators from not only economic aspects, but also from social and environmental aspects. This approach can help identify optimal solutions in a decision making process based on the principals of sustainable development. The resulting triple bottom line evaluation enhances more traditional analytical frameworks where economic, environmental, social and technical factors are looked at in isolation. The aspects can be weighted according to importance and the results while numeric are summarised and communicated graphically facilitating communication with stakeholders. The methodology clearly illustrates the strengths and weaknesses of each option under evaluation and as such provides a transparent framework for stakeholder engagement and business decisions. This paper will describe the methodology behind multi-criteria decision analysis in order to screen development scenarios in the extractive industry.

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Introduction

Developed by Golder Associates, the Golder Sustainability Evaluation Tool 'GoldSET'© (Copyright 2014 to Golder Associates Limited. All rights reserved) (Golder Associates, 2014) is a decision-support system developed to perform multi-criteria analysis while accounting for technical and non-technical considerations. Originally developed in 2007 to investigate sustainability issues involved with environmental remediation projects, the tool is now used to support decision analysis in a context where environmental protection, social acceptability, technical performance and financial rigour are key to securing project success. The approach can be applied throughout a project's lifecycle, especially during planning and design.

Used across various sectors such as extractive industries, oil and gas exploration and extraction, transportation schemes and manufacturing, GoldSET is regularly tailored to project specificities to support the decision making-process for developments including extractive scheme plans, earthworks, quarry closure and restoration, remediation, wastewater treatment, water supply management, mining waste management, municipal waste planning, corridor routing, biodiversity offset designs, etc. The multi-criteria decision analysis (MCDA) approach was selected as the basis for GoldSET because of its versatility in evaluating alternatives based on a broad range of decision criteria and stakeholder perspectives.

Methodology And Use Within The Extractive Industries

If for example for a quarry restoration scheme multiple options are available and require internal review, or, the Mineral Planning Authority or local stakeholders have identified an alternative scheme approach to that proposed, this multi-criteria analysis approach will allow the environmental, social, economic and technical aspects of each scheme to be scored, weighted and collated for un-biased comparison. A summary of potential indicators that could be compared within an analysis for each of the key aspects is shown in Figure 1.

The scoring of each environmental, social, economic and technical indicator, for each activity in a scheme can take the form of a quantitative or qualitative assessment. Quantitative indicators that can be measured include but are not limited to financial development cost, estimated surface area of affected watershed or distance from residences. An example of this quantitative scoring when comparing a number of potential extractive sites is presented in Figure 2.

For aspects of a scheme that cannot be measured, an interpretation based on a binary outcome or on a stakeholder survey can also be made; for example relating to the presence of a particular sensitive habitat or receptor. These qualitative scorings are made relative to a maximum score of 100 and hence would not require

Environmental

- Value of biodiversity offsetting and habitat creation
- Flood risk
- Surface area of affected watershed
- Waste management
- Pollution risk

Social

- Local requirement for employment, development land, access land….
- Corporate image
- Public safety
- Worker safety

Economics

- Option's development cost
- NPV of long term liability costs
- NPV of long term revenue
- Cost of sterilisation of mineral
- Mothballing costs
- Re-opening costs

Technical

- Project duration
- Standards, laws and regulations
- Precedent for methodology
- Likelihood of receiving planning permission

Figure 1. *Potential quantitative and qualitative indicators used to screen development options. (NPV: Net Present Value)*

Environmental Aspect

Code	Indicator	Units	Site A	Site B	Site D	Site E	Site F
ENV-1	Surface area of the affected watershed	Square kilometre	22	1.5	13	2.3	7.4
ENV-4	Actual distance from water body (stream or lake)	Metre	402	0	1632	532	1432
ENV-6	Stream crossing by the road/pipeline	Number of crossings	5	2	7	1	1
ENV-8	Presence of downstream fish habitat	Metre	402	0	1	750	1300
ENV-10	Presence of wetlands on the site	Square metre	157065	26547	298760	93026	73879
ENV-11	Presence of downstream wetlands	Metre	0	300	0	0	0
ENV-13	Distance from a natural park or protected habitat	Metre	2145	4970	1650	4530	5860
ENV-16	Length of the road or pipeline (footprint)	Kilometre	8.4	2	11.4	5.7	4.9

Social Aspect

Code	Indicator	Units	Site A	Site B	Site D	Site E	Site F
SOC-3	Distance from a permanent or seasonal residence	Kilometre	2.3	1.6	1.2	0	0.7

Economic Aspect

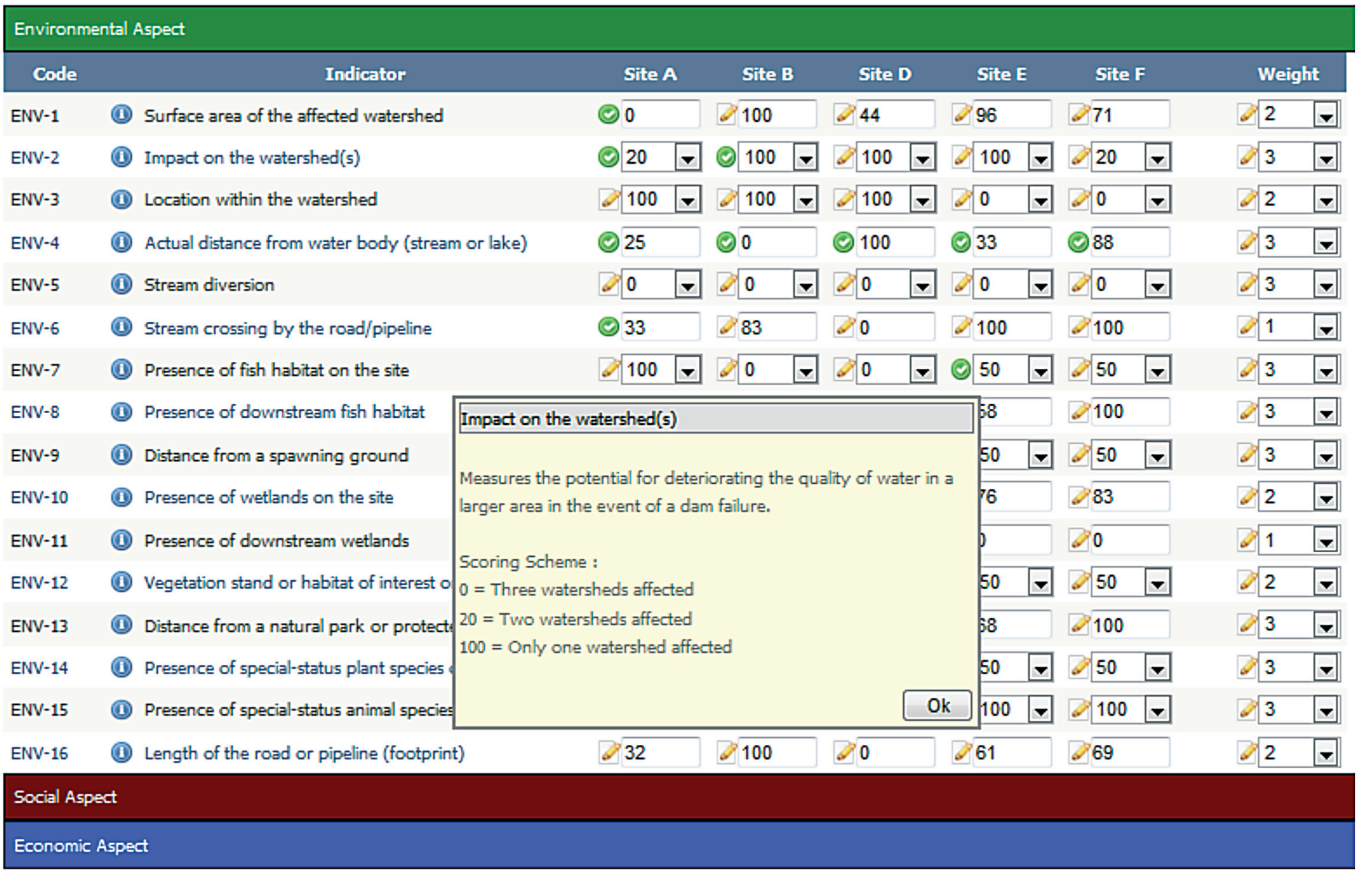
Code	Indicator	Units	Site A	Site B	Site D	Site E	Site F
ECONO-1	Claims	Percentage	75	90	0	0	0
ECONO-2	Dam volume	Cubic metre	4634000	5894000	5345000	2987000	4897000
ECONO-3	Length of grouted dam	Metre	4670	2100	3675	3053	2380
ECONO-4	Dam height	Metre	32	67	41	39	59
ECONO-5	Site surface area (liner, cover)	Square kilometre	3.5	0.98	1.54	1.41	1.79
ECONO-8	Max. difference in elevation between concentrator	Metre	203	65	173	25	35
ECONO-9	Pipeline length or hauling distance	Kilometre	12.4	4.3	15.7	6.8	4.1
ECONO-12	Site accessibility	Kilometre	6.7	2	11.4	6.3	4.7

Figure 2. *Quantitative scoring of environmental, social, economic and technical aspects for each activity in a scheme.*

subsequent normalisation. An example of qualitative scoring is presented in Figure 3. The figure also shows that at this stage the quantitative interpretation is normalised within a 0 to 100 scale to enable direct comparison between each contributing parameter. Subsequent to normalisation all of the indicators are allocated a weighting to identify their relative significance.

The scoring and the weighting that is defined throughout the project can be agreed by a committee of stakeholders with agreement that the outcome of the multi-criteria analysis is a reflection of the overall impact of the scheme. The highest scoring scheme is as such the most balanced compromise available.

The software provides an intuitive visual representation of results to support transparent decision making as presented on Figure 4.



Code	Indicator	Site A	Site B	Site D	Site E	Site F	Weight
ENV-1	Surface area of the affected watershed	0	100	44	96	71	2
ENV-2	Impact on the watershed(s)	20	100	100	100	20	3
ENV-3	Location within the watershed	100	100	100	0	0	2
ENV-4	Actual distance from water body (stream or lake)	25	0	100	33	88	3
ENV-5	Stream diversion	0	0	0	0	0	3
ENV-6	Stream crossing by the road/pipeline	33	83	0	100	100	1
ENV-7	Presence of fish habitat on the site	100	0	0	50	50	3
ENV-8	Presence of downstream fish habitat				58	100	3
ENV-9	Distance from a spawning ground				50	50	3
ENV-10	Presence of wetlands on the site				76	83	2
ENV-11	Presence of downstream wetlands				0	0	1
ENV-12	Vegetation stand or habitat of interest o				50	50	2
ENV-13	Distance from a natural park or protecte				68	100	3
ENV-14	Presence of special-status plant species				50	50	3
ENV-15	Presence of special-status animal specie				100	100	3
ENV-16	Length of the road or pipeline (footprint)	32	100	0	61	69	2

Figure 3. *Qualitative scoring of environmental, social, economic and technical aspects for each activity in a scheme.*

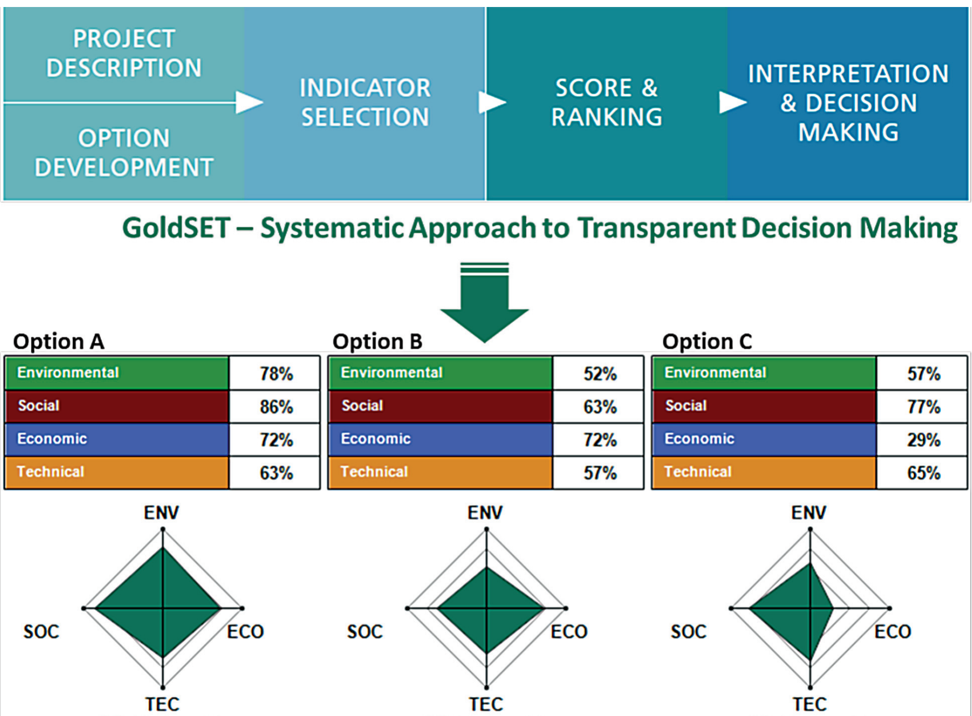


Figure 4. *The GoldSET methodology and graphical results for three options under consideration.*

Although the largest coloured diamond in the graphical representation of GoldSET results is not an absolute criterion for selecting a preferred option, it facilitates discussion on the sensitive issues and trade-offs, leading to more effective decision making. Furthermore, through the intuitive graphics, the software can also be used to support communication among various stakeholders. The framework facilitates communication on the key impacts, benefits, and drawbacks of different alternatives, and provides traceability and transparency throughout the decision-making process.

The approach can be used as an opportunity to seek buy in from extractive industry stakeholders and to incorporate their concerns within a transparent weighting system. From an industry perspective the approach can also consider safety, economics of mineral extraction and environmental risks.

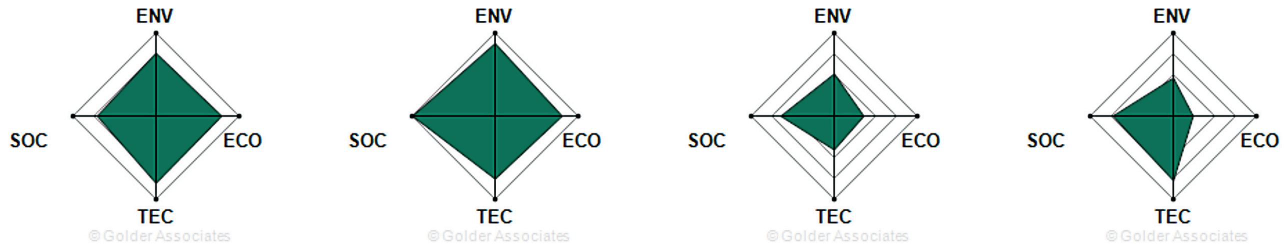
Case Study: Examples Of Assessment Outcomes

In the following two case studies; relating to an open pit restoration and for dewatering water management options, the outcome of the screening and scoring process is presented. Each approach considered quantitative and qualitative indicators screened in relation to environmental, social, economic and technical aspects of the project. The outcome of the screening, scoring, normalisation and weighting of each indicator is presented in Figure 5.

The outcome of the assessment for the open pit restoration case study is clear - that the second scenario presents the largest diamond and hence is the preferred option in terms of environmental, social and economic factors. The technical deliverability of the project was broadly comparable for scenarios 1, 2 and 4.

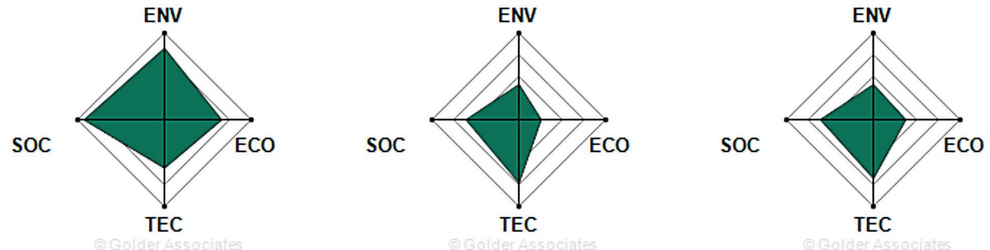
For the outcome of the water management case study scenario 1 has the largest diamond indicating that on balance this approach would be the preferred option in terms of environmental, social and economic factors. In this case however the technical scoring was much lower than for the other scenarios, because the approach was new and untested in this application. Given the risks to successful delivery of scenario 1 in this situation, the final agreed scheme combined scenarios 1 and 2. Commencing the water management scheme with scenario 2 safeguarded the project delivery and enabled the creation of a pilot scheme for scenario 1 to test the approach in advance of moving the management from scenario 2 to scenario 1 later in the project lifecycle.

Environmental	76%	Environmental	87%	Environmental	50%	Environmental	45%
Social	70%	Social	99%	Social	64%	Social	73%
Economic	79%	Economic	80%	Economic	35%	Economic	24%
Technical	81%	Technical	75%	Technical	40%	Technical	78%



Open Pit Restoration Case Study

Environmental	83%	Environmental	40%	Environmental	40%
Social	93%	Social	60%	Social	60%
Economic	65%	Economic	26%	Economic	38%
Technical	55%	Technical	73%	Technical	67%



Water Management Case Study

Figure 5. *Outcome of GoldSET assessments for example projects.*

Case Study: Biodiversity Offsetting

There are instances where an operator may consider offsetting the environmental impacts of a proposed development. In this situation different offsetting schemes can be compared to identify the benefit afforded by offsetting and to compare them against the impacts of the development.

In comparing offsetting schemes the following factors are considered:

- Ecological equivalency of offset and impact zones;
- Vulnerability of the offset site to future degradation/loss;
- Possibility of displacement of activities harmful to biodiversity elsewhere;
- Cumulative biodiversity gains compared with the predicted trajectory with no action;
- Feasibility of adding future offsets to site;
- Congruence with regional conservation goals;
- Buffering/connectivity enhancement potential;
- 'Offset efficiency'. Ratio of impact footprint to No-Net-Loss (NNL) offset area;
- Offset mechanism (=averted loss / condition gain) failure risk;
- Feasibility of fall-back offset methods;
- Likely speed of attaining targets;
- Complexity of offset design / implementation / evaluation;
- Can gains last at as long as the project impacts?

A biodiversity offsetting scheme was assessed to consider a NNL biodiversity offset for the ecological impacts of a mine in New Zealand in accordance with the Business and Biodiversity Offsets Programme (BBOP) framework.

To assist in determining the optimal biodiversity offset for the mine, a socio-ecological mitigation evaluation module within GoldSET was developed. This consisted of developing specific indicators for assessing the ecological values, social acceptance and economic implications of several potential offset mechanisms and site options. Then, in consultation with the mine developer and project stakeholders, a transparent comparative evaluation was undertaken to identify the most balanced compromise.

The output was a defensible evaluation of the site that provided the most appropriate ecological mitigation that was also most socially acceptable and economically efficient. The results of the GoldSET evaluation aligned well with both client and stakeholder expectations and the indicator scoring process was found to be a very effective way of creating social capital with stakeholders.

Conclusions

The use of GoldSET as a decision making tool provides the UK extractive industry a transparent platform between the developer and the stakeholders in which the options for development can be outlined. By using a normalised and weighted scoring approach the approach is collaborative and can include sensitivity analysis in order to address stakeholder concerns regarding the significance of a certain aspect of a project. The approach supports consistency in decision making throughout a project development.

In terms of the relevance to the UK extractive industry, the applications for multi-criteria analysis are broad. At project inception stage for an application for a new quarry the screening of alternative locations using a qualitative tool can assist in gaining a positive dialogue with Planning Authorities and local stakeholders in moving on to the next stages. The approach has the capability to formally screen alternative site operating methods, restoration schemes or technologies that are difficult to compare on like for like terms. This has particular advantages when comparing different views to those preferred by the Mineral Planning Agency, Environment Agency or local stakeholders.

In terms of transparency and gaining trust with stakeholders the tool is a valuable project risk management tool, especially in the context of maintaining detailed defensible records of all decisions made during a projects development.

References

Golder Associates (2014) GoldSET website, https://golder.goldset.com/portal/default.aspx last accessed 07.07.2016.