SUSTAINABLE DEVELOPMENT MODEL OF GEO-ENVIRONMENTAL ENGINEERING: SPECIAL REGARDS TO GOLD MINING PROJECT

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ABSTRACT

The exploration, extraction and processing of mineral resources are environmentally and socially disruptive and mining clearly depletes the planet's limited stock of natural resources. The cultural, environmental, financial, global, and legal implications of mineral supply are driving significant changes in the industry. Mining is the foundation industry, i.e., one which provides the critical materials on which all global development and human progress is based resources. These factors contribute to a view by some that mining is a challenged industry. In addition, the socio-cultural dimensions of mineral supply in the 21st century are making the supply process increasingly complex. The scope of the Paper is mainly on the state of environmental problems in Kyaukpahtoe Gold Mine Project and adaptation of international environmental management measures into state owned mines and artisanal mining activities. Although it sounds better and more valuable to conduct a wide range research on major gold producing areas throughout the country in Myanmar, the present research would only examine the most well known Kyaukpahtoe Gold Mine Project. The problems were checked in the field by using Initial Environmental Examination (IEE) Checklist. The problem assessments were also based on legally released data from the mines, visual inspection, some formal requests and informal conversations with local people and miners. New technologies and expensive modern equipment of analyzing physical, chemical, biological and socio-economic environment could not be applied due to research funding and time constraints. Moreover, this research was carried out on individual scale and consequently, could not be a perfect or complete one. In practice, assessments are usually conducted by many experts

INTRODUCTION

This Paper is to present an environmental assessment model by adapting geographic information analysis and it's intended to partially discharge the functions of the National Environment Policy by conducting Initial Environmental Examination (IEE) individually on mining development projects. IEE on Kyaukpahtoe Gold Mine Project was made personally and demonstratively, the results of which can be beneficial and applicable to any industrial project. and then, Basic Concept of Modelling of Geographic Information System (GIS) and Logical Sequence of Environmental Development Program were applied in the Environmental Assessment Model.

OBJECTIVES

The objectives of the paper is mainly to alert the responsible personnel and miners about the environmental degradation by gold extraction. Then, based on the available data, equipment and knowledge, it tries to initiate and accelerate the practice of Initial Environmental Examination (IEE) in Myanmar mines. This research attempts to set up certain environmental control or management plan for Myanmar mines by analyzing those of world standard mines.

DEVELOPMENT OF THE ENVIRONMENTAL ASSESSMENT MODEL

In this model, Modelling of Analysis of Geographic Information for Environmental Problems of Kyaukpahtoe Gold Mine Project have been writtened and The development of Environmental assessment model based on the collected data from Kyaukpahtoe Gold Mine Project is outlined below.

Collection of Public Opinions

For impact assessment, no direct measurement could be made. The assessment was based on visual checks, opinions, and experiences of some people. In conducting this research, some questionnaires were used to illicit opinions, information from a number of people, grouped into three levels. The levels were ranked on the basis of education, experiences and reliability. Numbers of level were described into three groups as follow:

(1) High Expert Level (Level. 1)

(2) Medium Expert Level (Level. 2)

(3) Low Expert Level (Level. 3)

To collect Environmental Information of Kyaukpahtoe Gold Mine Project Area, opinions in each level are shown in Table 1.1

Table 1.1. Description of Levels and Opinions in development program

Level	Opinion
High Expert Level (Level. 1)	Assistant Director (AD),Executive Engineer (EE) Assistant Engineer (AE)
Medium Expert Level (Level. 2)	Bachelor of Science (B.Sc), Bachelor of Art (B.A) Sub Assistant Engineer (SAE), A.G.T.I. level Labors
Low Expert Level (Level. 3)	High School Students, Middle School Students, Mine Workers and Rural Publics around the project

Assessment of the Impacts

In practice, the checklist in Table 1.2 is used to determine if a project has potential or significant environmental impacts. A team of experts or at least an expert is involved in the process.

Development of Computer Program

Depending on the number of participants, level of trust, parameters of impacts and actions affecting environmental resources, the three levels of magnitude of impacts are determined by the use of a computer programme (ALTPG). From the interview results, the degrees of impact (D_1, D_2, D_3, and D4) are determined by using a computer program. Depending on knowledge, involvement and competency, three levels of interviewees are grouped. In this program, equal weight is given to all three levels such as way as 33.3333 % for level 1, 33.3333 % for level 2 and 33.3333 % for level 3. Total weighted value is 1 for each level and for each actions.

Table (1.2) The Checklist of Environmental Parameters for Initial Environmental Examination (IEE)

Action Affecting Environmental Resources and Values	Result of Interview for Public Opinions (Number of Response Persons)			
A. Environmental Problems due to Project Location	No Significant Effect	Significant Effect		
	D1	D2	D3	D 4
1. Disruption of hydrology				
2. Resettlement				
3.Encroachment on ecology				
4.Encroachment on historical / cultural value				
5. Encroachment into forest				
6.Conflicts in water supply rights				
7. Regional flooding and drainage hazards.				
Total				
B. Environmental Problems Relating to System and Design	No Significant Effect	Significant Effect		
	D1	D2	D3	D 4
1. Liquid waste				
2. Solid waste				
3. Gas waste				
4. Mineral processing				
5. Dangerous waste				
6. Quality of Operation and Maintenance assumed in design				
7. Occupational health and safety				
8. Mine drainage				
9. Tailing				
10. Noise and Vibration				
11. Dust and other emission to air				
Total				
C. Environmental Problems during Construction Stage	No Significant Effect	Significant Effect		
	D1	D2	D3	D 4
1. Loading, Hauling problems				
2. construction silt runoff				
3. accident				
4. Continuing silt runoff from non-replanted areas				
5. Noise and Vibration				
6. Dust and Smoke				
7. Exploitation hazards				
8. Erosion of unprotected exposed areas				
9. Other construction stage hazards				
Total				

D. Environmental Problems relating to Inadequate Operations	No Significant Effect	Significant Effect		
	D1	D2	D3	D4
1.Adequacy of O&M funding				
2.Funding of occupational ealth and safety				
3.Erosion and aesthetics				
4.Pollution from spoils deposition				
5.Land use damage				
6.Inadequate operation monitoring				
Total				

E. Other potential environmental problems	No Significant Effect	Significant Effect		
	D1	D2	D3	D4
1.Trerrestrial				
2. Aquatic				
3. Land				
4. Surface water				
5. Atmosphere				
6. Health				
7. Socioeconomic				
8. Aesthetic				
Total				
F. Overall critical review criteria	No Significant Effect	Significant Effect		
	D1	D2	D3	D4
1. Loss of irreplaceable resources				
2. Accelerated use of resources for short term gain				
3. Endangering species				
4. Promoting Undesirable rural to urban migration				
5. Increase affluent				
6. Poor Income Gap				
Total				
G. Realization of feasible enhancement measures	No Significant Effect	Significant Effect		
	D1	D2	D3	D4
1. Adequacy of O&M fundings				
2. Inadequate Operation and Monitoring				
3. Socioeconomic				
Total				

In practice, there can be many more levels as needed. Similarly, more other questions relating to actions affecting on resources than used in the program can be added in actual cares. For example, although there are seven actions in stage A that can cause environmental impacts, items may need to be considered depending on the scale of the project.

The weight of importance regarding the reliability of participants in the research can also vary in practical works in such as way as 60 % for level 1, 30 % for level 2 and 10 % for level 3. In this program, equal weight is given to all three levels. In the same way, all types of actions from A to F are given the same weight of importance in this model program; in practice, are on any particular types of actions can be more significant and thus given more weight.

Basic Concept of Modelling of Geographic Information System (GIS)

The combination of human and computer based resources that results in systems that are capable of the collection, storage, retrieval, communication and analysis of spatially referenced data for the purpose of efficient management and planning of resource mobilization are called Geographic Information Systems (GIS). In this program, procedures of data analysis were described layer by layer as shown in Figure 1.1 and situation of each action affecting environmental resources and values (Actions) need to be considered layer by layer.

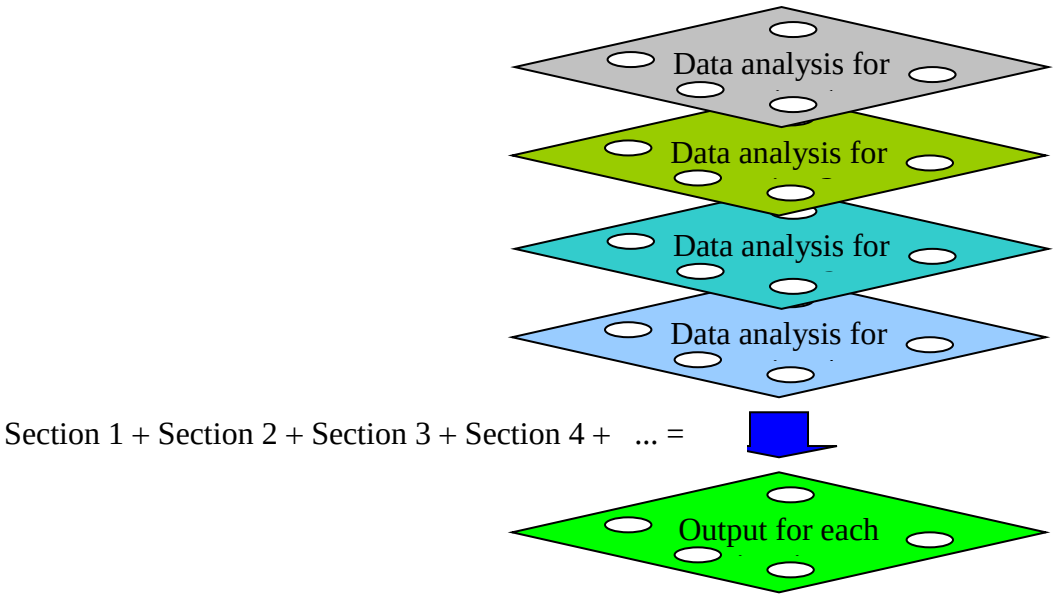

Figure 1.1 Procedure of Data Analysis

Key Components of GIS Model

In the Geographic information system for development computer program, generally, there are numbers of key components. Included factors in Geographic information system (GIS) are as follow:

(a) Digital image processing of remote sensing data	(b) Reports and publications	(c) Analog Maps
1. Geo-statistical software 2. Databases and their management 3. Table operations with spreadsheet like functions	1. Water consumption 2. Evapotranspiration 3. Rainfall 4. Stream flow 5. Groundwater 6. Water quality 7. Population 8. Livestock	1. Agro-climate 2. Agro-ecology 3. Soils 4. Admin Boundaries 5. Topography 6. Social Infrastructure 7. Economic Infrastructure 8. Land use

The Degrees of impacts (D1, D2, D3 and D4) are determined by using a computer program. To use a computer programme, users must use environmental information data and then, decision making of each section and each level should be done systematically. The program logic of GIS is adopted for determining the magnitude of impacts such as D1, D2, D3 and D4. Key components of GIS used in the program are mentioned in Figure 1.2.

Logical Sequence of Environmental Development Program

Programme of statistic analysis considered constraints, objectives, and geo spatial data. Functions in the logical sequence used in the program are shown in Figure 1.3.

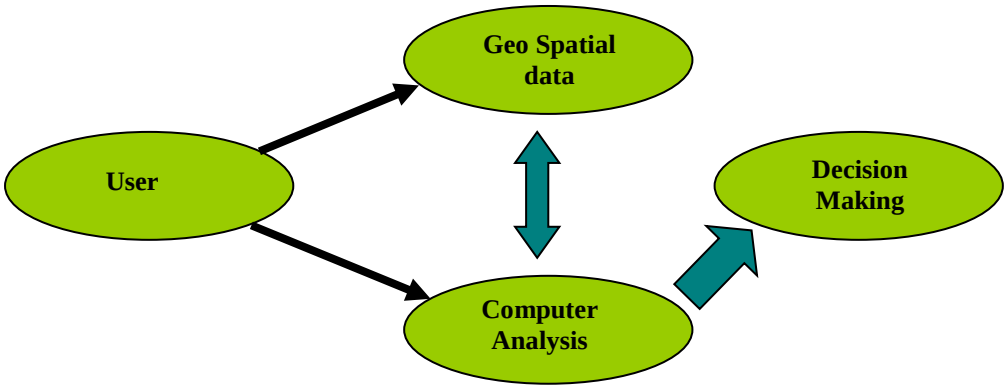

Figure 1.2 Components of GIS Model
Source: University of Moratuwa (2005)

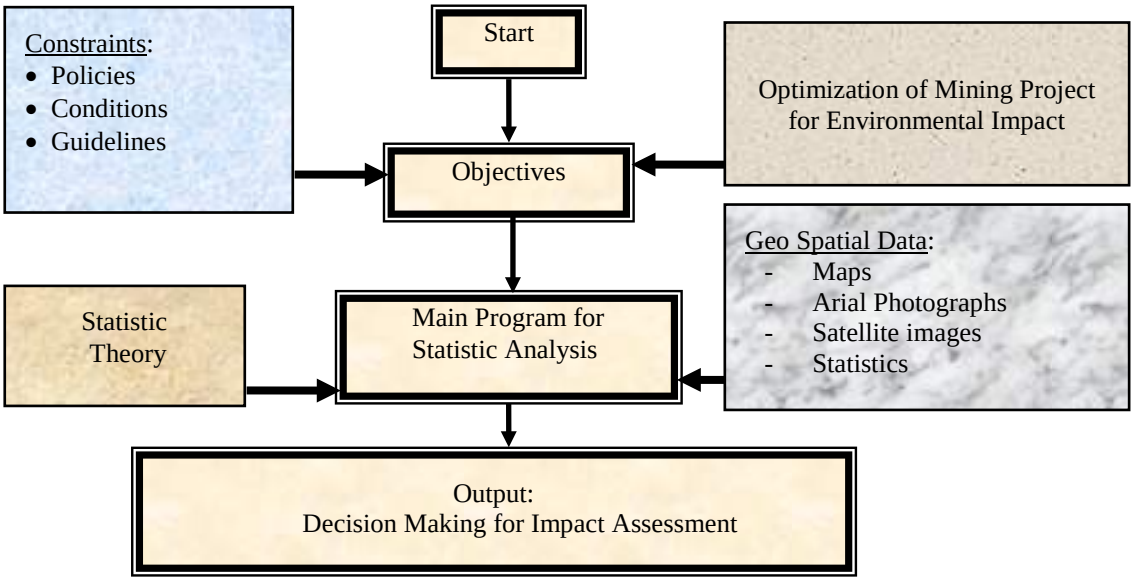

Figure 1.3 Logical Sequence of Program ALTPG for Statistic Analysis

Decision Making of Environmental Impact Assessment

Environmental Impacts Assessment for Kyaukpahtoe Gold Mine by Total Expert Level

As case study, types of actions from A to G, that can have environmental impacts by Kyaukpahtoe Gold Mine Project, are given the same weight of importance in this program and equal weight has been given to all three levels. If rating is greater than 25, it is decided that this action has significant effect and if the rating is less than 25, this action is decided not to have significant effect In Figure 1.4, the number 1 to 7 represent actions A to G affecting environmental resources and values and from 0 to 35 is referred to rating of environmental impact assessment for each action by the experts at three levels. The relationship between the numbers and the actions are as follow:

1 means action A (Environmental problems due to project location)
2 means action B (Environmental problems relating to system and design)
3 means action C (Environmental problems during construction stage)
4 means action D (Environmental problems relating to inadequate operations)
5 means action E (Other potential environmental problems)
6 means action F (Overall critical review criteria)
7 means action G (Realization of feasible enhancement measures)

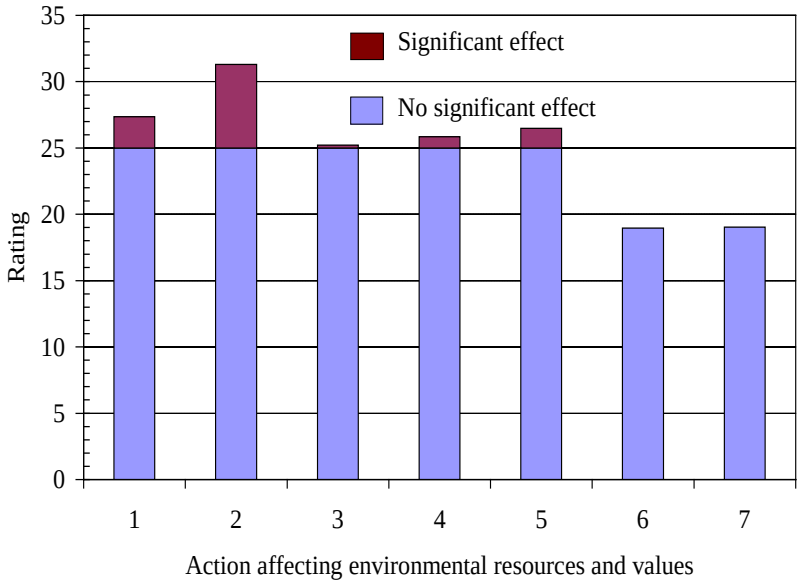

Figure1.4 Impact Assessment of each Action Affecting Environmental Resources and Values for Equal Weighted Actions and Levels

Figure 1.4 shows that the Kyaukpahote Gold Mine Project needs to improve its system of operation and some mechanical designs throughout the process in mining and metallurgical portions. To reduce the impacts likely to be caused by project location, it is recommended that the mine has to pay special attention to shrinking the tailing pond area, curbing the flows of tailing in cultivated lands and limiting the working boundary.

Variation of Impact Assessment of Environmental Development Model

Types of actions from A to G, that can have environmental impacts by Kyaukpahtoe Gold Mine Project and, are given the different weight of importance in this program and different weight has been given to all three levels. Results of Sensitivity Analysis for the Variation of Impact Assessmentof Kyaukpahtoe Gold Mine with Different Weighted Values for Actions can be various changes.

Variations of Impact Assessment with Different Weight for Actions A and B

Impact assessment rating varies depending upon the different weight for actions affecting environmental resources and values. If weighted value of the action 'A' is 0%, the rating is found to be 24.47 but weighted value for the action 'A' is 20%, the rating is 24.53. Such variations for actions A and B are shown in Table 1.3 and are described in Figure 1.5.

Figure 1.5 shows that the rating for action A does not vary very much depending on the different weighted values. But action B is found to have increase rating when the weighted values become greater. This means that action B is more sensitive and thus more important than action A. In actual case, the system and design for Kyaukpahtoe Gold Mine Project should be given more attention than the project Location.

Table 1.3. Comparison of Rating with Different Weight for Actions A and B

Variation of weighted value of action A	Rating of Action A	Variation of weighted value of action B	Rating of Action B
0.0	24.47	0.0	23.82
2.0	24.53	2.0	23.97
4.0	24.59	4.0	24.12
6.0	24.65	6.0	24.27
8.0	24.7	8.0	24.42
10.0	24.76	10.0	24.57
12.0	24.82	12.0	24.71
14.0	24.88	14.0	24.86

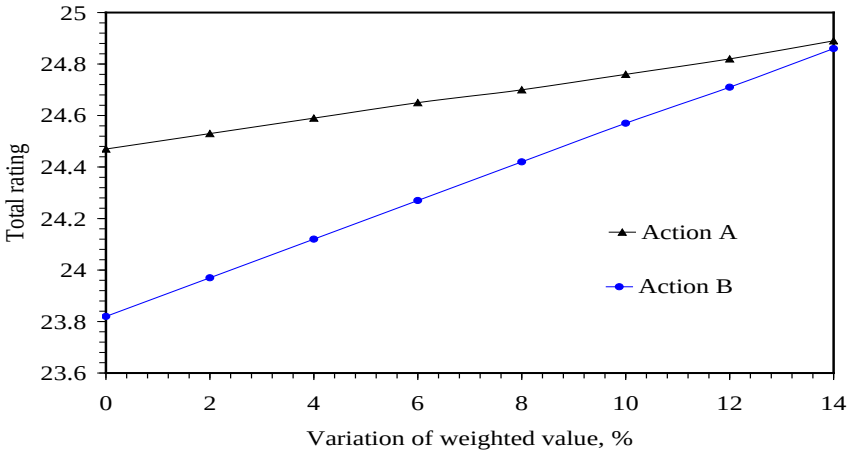

Figure 1.5. Results of Sensitivity Analysis for the Variation of Impact Assessment of Kyaukpahtoe Gold Mine with Different Weighted Values for Actions A and B

Variations of Impact Assessment with Different Weight for Actions C and D

Impact assessment rating varies depending upon the different weight of Action affecting environmental resources and values. If weighted value of the action 'C' is 0%, rating is 24.8306 and also weighted value of the action 'C' is 80%, rating is 24.8614 (see Table 1.4) and variations of impact assessment with different weight for actions C and D are shown in Figure 1.6.

Table 1.4. Comparison of Rating with Different Weight for Actions C and D

Variation of weighted value of action C	Rating of Action C	Variation of weighted value of action D	Rating of Action D
0.0	24.8306	0.0	24.7239
2.0	24.8384	2.0	24.7466
4.0	24.8462	4.0	24.7693
6.0	24.8536	6.0	24.7919
8.0	24.8614	8.0	24.8146
10.0	24.8693	10.0	24.8373
12.0	24.8769	12.0	24.8598
14.0	24.8848	14.0	24.8825

Figure 1.6 shows that the rating for action C does not vary very much depending on the different weighted values. But action D is found to have increase rating when the weighted values become greater. This means that action D is more sensitive and thus more important than action C. In actual case, the inadequate operations for Kyaukpahtoe Gold Mine Project should be given more attention than the construction stage.

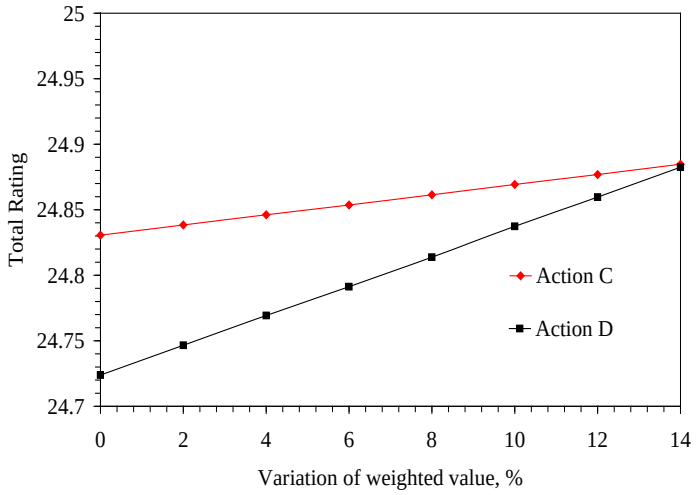

Figure 1.6 Results of Sensitivity Analysis for the Variation of Impact Assessment of Kyaukpahtoe Gold Mine with different Weighted Values for Actions 'C' and 'D'

Variations of Impact Assessment with Different Weight for Actions E, F and G

Impact assessment rating varies depending upon the different weight of Action affecting environmental resources and values. If weighted value of the action 'E' is 0%, rating is 24.6178 and also weighted value of the action 'E' is 80%, rating is 24.7679 (see Table1.5) and variation of impact assessment graph is shown in Figure 1.7. Other variations with different weight for actions F and G are in the same way.

Table 1.5. Comparison of Rating with Different Weight for Actions E, F and G

Variation of weighted value of action E	Rating of Action E	Variation of weighted value of action F	Rating of Action F	Variation of weighted value of action G	Rating of Action G
0.0	24.6178	0.0	25.8736	0.0	25.8620
2.0	24.6554	2.0	25.7353	2.0	25.7254
4.0	24.6929	4.0	25.5971	4.0	25.5887
6.0	24.7303	6.0	25.7172	6.0	25.4520
8.0	24.7679	8.0	25.5790	8.0	25.3153
10.0	24.8054	10.0	24.4470	10.0	25.1787
12.0	24.8428	12.0	24.0437	12.0	25.0419
14.0	24.8804	14.0	24.9055	14.0	24.9053

From Figure 1.7, it can be seen that the rating for action E and G does not vary very much depending on the different weighted values. But action F is found to have unstable rating when the weighted values become greater. This means that action F is more sensitive and thus more important than actions E and G. In actual case, overall critical review criteria for Kyaukpahtoe Gold Mine Project should be given more attention than other potential environmental problems and realization of feasible enhancement measures. Moreover, more interviews and measurements should be made to compensate this large variations.

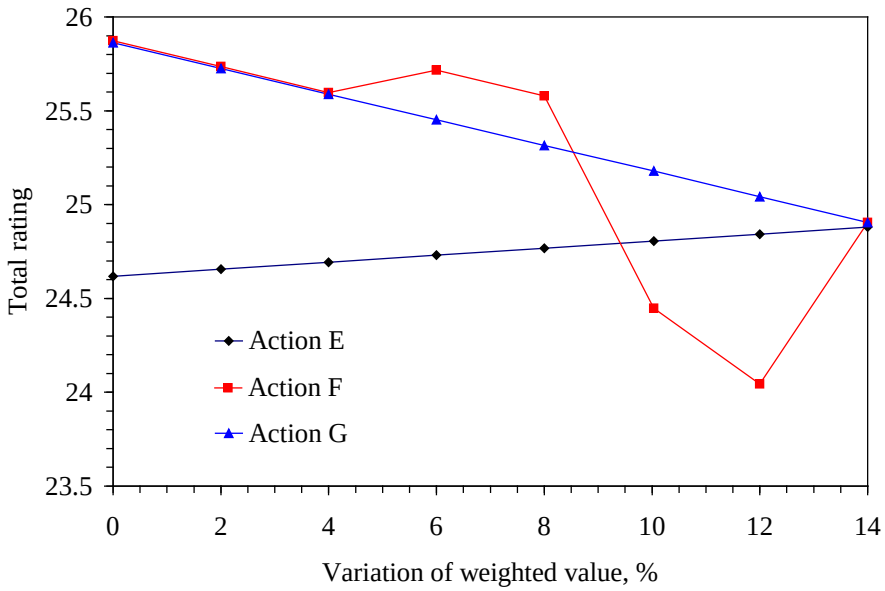

Figure 1.7. Results of Sensitivity Analysis for the Variation of Impact Assessment of Kyaukpahtoe Gold Mine with different Weighted Values for Actions E, F and G

Variation of Impact Assessment with Different Weight for Expert Levels 1, 2 and 3

Impact assessment rating varies depending upon the different weight for expert Level. If weighted values of level 1 is 0%, the rating is found to be 21.9473 but weighted values for High expert level is 20%, the rating is 23.7104. Such variations for expert level 1, 2 and 3 are shown in Table 1.6 and are described in Figure 1.8.

Table 1.6. Comparison of Rating with Different Weighted Values for Three Expert Levels

Variation of Weighted Values of Level 1, 2 and 3	Variation of Ratings of Levels		
	Level-1	Level-2	Lever-3
0.0	21.9473	26.4423	26.2677
0.2	23.7104	25.5084	25.4385
0.4	25.4735	24.5745	24.6094
0.6	27.2366	23.6405	23.7803
0.8	28.9996	22.7066	22.9511
1	30.7627	21.7727	22.1220

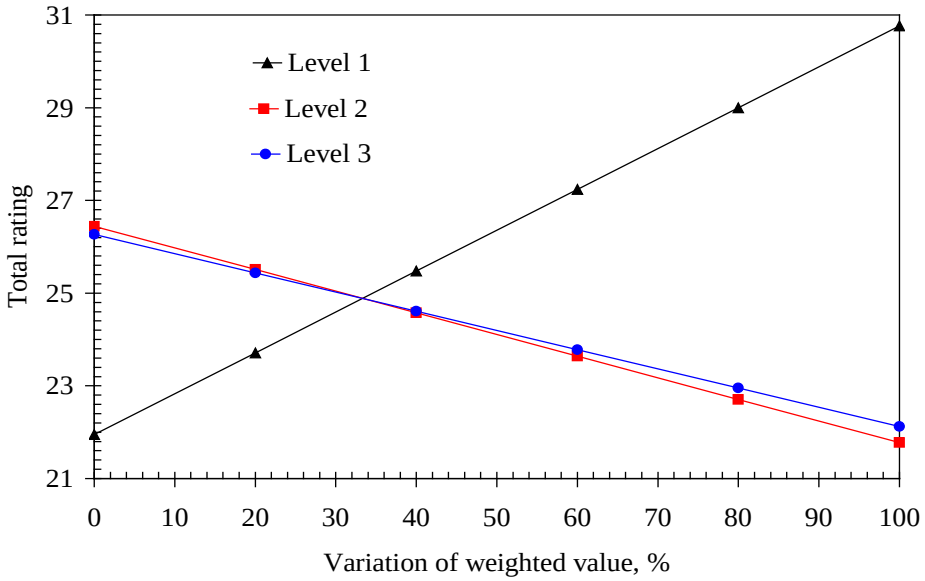

Figure 1.8 Results of Sensitivity Analysis for the Variation of Impact Assessment of Kyaukpahtoe Gold Mine with different Weighted Values for Expert Level 1, 2 and 3

CONCLUSION

In general, this research is an initial attempt to make environmental impact assessment for a mining project by the help of a computer program. It then necessarily focuses on laying down some management procedures, which would be beneficial to Myanmar mines as guidelines for environmental management guidelines. The computer program has been based on a number of variables such as different actions of a project that could generate environmental impacts, the sensitive changes of opinions in assessing the magnitude of impacts, the possibility of increase or decrease in numbers of related important parameters and the shifting nature of vitality of different actions. The program output presents different degrees of environmental impacts (D1.D2, D3, D4) with statistical basis on a wide range of assessment opinions. It proposes useful guidelines for studying environmental aspects of a project. Given the guidelines, management procedures and proper training, Myanmar engineers will be willing to protect the environment by controlling and minimizing the impacts originated from the projects.

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