

ORIGINAL ARTICLE

Impacts of Mine Closure on the quality of life of the neighboring Community

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ABSTRACT

The quality of life in the society in the neighborhood of mining is result of gradual adoption of a characteristic life-style that is highly influenced by mining industry. There are number of attributes of a family and the society that are affected by mining. The overall realization of these impacts is reflected on the quality of life. In order to sustain the societal developments beyond the mine closure, it is essential to plan post mining activities in the area. To minimize the societal impacts on the nearby communities, it is necessary to predict

the impacts of mine closure before closure planning is initiated. However, there are no comprehensive indicators and methodology to measure social impact of mine closure. This paper highlights the results of a study to quantify the degree of adverse effects of mine closure on the quality of life of neighboring communities adopting the Structural Equation Modeling (SEM) and the Latent Variables Interaction Modeling (LVM) techniques

Keywords : Mine closure, impact assessment, structural equation modeling, latent variable interaction modeling, quality of life

INTRODUCTION

The development of a country is largely dependent on the availability of raw materials and energy source. The mining industry provides the necessary fossil fuel or nuclear fuel for the growing energy demands. It also supplies the raw materials for steel making, aluminum extraction as well as all other metals required for sustaining the modern civilization.

Most of the mines are located in the remote areas and surrounded by villages of economically and opportunity deprived community. It should be noted that mining is a temporary business and every mining operation is bound to face closure after resource exhaustion or change in the economics of mining. Opening of a new mine in a remote area brings lot of social changes in the vicinity. The people cope with the changes and start living with a new life style and the neighboring community becomes dependent on the mining operations. Therefore, mine closure can induce a high level of social stress on the community and if not adequately addressed in time can lead to social unrest, agitations and even terrorism. Hence, it is important that mine closure is undertaken in a planned and effective manner to avoid social risks and reduce the post closure liabilities and economic burden of the mining company as well as of the government¹.

Managing the environmental impacts of mining and rehabilitation of mine land after closure have been major concerns for governments and mining companies². In most of the countries, mining companies are required to prepare rehabilitation and reclamation plans before starting of mining operations and require financial surety to ensure reclamation^{3,4,5}. Special funding arrangements are also available to clear up abandoned mine sites^{6,7}. However, such stringent regulations have not been imposed to address the local social and economic impacts of mine closure. The stresses induced by mine closure on the people living in the mining areas and impacts on the quality of life needs to be addressed adequately.

Socio Economic Impacts of Mine Closure

Every stage of mining is associated with specific environmental and social impacts, which often remain significant after closure. When mining operations are initiated in a remote area, they bring sudden changes in the social structure and supply/demand scenarios in the area. If a mineral deposit is found below grown-up areas, the mining project calls for rehabilitation of the project affected people (PAP). The site-specific characteristics of mining industry force the PAP for relocation. As mining progresses, large influx of population to the area put strain on the existing services and business structure. Services and infrastructure

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such as power, sewage and housing are developed to meet increased population which in turn increase tax burden on the existing community⁸.

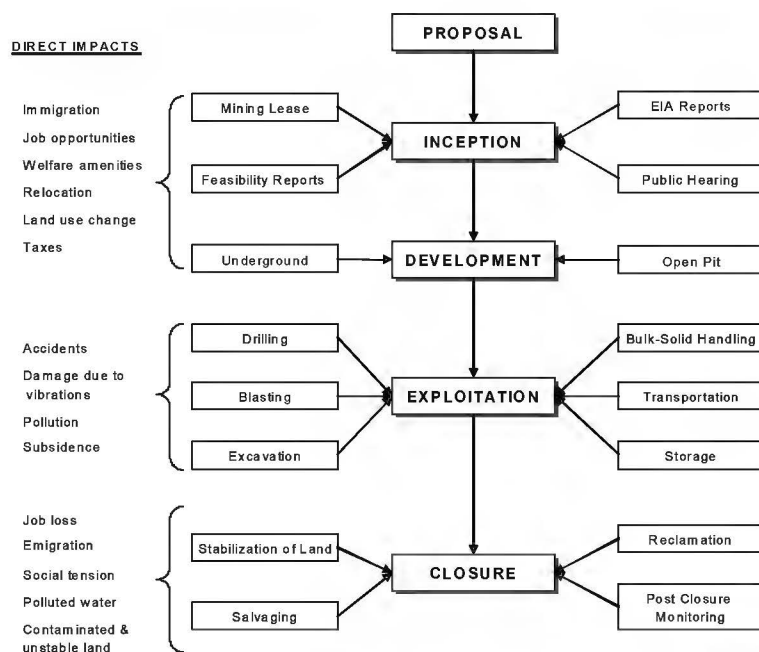
Further, impacts of mine closure on the community are often severe. Mine closure is associated with loss of livelihood of a larger fraction of the population of the mining area and results in a sharp decline in their standard of living. Such experiences frequently induce anxiety and stress. The strains on workers produce increased stress within the family. The demoralizing effects of mine closure on the

severe impact on the government's ability to sustain its services. It is, therefore, very important for governments and communities to understand and plan for the eventuality of mine closure. Figure 2 shows the network of impacts of mine closure which shows that there is a perpetual loop which makes the impacts are a never ending phenomenon.

There is no doubt that in a mining life cycle the issue of mine closure is very crucial and important because the post closure impacts of unplanned closing of a mine are severe on the natural environment and the community¹. Further,

abandoned mining sites continue to pose potential threat to human safety, health and environment¹⁰. The primary causes of all the above impacts are loss of employment, labor migration, abandoning of service and facilities, loss of community cohesiveness and environmental degradation⁹ which have close relation with Quality of Life (QOL). Current evidences suggest that the demographic variables, environmental characteristics, health, leisure, socio-economic status etc. are the potential factors influencing quality of life of the people^{11, 12}. Therefore, closure of a mine may have adverse affect on QOL of the communities.

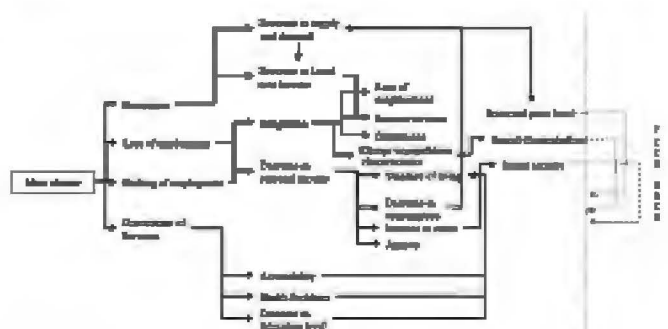
Figure 1. Socio environmental impacts of mining during its life



wider mining communities are evident in the deterioration of the physical environment, control over young people and participation in the community life. On the other side, mine closure may result loss of community facilities and withdrawal of informal services such as housing maintenance and emergency services, which were provided by the mine management⁹. Figure 1 illustrates the impacts of mining on social and natural environment at the different phases of the mining life cycle.

Mining industry plays a major role in the diversified economy of a mining area by providing income, employment and services. In most cases, the community and the mine develop an interdependent relationship, in terms of employment, services, infrastructure, environmental impact issues, or taxes and royalties. Moreover, a major portion of government tax revenue comes from mining⁸. Thus, after the mine closure government will not be able to maintain the same level of income. Hence, closure may leave a

Figure 2. Network of impacts of mine closure.



Quality of Life Approach

Quality of Life (QOL) is an area of study that has attracted an ever increasing amount of interest over the past two decades and emerged as salient construct on academic and political agendas in many developed and developing nations¹³. Initially, the concept was applied in

the field of sociology, but today it is commonly applied to other disciplines such as, health^{14, 15}, rehabilitation^{16, 17}, disabilities studies¹⁸ and social services¹⁹ but also in medicine²⁰, education²¹, environment²² and others. Most people accept that QOL is an aim for both individual and group of individuals²³. Although, it is defined in many ways, its objective is to enable people to live quality lives that are both meaningful and enjoyed.

In its efforts towards sustainability, the mining industry has used several environmental and economic indicators to assess its performance^{24, 25}. In recent years, Quality of Life (QOL) assessment has proved to be one of the most attractive approaches for this task. Mining activities improve the QOL of the communities living in the nearby areas, since it contributes a lot in terms of direct and indirect employment, services, local and national economic development^{26, 27, 28, 29}. However, impacts of mine closure on QOL is not same for all the families in a community, it depends on how the families depend on the mining in terms of personal income, services, education, health, etc. The basic questions involved in the present investigation are how does mining influences the quality of life of people living nearby, what is going to happen if mining is ceased and how mine closure decisions influence the well being of the neighboring communities.

Measuring Quality of Life

Prior to the 1970s, traditional objective indicators were accepted as suitable predictors of human welfare³⁰. However, in the early 1970's, social scientists concluded that quality of life was more than a city's financial position or a country's Gross Domestic Product^{31, 32}. Factors such as personal income, housing, education, number of doctors, and parks, and green space were recognized as indicators to quality of life^{32, 33}. By late 1970s and into the 1980s, there was a marked shift in how quality of life was defined and measured. Subjective measures were used to mediate the weakness associated with using objective indicators to measure quality of life³⁴. Cummins, 2000³⁵; Felce, 1995³⁶, 1997³⁷ and Smith, 2000¹³ recognized that both subjective and objective information are necessary to measure QOL.

The subjective nature of quality of life is commonly cited in the health related literature^{38, 39}. In contrast, objective factors play an important role in evaluating QOL of city and country level. Lee (2002)⁴⁰ and Singh and Chand (2000)⁴¹ used objective indicators such as wages and housing expenditure, infrastructure in evaluate QOL. However, both subjective and objective approaches found predominance in QOL measurement^{32, 35, 36}. Linga and Subramanya (2005)⁴² used both objective and subjective measures in assessing QOL of mining communities using

the economic, social, political, biophysical, biomedical, and spiritual dimensions. Poston et al., (2003)⁴³, made a qualitative inquiry into individual family quality of life using both subjective and objective dimensions.

Ontario Social Development Council (1997)⁴⁴ accepted that the purpose of the Quality of Life (QOL) measurement is to provide a tool for community development which intended to monitor conditions that affect the living and working conditions of people and focus community action on ways to improve health. Whether we measure the quality of life in terms of subjective variables or objective variables, to improve quality life one has to ameliorate the objective variables of the Quality of life. For example one person's subjective response of health is poor; to improve his health one has to search for objective variables which are responsible for his poor health. However, objective measures alone can not give true picture of QOL^{35, 36}. Thus, in order to improve quality of life of a community or group of people, it is necessary to establish a relationship between subjective and objective QOL dimensions. These dimensions near a mining site vary significantly with the performance of the industry as well as with the phase of the mining operations. In the closing phase the situations may worsen if adequate technical measures are not taken at the planning stage.

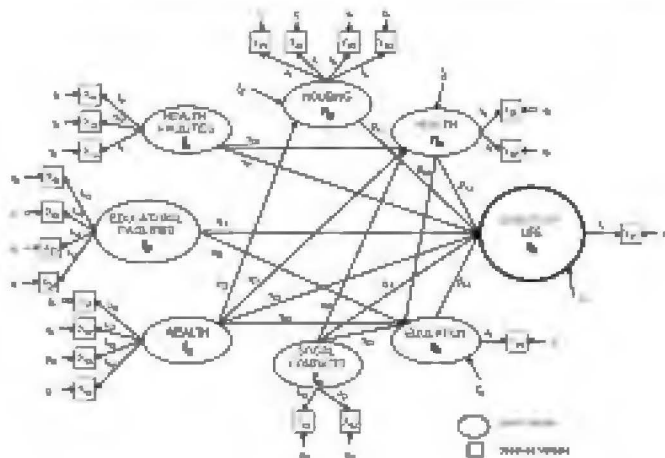
Methodology to Quantify Impact of Mine Closure

A quality of life based methodology was developed to quantify societal impacts of mine closure which would help in planning. It was identified that wealth, education, health, etc. are the key factors to define the quality of life of mining communities. QOL of mining community depends on number of domains that are having direct, indirect or both type of dependencies on the mining activities. However, these domains cannot be quantified easily. The most appropriate method is to take a site specific methodology for collection of data from the families and individuals through structured questionnaire. In the present study, both quantitative and qualitative information was obtained from the selected mining areas. Structural Equation Modeling (SEM) technique was used to evaluate the interrelationship between QOL domains. The LISREL (Linear Structural RELations) software was used for this purpose. SEM provided latent variables scores were used for further testing of changed scenario. The developed methodology was validated in a surface iron ore mine using data obtained through the structured questionnaire. The datasets so obtained were subsequently analyzed using the software LISREL 8.72 and possible impacts of mine closure were estimated. The overall methodology used for the study is illustrated in Figure 3.



In the last few decades, scientists offered several alternative approaches to define and measure quality of life using social indicators such as health and levels of crime, subjective well-being, and economic indices. Quality of life is a multidimensional concept¹⁹ and is associated with many factors, accounting and identifying all the parameter is rather difficult. In most cases the quality of life is accounted by only health; however other parameters like socio-wealth, education, services, and housing also contribute to the quality of life. Figure 4 shows the conceptual QOL model which illustrates the factors of quality of life and their influencing parameters.

Figure 4. The conceptual SEM model for evaluating QOL of mining communities.



NOTE: Y11=Subjective QOL, Y21=Spaciousness, Y22=Room/Head, Y23=Type, Y24=Repair Status, Y31=Physical Health, Y32=Disease Status, Y41=Education, X11=No of Physicians, X12=No of Beds, X13=Distance, X21=Teacher-Student Ratio, X22=Maximum Class Level, X23=Teacher Education Level, X24=Distance, X31=Income, X32=Expenditure, X33=Goods, X34=Infrastructure, X41=No of Contacts, X42=Frequency of Visiting

Figure 5 indicates that all path coefficients in the developed model are significant at 0.05 level, with an exception to the following two paths:

- 1) From the social contacts to the personal education
- 2) From housing to quality of life.

Impact Analysis

Impact of mine closure on the QOL of the nearby communities was quantified using latent variable models. The impact was measured in step-wise manner, i.e. first impact of mine closure on a variable was measured then influence of that variable on overall QOL was quantified. Similar procedure followed for each

Figure 3. The methodology used for the present study

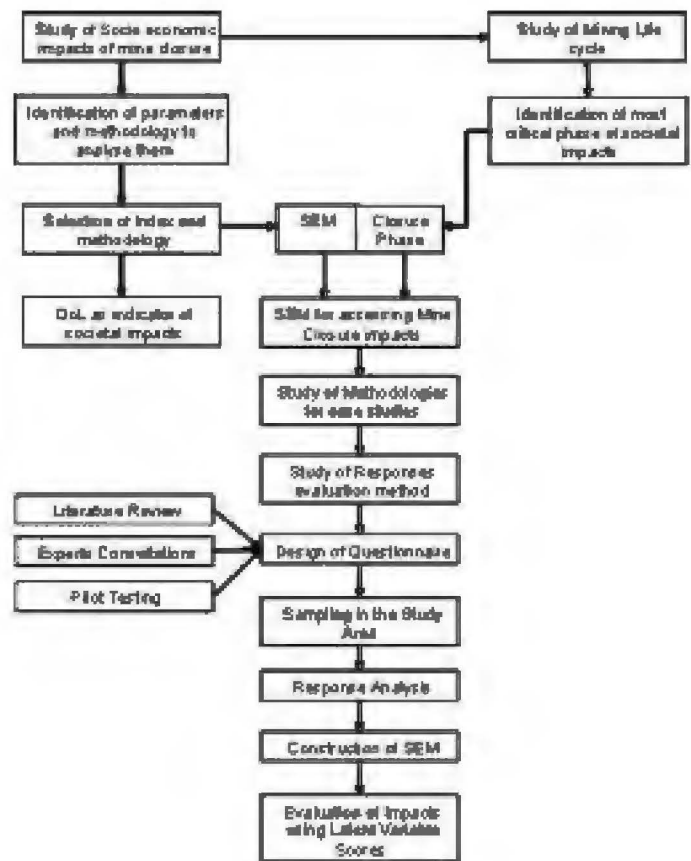


Figure 5. Quality of life model established for the study

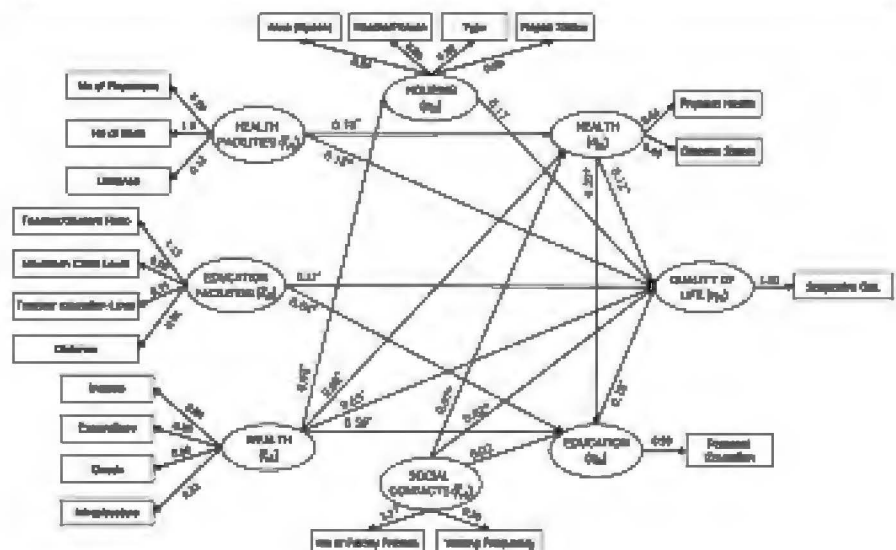
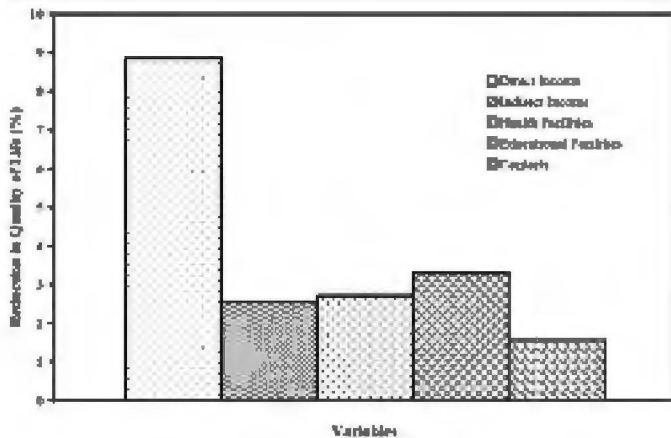


Figure 6. Possible reduction in the quality of life of the communities due mine closure.



variable separately to evaluate the impact QOL due to each variable. Prior, to measuring the impacts, the present QOL was quantified using the data collected from mining communities using structured questionnaire and latent variable models.

Impact on the QOL due to loss of mining income was evaluated by recalculating the monthly income of the families after subtracting the income derived from mining. Modified monthly income was taken as an input to the latent variable model (LVM) and recalculated the QOL. The percentage of change in the QOL has been shown in the Figure 6. This shows the impact on the people who directly draw income from mining company in the form of their monthly salaries. However, the benefits that may be received from the mining company after mine closure is not considered in the evaluation the impact.

It was calculated from questionnaire responses that on average ~43% of the present mining based indirect income will be lost due to mine closure. Impact due to loss of this income was evaluated by recalculating the family income by subtracting the 43% of the indirect mining depended income. Modified income was taken as an input to the latent variable model (LVM) to calculate the QOL. The Figure 6 shows the impact on the people who indirectly depend on mining for their monthly income such as businessmen, daily labors, temporary workers in the mines, domestic workers etc.

Impact of health and education facilities was calculated by replacing health/education facilities variable values by the facilities that will remain after closure (assumed that Govt. provided health/education facilities and other private facilities will remain in place after closure). Similarly, impact on QOL due to emigration was derived by subtracting the number of migrated family friends from present family friends. Figure 6 shows the impact on QOL of the communities due above variables.

DISCUSSION

Mine closure has a significant impact on the QOL of the neighboring communities. This is quantitatively established through structural equation modeling and latent variable modeling which had demonstrated that satisfaction with life in general could be predicted by objective life status. Structural equation modeling was used to propose and test a good fit model for evaluating impacts of mine closure on the neighboring communities. This was done by examining the effects of income, health and education facilities, inter-family relations on housing, health, education and finally on QOL.

Conforming to the findings of Smith (1999)⁴⁵ and Ettner (1996)⁴⁶, the developed model in the present study shows positive correlation between health and economic resources. The model establishes that income, expenditure, goods and facilities are proxies for wealth and have positive contribution to health. Health facilities have positive significant role in improving health of the communities and family health has significant contribution in improving QOL, hence health facilities directly as well as indirectly brings a significant change in the QOL. It was observed that number of physicians and number beds are appear to be good predictors of health facilities than distance form the community, possibly because people prefer better health facilities even at a greater distance.

It was revealed that education facilities have little influence on QOL. Most of the villages in the study area have elementary schools and high schools which are maintained by the government. Further, most of the people are illiterates due to lack of educational awareness. This may be the reason for little influence of education facilities on education. Teacher student ratio, education level of teacher and class size are emerged as good predictors of educational facilities than the distance of the educational facilities from the residence.

The developed model suggests that interfamily relations have significant contribution to the QOL. These effects are significant both direct and indirect paths through health. However, it is well documented that more interaction with other families and helping each other improves the QOL. Inter family relations have insignificant influence on the education. This is attributed to lack of educational awareness amongst families.

CONCLUSION

It is evident from the study that exploring alternative economic arrangements should be the primary concern during mine closure planning in the study areas. From the model it was noticed that satisfaction with life in general was confirmed to be significantly predicted by objective factors such as personal income, health, education, service



and facilities, etc. A linear relationship was revealed between objective quality of life status and subjective quality of life satisfaction. Further, identification of proactive factors that influence the QOL of the communities nearby mining area provides useful information for mine closure planners to minimize the post closure social impacts.

REFERENCES

1. Sarkar, S. K. and Sarkar, S.: 1996, *State of Environmental and Development in Indian Coal Fields: Coal Fields in West Bengal*, Oxford & IBH publishing.
2. Andrews-Speed, P., Guo, M., Bingjia, S. and Chenglin, L.: 2005, 'Economic responses to the closure of small-scale coal mines in Chongqing, China', *Resources Policy*, 30, 39-54.
3. Kahn, J. R., Franceschi, D., Curi, A. and Vale, E.: 2001, 'Economic and financial aspects of mine closure', *Natural Resources Forum*, 25, 265-274.
4. Kuhne, G.: 1992, 'Abandonment and reclamation of energy sites and facilities: Germany' *Journal of Energy and Natural Resources Law*, 10(1), 4-20.
5. Redgwell, C.: 1992, 'Abandonment and reclamation obligations in the United Kingdom' *Journal of Energy and Natural Resources Law*, 10(1), 59-86.
6. Brook, D.: 1994, 'Reclamation of abandoned underground mines in the United States', *Mineral Planning*, 61, 21-26.
7. Meyer, P.B., Williams, R.H. and Young, K.R.: 1995, *Contaminated Land—Reclamation, Redevelopment and Reuse in the United States and the European Union*, Edward Elgar, Cheltenham.
8. Finsterbusch, K.: 1980, *Understanding Social Impacts*, Saga library of Social research, (110).
9. Michael, H. and Maria, S.: 2003, *Mine Closure and its Impact on the Community: Five Years after Mine Closure in Romania, Russia and Ukraine*, Environmentally and Socially Sustainable Development Network, World Bank, social development papers, 42.
10. Chattopadhyay, S. S.: 2001, 'The ratholes of Raniganj', *Frontline Magazine*, 18(24).
11. Berkman, L. F. and Breslow, L.: 1983, *Health and Ways of Living: The Alameda County Study*, New York: Oxford University Press.
12. Raphael, D., Renwick, R. Brown, I. and Rootman, I.: 1996, 'Quality of life indicators and health: Current status and emerging conceptions', *Social Indicators Research*, 39, 65-88.
13. Smith, A. E.: 2000, 'Quality of life: A review', *Education and Aging*, 15(3), 419-435.
14. Derrett, S., Paul, C. and Morris, J.: 1999, 'Waiting for elective surgery: Effects on health-related quality of life', *International Journal for Quality in Health Care*, 11 (1), 47-57.
15. Gill, T. and Feinstein, A.: 1994, 'A critical appraisal of the quality-of-life measurements', *Journal of American Medical Association*, 272 (8), 619-626.
16. Fabian, E. S.: 1990, 'Quality of life: A review of theory and practice implications for individuals with long-term mental illness', *Rehabilitation Psychology*, 35, 161-169.
17. Packer, T., Race, K. E. H. and Hotch, D. F.: 1994, 'Focus groups: A tool for consumer-based program evaluation in rehabilitation agency settings', *Journal of Rehabilitation*, 60, 30-33.
18. Jones, J., Dagnan, D., Trower, P. and Ruddick, L.: 1996, 'People with learning disabilities living in community-based homes: The relationship of quality of life with age and disability', *International Journal of Rehabilitation Research*, 19, 219-227.
19. Linda, S. and Robert, G.: 2005, 'Sustainable transportation and quality of life', *Journal of Transport Geography*, 13, 59-69.
20. Michael, K., Monika, K. S. and Wilfried, L.: 2005, 'Outcome and quality of life in medicine: A conceptual framework to put quality of life research into practice', *Urologic Oncology: Seminars and Original Investigations*, 23, 186-192.
21. Tankova, T., Galina, D. and Dragomir, K.: 2005, 'Education and quality of life in diabetic patients', *Patient Education and Counseling*, 53, 285-290.
22. Robert, W. M.: 2003, 'Understanding environmental quality through quality of life studies: the 2001 DAS and its use of subjective and objective indicators', *Landscape and Urban Planning*, 65(1-2), 73-83.
23. Hanestad, B.: 1990, 'Errors of measurement affecting the reliability and validity of data acquired from self-assessed quality of life', *Scand. J. Caring Sci*, 30(6), 1349-1359.
24. John, M. and Catherine, E. R.: 2005, 'Education, learned effectiveness and health', *London Review of Education*, 3(3), 205-220.
25. Azapagic, A.: 2004, 'Developing a framework for sustainable development indicators for the mining and minerals industry', *Journal of Cleaner Production*, 12(6), 639-662.
26. Scott, P.: 2005, 'Mining and poverty reduction: Transforming rhetoric into reality', *Journal of Cleaner Production*, 14(3-4), 376-387.
27. Figueroa, B. E. and Calfucura, T. E.: 2003, 'Growth and green income: Evidence from mining in Chile', *Resources Policy*, 29, 165-173.
28. Patricio, A.: 2001, 'Impacts and development in local economies based on mining: The case of the Chilean II region', *Resources Policy*, 27, 119-134.
29. Benjamin, N. A.: 2001, 'Ghana's mining sector: Its contribution to the national economy', *Resources Policy*, 27, 61-75.
30. George, S. D. and Weitz, B. A.: 1977, 'Comparative urban social indicators: problem and prospects', *Policy Sciences*, 8(4), 423-435.
31. Mirinogoff, M. L.: 1996, 'The growing gap between standard economic indicators and the nation's social health', *Challenge*, 39, 17-22.
32. Pacione, M.: 1982, 'The use of Objective and subjective measures of quality of life in human geography', *Progress in Human Geography*, 6, 495-514.
33. Rogerson, R. J., Findlay, A. M., Morris, A. S. and Coombes, M. G.: 1989, 'Indicators of quality of life: Some methodological issues', *Environment and Planning*, 21, 1655-1666.
34. Abrams, M.: 1977, 'Social indicators and social equity', *New Society*, 22, 454-455.
35. Cummins, R. A.: 2000, 'Personal income and subjective well being: A review', *Journal of Happiness Studies*, 1, 133-158.
36. Felce, D. and Perry, J.: 1995, 'Quality of life: Its definition and measurement', *Research in Developmental Disabilities*, 16(1), 51-74.
37. Felce, D.: 1997, 'Defining and applying the concept of quality of life', *Journal of Intellectual Disability Research*, 41(2), 126-135.
38. Beckie, T. M. and Hayduk, L. A.: 1997, 'Measuring quality of life', *Social Indicators Research*, 42, 21-39.
39. Fakhoury, W. K. H. and Priebe, S.: 2002, 'Subjective quality of life: It's association with other constructs', *International Review of Psychiatry*, 14(3), 219-224.
40. Lee, E.: 2002, 'Estimation of quality of life Korean cities', *Humanities and Social Science*, 93-95.
41. Singh, P. and Chand, R.: 2000, 'Quality of life approach for identification of poor', *Journal of Rural Development*, 19(1), 27-68.
42. Linga, N. and Subramanya, N.: 2005, 'Assessing quality of life in a mining region', *Economic Political Weekly*, January 1, 2005.
43. Poston, D., Turnbull, A., Park, J., Hasheem, M., Jane, M. and Wang, M.: 2003, 'Family quality of life: A qualitative inquiry', *Mental Retardation*, 41(5), 313-328.
44. Ontario Social Development Council: 1997, *Quality of life in Ontario*, report prepared by Ontario Social Development Council, Ontario.
45. Smith, J. P.: 1999, 'Health bodies and thick wallets: the dual relation between health and economic status', *Journal of Economic Perspectives*, 13(2), 145-166.
46. Ettner, S.: 1996, 'New evidence on the relationship between SES and health', *Journal of health economics*, 15, 67-85.

