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RRR (Reclamation, Remediation and Recovery): Green Phases of Mining and Drilling Lifecycle Influence on and/or Influenced by Sustainable Development

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Abstract

Today industries play comprehensive role in modern and developed societies. Pollution and wastes as output of these processes- here: mine and drilling - are important concerns of both environmental authorities and managers. Recently green studies are favored as a key factor in environmental management systems. It can also be served as a study field in sustainable development. One environmentally-concerned phase of industries is closure and abandonment of mine and well when permanent environmental impacts must be dealt with. Reclamation and/or rehabilitation of mined and drilled lands not only can decrease environmental problems but also can establish environment-friendly conditions having substantial benefits. Wastes can be lowered or even eliminated by being returned into source or by remediation and reuse processes. Circumstantially in mining, the mined land can approach post-mining land uses such as recreational, residential and agricultural uses. These make losses and disadvantages to turn into benefit and advantage. In terms of drilling, practices like subsurface injection can procure demanding disposal. Post closure acts are the long-term phases of industries which should integrate well-designed engineering, management and monitoring to bring about the aimed results and to comply with the environmental management systems.

Keywords: Environmental Management System EMS; Green Industry; Sustainable Development; Waste Management

Introduction

As prerequisite and necessities of modern world are surface and subsurface earth products such as minerals, oil, gas and agricultural crops. However, the corresponding industries occupy the most environments and are so crucial for environmental protection via environmental management systems. On the other hand, new research world's approaches target new and green technologies around savings of energy, material, costs and environment the most. Hence, it has been tried a lot to link the mentioned studies in foundation of sustainable development and its policies to optimize the naming savings and to establish the correct relation between economic, society, industry and environment according to figure 1. It can be stated that as the links come closer to each other, the proposed society more closely approaches to sustainable development. Actually the intersection of the links would be an important parameter or phenomena for countries development.

Regeneration of post-industrial landscapes in the UK and other countries has moved beyond hard redevelopment solely for industrial, commercial and housing end-uses towards a focus on ecological restoration (Dickinson et al., 2005; Hartley et al., 2012). A paradigm shift is occurring to accommodate ecological approaches to what was formerly done through rigid engineering and a general avoidance of any reliance on natural systems (Mitsch and Jørgensen, 2003).

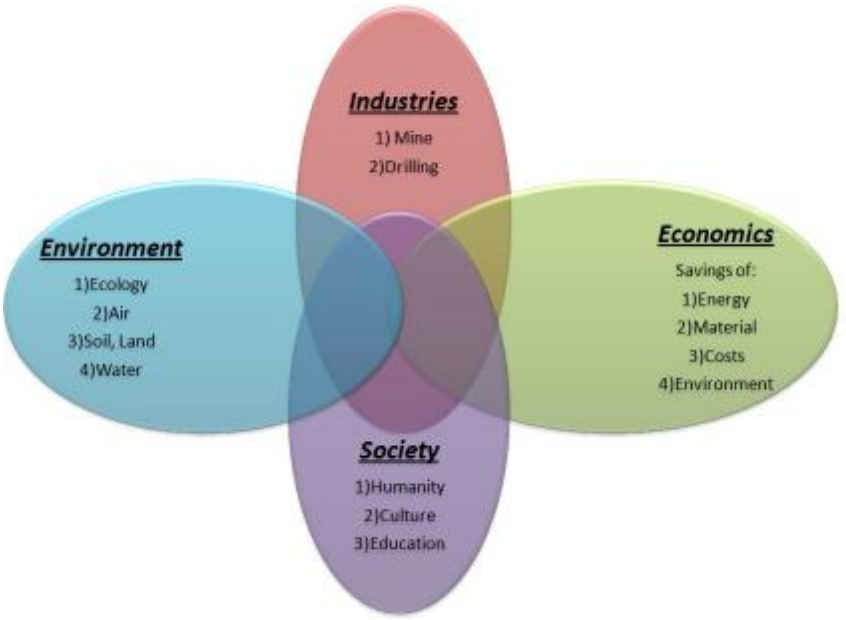

Figure 1: The relationship of aspects of present study

Agroforestry comprises various benefits for farmers such as firewood, timber but also supplementary income possibilities due to tree crops (Nair, 2007b). In addition, it is a promising solution to alleviate soil erosion on agricultural plots and hence helps to stabilize or even improve yields (Gebreegziabher et al., 2010; Nair, 2007a, 2007b). However, these positive effects only persist if agroforestry is preserved over a long time period (Mercer, 2004). Overutilization of agroforestry systems, associated with the decline of tree stocks, may weaken the positive impact on soil fertility, food production, firewood and timber availability, and thus farmers' income in rural areas. Some studies solely promote the implementation of agroforestry as a sustainable system (Kang and Akinnifesi, 2000; Tambula and Sinden, 2000). These are all while intrusions of industry especially large ones such as mining and drilling have vast potentials to adversely affect forests, farms, lands and the engaged people inhabitant in the naming land uses.

Materials and Methods

In mining industry, existing environmental consequences would be the changes to the original topography, the effects on soil and hydrologic conditions, the issues of mining and processing wastes, and the effect on the future economic potential of the mined areas and communities (Raja et al., 2012). This is while, these consequences appear in post closure phase the most; even though they exist continuously from the beginning of the project. In mining projects Environmental studies and acts are advised continuously and regularly. As figure #2 expresses, the most time of a mining project must be dealt with post closure activities in which the environmental requirements and sustainable development are the predominating factors. The last of the unit operations in mining sites is the initial remediation of the mined area in preparation for the long term reclamation. Depending on the type of surface mining method, several critical actions can be performed at this stage (Raja et al.,2012):

•Burial of toxic materials
• Encapsulation of toxic materials
• Surface soil and sub-surface spoil amendments
• Backfilling, contouring and rough grading the land surface for future land uses
• Top soiling and plantings for immediate growth to control erosion

These actions are essential for successful mine closure, reclamation and rehabilitation of mined lands.

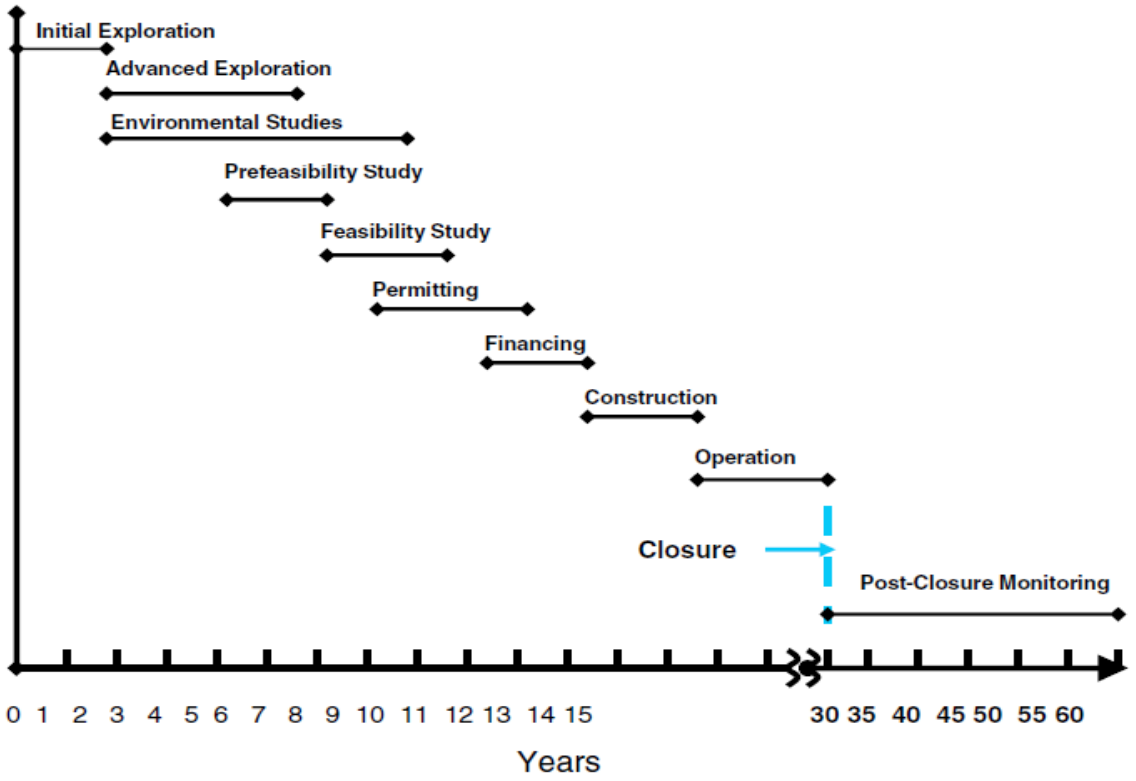

Figure 2: Typical time frame for a completed mine project (Raja et al.,2012)

In terms of drilling, there are several functions in this industry that also have environmental effects. In addition to the drilling fluid, there is the effect of oil leaks from the mechanical parts of the rig, the reserve pits, wash down water from the rig floor, and the drilling location itself (Navarro, 1995). Here, the importance of remediation is well perceived and appreciated.

The concept of re-use or recycling has also made its way into the oil and gas industry. The re-use of location materials, drilling fluids and drill cuttings all have been introduced in the drilling industry (Navarro, 1995).

Theory and Results

Green RRR in Mining industry

Depleted mining areas which have undergone very intensive mining activity present a challenge to local governments to overcome their potential hazards (Martinez et al., 2011).

Mining environmental problems appear in two periods of the proposed project life cycle, 1) during mining and 2) post mining. During the mining, environmental pollution are the most concerning issues which need for recovery and remediation measures. While, post mining environmental issues –served as long-term impacts– can be categorized as landscape and ecology changes needing for restoration and/or reclamation measures. Figure 3 presents a perspective from this division.

About green methods in mining waste management are reusing of coal wastes as fuel for generating plants and recycling the emitted fly ash for cement production. Remediation methods during the mining would be addition of mined land to waste for dilution or use of mine gas.

The focus in mine-water environmental research is on the conservation of aquifers during mining, making full use of mine water and the remediation of polluted mine water (Daniels et al., 2010).

The conservation of aquifers is an important component of green mining (Daniels et al., 2010). For land subsidence, the major solution is back filling the mined lands by wastes or mined earth as remediation or restoration green methods.

The green resolution for land use change -which needs spending more time, effort and fund- would be reclamation or rehabilitation methods which can result in the opportunity for other industries or even ecosystems. Reclamation and Rehabilitation of mined lands support the future economic development of the area. Sometimes it is not possible to imagine how current mining can lead to future economic development of the mined area or improve the conditions for the community after mining (Raja et al., 2012).

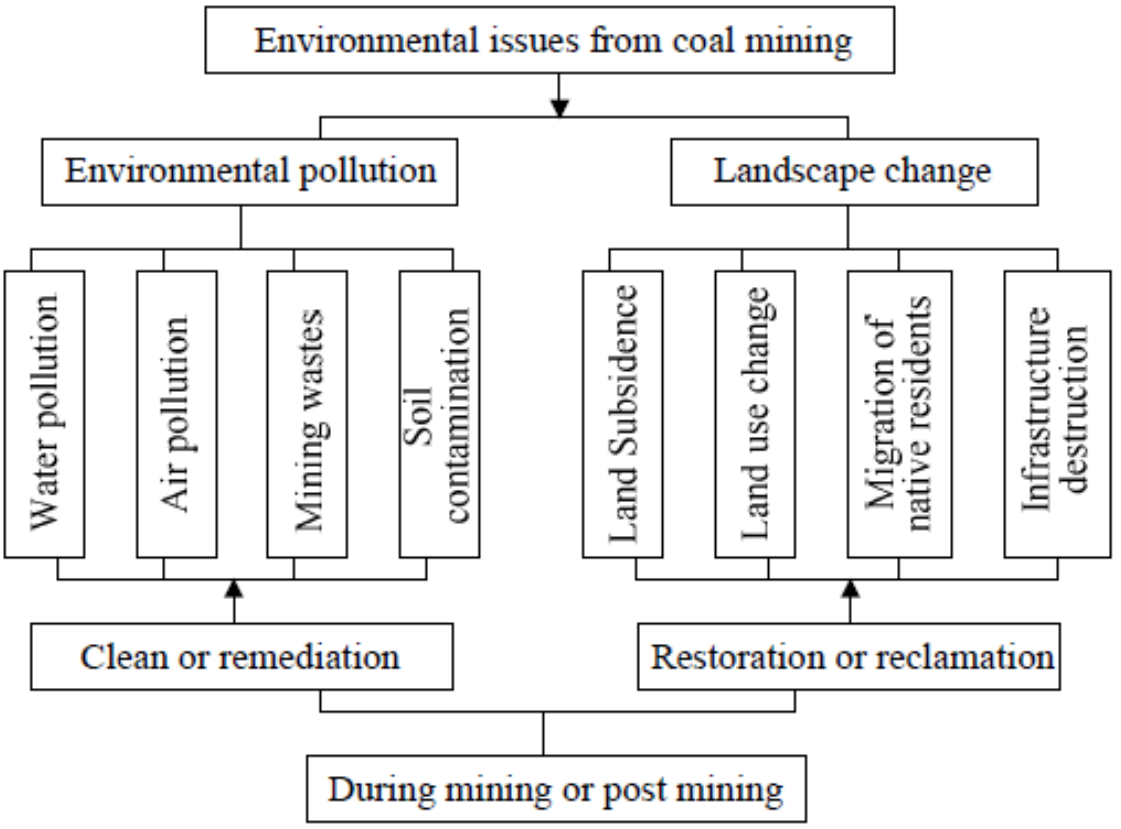

Figure 3: A conceptual framework for solving mine environmental issues (Daniels et al., 2010)

Among the post mining environmental consequences are migrations of native residents. This can be studied in two views: one which deals with restoration or reconstruction of villages and farms usually due to their rights and the other one that is the reclamation of the region which prepares sufficient ecological, social, economical conditions in area for the residents. Integration of these two views can approach to sustainable development. Stone, sand, gravel, and coal mines have been reclaimed to several successful post-mining land uses including agricultural, commercial, residential, institutional, recreational, and industrial land uses. In this case, environment i.e., the third factor of HSE, as a basis of sustainable development is highlighted to bring the realms of figure 1 closer. Figure 4 illustrates reclamation results of some mining projects after operations.

Figure 4: Development of mined lands for post-mining land uses.
Left: recreational, right: agricultural (Raja et al., 2012)

In table 1 are presented the green mining methods for converting negative environmental factors to positive ones along with their results in frame of sustainable development.

Table 1: Green RRR methods and their applications in mining

No	Negative Impact	Converting RRR	Positive Impact	Results
1	Mining wastes.	Remediation. Backfilling.	Less pollution	Native ecosystem accommodation. Subsidence prohibition.
2	Land use change.	Reclamation. Rehabilitation. Restoration.	Post-mining Land uses	agricultural, commercial, residential, institutional, recreational, and industrial
3	Native Migration. Resident vacancy.	Reconstruction. Reclamation. Rehabilitation.	Native and Foreign Residents	Native and New Jobs. Rural, Urban structure development. Industrialization. Cultural Exchanges.
4	Environment Destruction (Air, Water, Soil)	Reclamation. Remediation. Restoration.	Environment Secured	New natural resources. Ecotourism. No subsidiary environmental problems.

Green RRR in drilling industry

Different drilling waste management practices are implemented in E&P operations according to the specific environmental legislations in the world (Tahmasbi et al., 2014). Drilling waste management systems require to be defined according to the environmental legislation and operator compliance with the current regulations (Tahmasbi et al., 2014). The important factors -on the basis of this study- for optimization of a fair drilling waste management plan would be: meeting requirements for environmental legislations, case ecological and geographical specifications, economical and operational considerations, green technologies, social and cultural beliefs and concerns, and finally sustainable development.

It is highly advised to perform waste minimization and elimination acts before the green RRR methods. One of the best practices is done on the fluid to recover the mud system for several intervals by implementing proper treatment on site. This can be processed via various closed loop systems CLS. Some CLS are: 1) physical one step closed loop system which acts as a static separator, 2) Multiple shaker centrifugal system acting as a physical dynamic separator and 3) Chemical flocculation system. In all mentioned CLSs, the recovered drilling fluid is sent back to

drilling system after the wastes are discarded. Then, the remaining wastes can be sent to a remediation process to minimize the environmental risks.

Petroleum drilling operations use drilling muds to lubricate the drill bit, control borehole pressure and flush rock cuttings out of the well (Sadiq et al., 2004). The disposal of drilling fluids in the marine environment is of major concern for two main reasons: economical loss associated with expensive synthetic based fluid discharge with rock cuttings, and potential adverse ecological impacts (Sadiq et al., 2004).

About drilling wastes, it can be implied that discharging returned drilling fluid and drill cuttings under environmental regulations can be difficult. Nonetheless, if the well is located in an area that allows land farming of these wastes, it can save the contractor or operator thousands of dollars in handling and disposal fees per well (Navarro, 1995). The dried cuttings then can be tilled into the soil and farming of the property can continue as if nothing had changed. In most cases, the land farming of these cuttings and fluids will increase the yield of the crops grown on the land farmed area because most fluids that are allowed to be land farmed is extremely rich in nutrients and thus acts as a fertilizer (Navarro, 1995).

Samplings from land farming site will help explain any problems that may occur on the land as a result of the land farming operation and in the event the farmer yields higher returns as a result of the land farming operation (Navarro, 1995).

Some other RRR methods in drilling projects comprise:

• Drilling fluid programming by selecting environmentally-based drilling fluids instead of oil based mud.

• Recycling as a construction material.

• Slurrification and subsurface injection.

One environmental requirement is that the ecologies should be kept unchanged to ensure ecosystems survival and native creature's residency. Accordingly it must be of industries' environmental management systems policies to return wastes and pollution to their origin for environmental consistency.

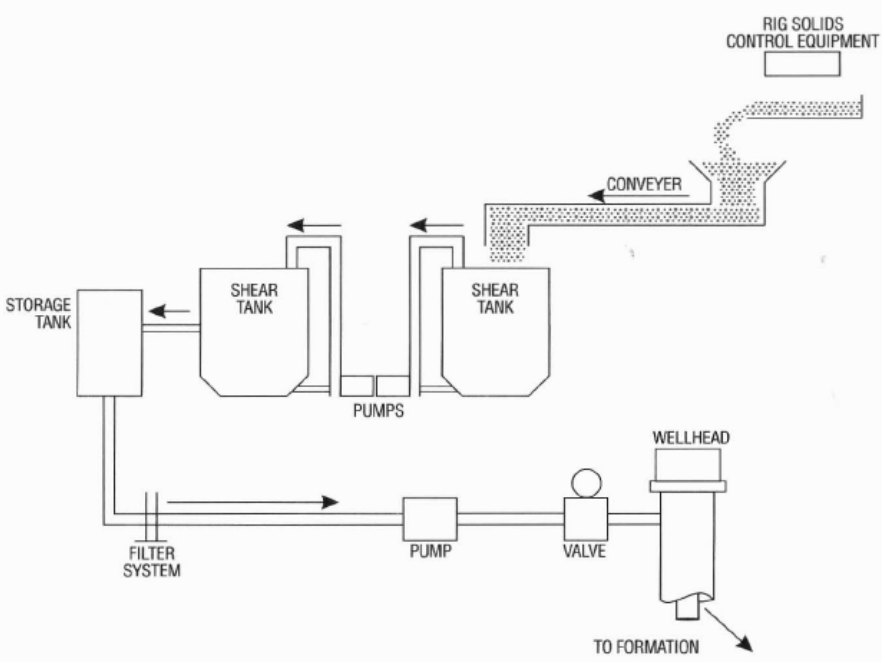

Figure 5: Process of slurrification and subsurface injection (Navarro, 1995).

Some important items for a subsurface injection to be operated as a green method are (Navarro, 1995):

- Amount of waste to be disposed of.
- Well accessibility or proximity to waste.
- Well-head integrity.
- Adequate drinking water zone isolation.
- Injection zone characteristics.
- Cost effectiveness.

In this case, in drilling industry, practices like slurrification and subsurface injection are studied and performed. The schematic of such processes can be found as Figure 5. This would be served as an integration or fulfillment of agents' cooperation and meeting requirements in the realm of sustainable development that means company has reached the very attitude of protecting environment– Ecosystem maintenance– by pollution management and cost optimization as a cultural structure via green technologies to follow the footprints of sustainable development.

Discussion

Mining and drilling industry are expensive and rich economic units which must study and comply with environmental and ecological requirements. Recently, managers try to approach their system to accommodate and prepare green technologies appropriate for their site specifications. In language of SD –sustainable development –they are mostly seeking the membership and implementation of some goals like pollution cost optimization and green technologies cost effectiveness according to cost-benefit analyses obtained from simply complying with environmental requirements or even higher requirements by preparing a fair and friendly sustainable culture all through their human resources or even a society due to utilizations of scientific and expertise studies for triumph over old facilities efforts and costs.

Many implications of sustainable development exist in literature and sustainability has become an important role of any business. In the context of mining and drilling, some of them are as follows: sustainable development is an integrated approach that recognizes the interdependence of three dimensions: the economic, the environmental, and the social performances of an organization (Govindan, 2013, Chaabane et al., 2010). sustainable development is the integration of four spheres—economic development, social concerns, environmental pressures, and governance—that maximizes the contribution to the well-being of the current generation with an equitable distribution of costs and benefits without compromising the potential for satisfying the needs of multiple future generations (Fleury and Davies, 2012).

Generally, sustainable development is the combination of enhanced socioeconomic growth and development, and improved environmental protection and pollution prevention (Hilson and Murck, 2000) "SD espouses the complex objective of giving commensurate emphasis to developing the economic and social dimensions while sustaining the earth's ecological resources" (Perez Batres et al., 2011).

It can be understood from the above definitions that sustainable development has three dimensions: an economic goal, environmental performance, and social aspects. In order to achieve sustainable development, all three interdependent dimensions have to be addressed simultaneously. Table 2 dedicated three main parts of sustainability issues associated with the mining and drilling industries.

Table 2: three main parts of sustainable development issues in the mining and drilling industries.

Economic	Environmental	Social
➢ Contribution to GDP and wealth creation ➢ Reduction of costs ➢ Increased sales and profits ➢ Creation of new business opportunities ➢ Distribution of revenues and wealth ➢ Investments (capital, employees communities, pollution prevention and impacts, mine closure) ➢ Shareholder value ➢ Value added ➢ Wide spread smuggling activity leading to losses to miners and government	➢ Natural radon gas permission ➢ Biodiversity loss ➢ Dust emissions to air ➢ Energy consumption ➢ Global warming ➢ Land use, management and rehabilitation ➢ Product toxic materials ➢ Resource use and availability ➢ Solid waste ➢ Water use, effluents and leachates (including acid mine drainage) ➢ Noise pollution ➢ Underground mine fires ➢ Sedimentation of rivers and flooding in nearby villages ➢ Reduction in rainfall rates. ➢ Lock-up of large areas of fertile land under waste/tailing dump. ➢ Mercury pollution. ➢ Water scarcity	➢ Increased fatality, Create families of orphans ➢ Bribery and corruption ➢ Creation of employment ➢ Employee education and skills development ➢ Equal opportunities and non-discrimination Health and safety ➢ Human rights and business ethics ➢ Worker/manager relationship ➢ Relationship with local communities ➢ Stakeholder involvement ➢ Wealth distribution ➢ Displacement and loss of land ➢ Destruction of traditional forms of livelihoods ➢ Degradation of social customs ➢ Occupational illness ➢ High/Heavy vehicular traffic and accidents.

As can be deduced from table 2 and also, given that material resources are finite; hence, mining operations that result in the depletion of these material resources are unsustainable. Sustainable development in the mining sector can be practiced by annually saving and investing the revenue that mining generates in activities that will be available to multiple future generations (Mikesell, 1994).

According to Frändegard et al. study's in one the mining landfills in Sweden, can be proved economic plan of integrating of 2 parts of RRR phases (reclamation and resource recovery) into a mining landfill remediation project. This analysis was done using a direct costs/revenues approach and the stochastic uncertainties were handled using Monte Carlo simulation. Two remediation scenarios were applied to a hypothetical mining landfill. One scenario includes only remediation, while the best results were derived from the second scenario so that, were added resource recovery to the remediation project (Frandegard et al., 2015).

Between mining and drilling waste management and environmental protection methods are green parts as reclamation, remediation, recovery, reuse and recycling which try to minimize or eliminate pollution or impacts by some processes such as: chemical, physical and biological transformation, native ecosystem maintenance, pollution transfer to safer or enclosed area, separations and dilutions all of which need for new comprehensive studies.

Some important environmental targets of these attitudes are:

- Protection of subsurface aquifers and ground water resources
- Soil protection and native landscape restoration
- Dirty gold philosophy
- Preparing fortunes for and supporting new fields of study and inventions
- Preparing fortunes for new fields of careers, industries and jobs
- Preparing new municipal structure designs
- Make ease of public uses of national natural resources

A typical framework for performing green RRR acts is shown in figure 6. It can be served as a time table for managing green processes by environmental experts.

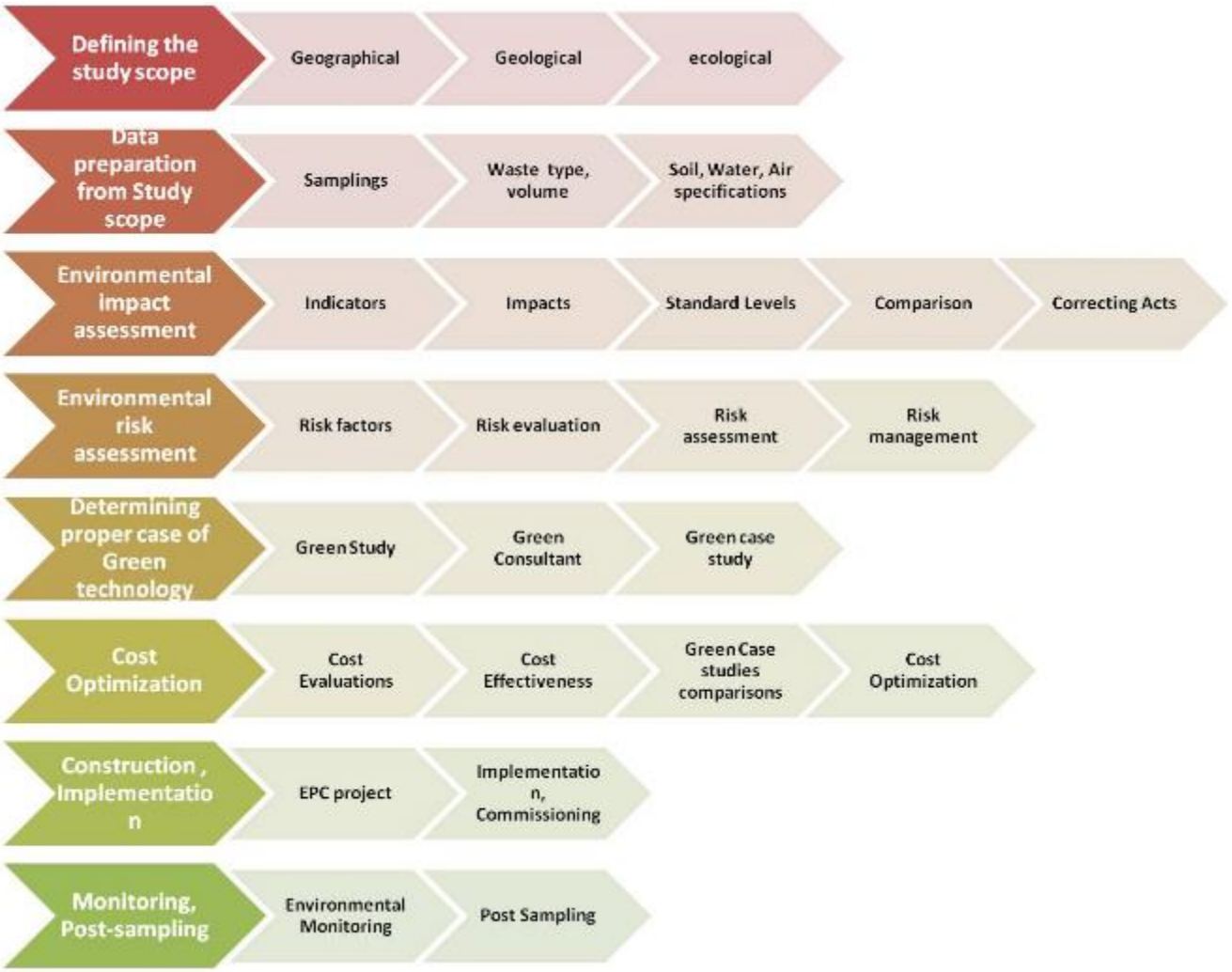

Figure 6: Time table of Green Technologies implementation in mining and drilling.

Conclusion

In this study, the green RRR methods and their applications in mining and drilling industries were studied in premise of sustainable development for challenging environmental, economical and social issues based on new technologies specifications. It is believed that Green industry generation is an integrated attitude comprising all managerial, scientific, engineering, economical and cultural fields of studies.

New approaches in environmental projects deal with from environment- to environment insights. On this basis, it is advantageous for both human and environment to perform green RRR processes as they exert less or none adverse impacts and less or none ecological changes. On other hand, they can even return some costs of operations or minimize them.

Human is the basis of sustainable development that can both be influenced by and influence on nature. In this view green industry help influences grow positive and keep harmful ones away.

In order to establish sustainable land uses integrated with industries: mining and drilling, land property definite rights, human resources, and environmental knowledge are important factors. Education and environmental awareness are expected to increase sustainability in agroforestry and also the conditions of under study land uses (Anja et al., 2013).

Also the establishment of definite possession rights in the land uses can reduce or even omit the irritating problems of cc-pp (Communized Costs and Privatized Profits) games. However, the community must not navigated toward strict environmental theories like ecofascism stating that people have to live their own lives without technologies and sustainable development lackages or even scoping on only and only the environment paying no attention to the human rights.

Some attitudes of post-modernism may be effective as the recommendation of study to prepare a well-planned and balanced strategy for environmental capitals engaged with the green RRR industries from past till now and up to future in order to manage the land use changes by passing time.

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