Chapter 33

Reclamation of Degraded Landscapes due to Opencast Mining

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/55796

1. Introduction

Even though it is regarded as a crucial economic activity worldwide, mining has a significant negative impact on environment. Due to its nature, especially opencast mining inevitably leads to serious degradation on ecological and aesthetic values of the landscape. Topography and drainage, air, soil and water quality, vegetation including forest ecosystems, noise levels and ground vibrations, human health and habitation can be listed as the typical parameters that are mainly affected by opencast mining activities. When the extraction of reserve is over, the altered landscape has to be reclaimed in order to relieve the damaging effects of opencast mining and restore the landscape and its immediate surroundings.

On the other hand, reclamation of post-mining landscapes is a very challenging task since there is no unique reclamation planning scheme for such landscapes, and it highly depends on the site-specific characteristics. Therefore, successful and sustainable reclamation requires interdisciplinary approach leading to an integrated and effective proposal to restore ecological, hydrological, aesthetic, recreational and other functions of the post-mining landscape. Different methods and approaches for the reclamation of opencast mine sites have been proposed by several disciplines such as landscape architecture, environmental and mining engineering, forestry, archeology and social sciences.

The main motivation of this chapter is to emphasize both the importance of reclamation studies and the fact that natural and cultural characteristics of the post-mining landscapes have to be considered within different point of views by various disciplines simultaneously in order to obtain the most suitable landscape use planning for such areas.

The remainder of this chapter is organized as follows. The next section gives basic overview of the effects of opencast mining activities on both environment and human health. In

Section 3, reclamation and rehabilitation are addressed within a broader perspective, including the definition of basic terminology; the aim, the importance and the necessity for the reclamation of opencast mine sites; methods and techniques; evaluation of the success of reclamation; interdisciplinary dimension of the issue; several case studies; and legislative matters as well. Finally, Section 4 concludes this chapter.

2. The effects of opencast mining activities on environment and human health

Mining is important for local and global economy, but this operation mostly and inevitably leads to substantial environmental damage and due to these kinds of activities, original potential of landscape is extremely altered.

Especially in the case of opencast mining, where a mineral is fairly close to the surface in a massive or wide tabular body, or the mineral itself is part of the surface soil or rock, surface mining methods are often considered as more economical. The most common surface mining methods such as strip mining, open pit mining, opencast mining and quarrying start from the earth’s surface and keep exposure to the surface during the extraction period. Disruption of the surface significantly affects the soil, fauna, flora and surface water, thereby influencing all types of land use. Additionally, if the operation goes further below the water table, it will affect the near-surface groundwater (Chamber of Mines of South Africa 2008).

Most surface mining methods are large scale, involving removal of massive volumes of material, including overburden, to extract the mineral deposit. Large amounts of waste can be produced in the process. Surface mining also can cause noise and disturbance, leave scars on the landscape and may pollute the air with dust (Bell and Donnelly 2006). Therefore, it is not only crucial to have a detailed understanding of the pre-mining environment, but also important to apprehend the utilized mining method in order to plan a meaningful surface rehabilitation, wherever possible (Chamber of Mines of South Africa 2008). The process of removing, storing and subsequently replacing the soil during the mining activity lead to potential problems in relation to subsequent restoration. In this respect, a major distinction should be drawn between those sites where, for operational reasons, soil has to be stored for a period of years while the mining progresses, and those, usually larger, sites where a progressive system of restoration can be practiced (Rimmer and Younger 1997).

The negative impacts of surface mining on environment can be listed as the following (Kavourides et al. 2002):

- occupation of large farming areas needed for excavation and dumping operations,
- alteration of land morphology,
- disturbance of native fauna and flora,
- modification of surface and ground water balance,
- resettlement of residential areas, roads and railways,
- release of air, liquid and solid pollutants and noise pollution.

Water resources and the quality of air are seriously modified by surface mining operations. One problem introduced during surface mining operations is groundwater, which contains dissolved salts derived from the rock that it has been in contact with, and it is characterized according to the concentrations and proportions of combinations of ions that it contains. Impacts of surface mining are often large and unpredicted such as a former zinc-copper mine polluting the environment due to cadmium leachates or a former gold-copper ore causing arsenic pollution of surface waters (Sengupta 1993; Sams and Beer 2000; Salonen et al. 2003; Bell and Donnelly 2006).

Pöykiö et al. (2002) have evaluated the impact of a chromium opencast mining complex on the ambient air environment at Kemi, Northern Finland. The total suspended particles and associated metal (Cr, Ni and Pb) concentrations in the air were determined in their study area.

Soil destruction is one of the most crucial environmental impacts of opencast mining activities. In the course of removing the desired mineral material, original soil become lost, or buried by wastes. When mining is going and has gone on, particularly top soil must be conserved because it is an essential source of seed and nutrients, and should be preserved for use in reclamation. According to Mummey et al. (2002), disturbance of soil ecosystems that disrupts normal functioning or alters the composition of soil microbial communities is potentially destructive for both short and long term ecological stability.

Surface mining speeds up erosion and sedimentation and short duration, high intensity storms can be a violent force moving thousands of tons of soil. Physical characteristics of the overburden, degree and length of slope, climate, amount and rate of rainfall, type and percentage of vegetative ground cover affect the vulnerability of strip mined land erosion (Sengupta 1993). According to the Kleeberg et al. (2008); soil erosion is frequently related to high rates of particulate phosphorus (P) transfer from land to water bodies. Providing a long term source of P for aquatic biota, and accelerating freshwater eutrophication, information on P sources is important for good environmental management. In their study, a year-long monitoring, and ten short rainfall simulations on plot scale, at ridges and rills and a combination of them, revealed high erosion from bare lignite mining dumps at Schlabendorf-North, Lusatia, Germany.

Another adverse impact of opencast mining on land is soil contamination with a range of potentially hazardous substances (both chemical and biological) which, if present at sufficiently high levels, may introduce potential problems related to public health and environment. For example, soils can contain high levels of heavy metals such as cadmium and lead, which can severely affect the local population (Kibble and Saunders 2001). So, identifying and dealing with contaminated land is important in order to support increased quality of life for communities and conservation of biodiversity (Kibblewhite 2001).

It has been recently declared by the *United States Environmental Protection Agency* (*US EPA*) that the imperfect management of wastes produced in the course of mining and reclamation works is detrimental to environmental and human health. The effect of wastes due to mining and processing activities on ecosystems can be observed in groundwater, surface water, and soil and the following points may put human health in danger (Passariello et al. 2002):

- inhalation of aerosols containing high levels of metals,
- percutaneous absorption following skin contact,
- use of contaminated water,
- consumption of food from contaminated areas.

As a result of the study of Coelho et al. (2007), it has been stated that irritating symptoms have been found in the eye mucous and respiratory system of people living near abandoned mine pits, and population in the Vila Real district, in the Northeast of Portugal have been exposed to higher level of lead and cadmium.

Razo et al. (2004) assessed the environmental impact of arsenic and heavy metal pollution of soil, sediment and surface water in the Villa de la Paz-Matehuala, San Luis Potosi in Mexico, and the results of soil samples reported high concentrations of chemicals hazardous to human health. In order to give a specific example, the maximum arsenic concentration in pluvial water storage ponds (265 $\mu g.L^{-1}$), near the main potential sources of pollution, exceed by 5 times the Mexican drinking water quality guideline (50 $\mu g.L^{-1}$).

It is a matter of necessity at this point to both emphasize and focus on the negative effects of opencast coal mining on ecosystems at a landscape level, which may not only be large scale, but also be intense.

Environmental impacts of opencast coal mining have been thoroughly investigated by many researchers and defined for the various stages of the coal fuel cycle. The "coal cycle" comprises five main activities: i) Exploration and extraction; ii) Preparation; iii) Handling and supply; iv) Conversion (where applicable); and v) Utilization, including waste disposal. The principal environmental impacts and concerns specific to exploration, extraction, and preparation phases are listed below (Buchanan and Brenkley 1994):

- Surface mines: siting; large-scale land use; overburden removal and disposal; disturbance of hydrology and run-off; acid mine drainage; visual intrusion; noise; blast vibration; fly rock; fugitive dust; transportation/traffic; high wall stability; restoration of soil fertility; recreating ecosystem diversity; recreating landscape; amenity value; historic resource preservation.
- Abandoned mines: methane migration; flooding; groundwater contamination; structural integrity; land rehabilitation.

The environmental impacts resulting from coal mining activities are mainly attributable to the exposure of decreased earth materials, especially such as coal, pyrite, siderite, and ankerite, and to the oxidizing power of the Earth's atmosphere. The consequences range from the spontaneous combustion of coal to the release of acidic waters from pyrite oxidation. If no extenuating measures are used, potentially many unpleasant environmental impacts result from surface coal mining area. A typology of the known impacts resulting from mine voids and wastes in coal mining districts has been developed, which recognizes many subcategories of impacts such as air pollution, ground deformation, water pollution and water resource depletion (Sengupta 1993; Younger 2004).

According to Ghose (2002), opencast coal mining causes much more environmental pollution especially air quality deterioration in respect of dust and gaseous pollutants. It creates air pollution problem in the mining premises and the surrounding locations. In the study, the sources of air pollution in Jharia Coalfield, Indiana were identified, and *Suspended Particulate Matter* (*SPM*) and *Respirable Particulate Matter* (*RPM*) concentrations were found to be very high in work zone as well as surrounding locations. The study emphasized that stringent air quality standards should be set for coal mining areas.

In Sokolov coal mining district in Czech Republic, total area of more than 6000 ha will have been disturbed around year 2036 at the end of mining activities. Spoil material overlying the coal layer was removed and deposited in heaps. The largest heaps formed by removal of spoil material are thousands of hectares in the area and reach elevations of more than 100 m above the original terrain (Frouz et al. 2006).

In the Lusatian mining district of eastern Germany, where 6% of the global lignite production occurred during 90s, this influence is of particular concern. Over the last hundred years 75,000 ha of land have been turned into dumps. The water balance of the whole region has been changed by groundwater pumping. Fifty percent of the dump area was not reclaimed by the year 1998. At many places recultivation efforts were impeded by extreme ecological site conditions mainly due to the high pyrite content of the spoil material (Hüttl 1998).

Xin-yi et al. (2009) investigated Yanma coal mining waste dump in China in their study. The surface layer soil around the mountain was gathered, and the heavy metal content and pH were measured out. The heavy metal (Pb, Zn, Cu, Cr, Cd) pollution situation of the soil was researched according to the distance of coal mining waste dump. As revealed out from the study, heavy metal polluted the soil in certain distance to the coal mining waste dump, and the content is in negative correlation with the distance to the coal mining waste dump.

Bell et al. (2001) studied the environmental degradation associated with the abandoned Middelburg Colliery in the Witbank Coalfield, South Africa. The chemical composition of spoil materials of the mine mainly consist of two principal oxides: silica and alumina; calcium, magnesium, iron, sodium, potassium, and titanium oxides are also present in small concentrations. Pyrite takes place in the shales and coal of the spoil heaps, and its contact with air gives a toxic nature to soil heaps, which is not in favor of healthy vegetation growth and plant life.

The chemistry of groundwater in contact with coal mine workings may change due to reactions with iron pyrite, which may result either from oxidation of pyritic materials increasing the acidity of the water, or from dissolution of soluble salts in the spoil, overburden, or increasing levels of dissolved solids in the water. The oxidation process requires that both air and water come in contact with pyritic materials, whereas air is not required for dissolution of soluble salts. As a result of these chemical changes, groundwater becomes highly ferruginous and often has a low pH value, and hence it is referred to as *acid mine drainage*, which can be toxic due to high values of sulphate and increased levels of heavy metals. Where this groundwater flows into surface watercourses, the latter may become grossly polluted, and it may also cause other problems such as faults and subsidence being reactivated or the displacement and emergence of mine gases into the environment. *Acid mine drainage* is a significant, unremedied environmental problem which deteriorates surface and ground water quality. Also, it is of value to notice that some of the closed mine sites under investigation still cause severe environmental degradation due to metal load resulting in disruption of fish and algae growth (Sengupta, 1993; Sams and Beer, 2000; Salonen et al, 2003; Bell and Donnelly, 2006).

In the case of Britain, most coal field areas have been closed and mine water pumping has stopped. As a result, the emission of ferruginous effluents and *acid mine drainage* from the various exits to mines due to groundwater rebound are two of the most remarkable effects of coal mine closure (Bell and Donnelly, 2006). In Adak, located in the Vasterbotten district in northern Sweden, surface water, sediment and soil samples contain higher concentrations of As, Cu, Fe and Zn, compared to the target and intervention limits set by international regulatory agencies (Bhattacharya et al. 2006).

Studies of both Song et al. (1997) in Daesong coal mine, Keumsan in South Korea and Sams and Beer (2000) along the Allegheny and Monongahela rivers in the US including their sub-basins revealed the extent of polluted area by *acid mine drainage* due to upward trends in sulphate concentrations. These trends appear to be related to increase in coal production.

Klukanova and Rapant (1999) showed that waters draining freely from the mines transport large amounts of toxic elements into surface streams which contaminate broader surroundings in the Handlova–Cigel brown coal district, Slovakia. The results from monitored localities indicated that long-term mining activities adversely influence the environment. Although during the past decades or centuries many of these effects may have been reduced or eliminated, such as in old dumps that were covered by vegetation and where their toxic elements washed out to become part of present-day environment. However, many past mining activities cause environmental problems even today, and they must be mapped and monitored.

In order to have detailed knowledge on the extent of impacts of opencast mining, site assessment is necessary and various kinds of investigations should be explored in order to choose the best technique for the environmental reclamation. Various analysis techniques, sampling and modeling schemes have been proposed and applied by researchers and according to Cuccu (2002), judgmental sampling, systematic and regular grid sampling, simple random sampling, stratified sampling, ranked set sampling, composite sampling can all be used as sampling method, and the techniques to achieve sampling operations may differ in function of number of sampling area and geometric features of sampling location.

Navarro et al. (2004) have carried out field and laboratory studies in order to investigate soil contamination derived from past mining activity in the Sierra Almagrera district in southeast Spain. According to the study, the tailings, soil and sediment samples that were collected showed high concentrations of Ag, As, Ba, Cu, Pb, Sb and Zn when analyzed.

Navarro et al. (2008) evaluated the dispersion and influence of soluble and particulate metals present in the materials from an abandoned mine, Cabezo Rajao, in Spain. Tailings and soils were sampled and analyzed for pH, EC, CaCO3, grain size, mineralogical composition and heavy metal content, while water samples were collected and analyzed for pH, EC, soluble metals and salts. A total of eighteen sampling stations were selected from Cabezo Rajao mining site, to be representative of the different soils or waste material types present at the site. Solid samples were air dried and sieved to < 2 mm for general analytical determinations. Equivalent calcium carbonate was determined by the volumetric method using a Bernard calcimeter. Textural analysis was performed after dispersion of the fine soil and by combining extraction by Robinson pipette and sieving, and the mineralogical composition of the samples was determined by X-ray diffraction analysis.

In the study conducted by Jun-bao et al. (2002) in the Fushun coal mine, the northeast China, the spatiotemporal variation of heavy metal element content in reclamation soil was studied and grid method was used in order to sample covering soil at the test field. The soil samples were taken at different locations, including three kinds of covering soil, three different depths of soil layers and four different covering ages of covering soil.

Komnitsas and Modis (2006) aim to map As and Zn contamination and assess the risk for agricultural soils in a wider disposal site containing wastes derived from coal beneficiation in coal mining region of Tula, south of Moscow, Russia. Geochemical data related to environmental studies show that the waste characteristics favor solubilization and mobilization of inorganic contaminants and in some cases the generation of acidic leachates. 135 soil samples were collected from a depth of 20 cm using a 500 m x 500 m grid and analyzed by using geostatistics under the maximum entropy principle in order to produce risk assessment maps and estimate the probability of soil contamination. The samples were oven dried, sieved, ground, dissolved in aqua regia and analyzed for 23 inorganic elements by atomic absorption spectrophotometry.

All types of opencast mining have serious impact on all landscape components and functions, leading to significant alteration of the original landscape, which is actually a subcategory of cultural landscape. Once mining operations start, the landscape development in progress is disturbed, the original ecosystems are removed, the topography is significantly altered, the basic ecological relations are unchangeably disrupted, and biodiversity is decreased. These factors consequently lead to total ecological destabilization, elimination of the aesthetic values and decrease in the recreational potential of the landscape. Therefore, post-mining landscapes are often called "*landscapes without a memory*", which gives landscape architects one of the few opportunities in order to create a new landscape that will rapidly improve the visual quality of a region. (Sklenicka et al. 2004; Sklenicka and Kasparova 2008).

As a result of the aforementioned changes in the ecosystem, disturbance on nourishment and energy flows is inevitable, which mostly leads to devastation of the ecosystem. When viewed in the landscape planning perspective, landscape evaluation can be considered as a management tool and the first thing to consider is to decide for which purpose the landscape will be used. Then, the implementation of reclamation should be carried out by taking the basic rules of ecology into account. In case of having connected habitats, a small portion of land may serve as a healthy ecosystem. The impacts of mining on the social and environmental structure are mostly long-term and closely associated with the social level of the local society (Gillarova and Pecharova 2009).

3. Reclamation of opencast mine sites

It's crucial to make a mine disturbed land environmentally stable in order to transfer an unpolluted environment and natural resources to the next generations. However, when a demolished land is left with its own, it may take years and years to recover and reach an ecological balance. During this period, these types of lands need human hand for reclamation and recovery. Therefore, post-mining reclamation works are those aiming to regain landscape's fertility, its ecologic, economic and esthetic values (Akpınar, 2005).

3.1. Basic terminology

There are different terms that have been used for reclamation such as *rehabilitation*, *restoration* and *recultivation*. Whereas these terms are mostly used interchangeably, there are obviously some fine differences in meaning.

Restoration is used as "the act of restoring to a former state or position or to an unimpaired or perfect condition". To restore means "*to bring back to the original state or to a healthy or vigorous state*". This usage implies returning to an original state and to a state that is perfect and healthy. On both sides of the Atlantic, the word is used in that way. Rehabilitation is "*the action of restoring a thing to a previous condition or status*". This may sound similar to restoration; however, there is little or no implication of perfection. In common usage, something that is rehabilitated is not expected to be in as original or healthy state as if it had been restored. Remediation is the act of remedying. To remedy is "*to rectify, to make good*". There is more emphasis on the process rather than on the endpoint reached. Reclamation is used particularly in Britain but also in North America. It is defined as "*the making of land fit for cultivation*". However, to reclaim is defined as "*to bring back to a proper state*". This definition does not imply returning to an original state but rather to a useful one. Replacement is, therefore, a possible alternative option. To replace is "*to provide or procure a substitute or equivalent in place of*" (although an alternative meaning is to restore). Mitigation is a word often used when restoration is considered. It is important to note that it is nothing to do with restoration. To mitigate means "*to appease or to moderate the heinousness of something*" (Bradshaw, 1996).

Three categories of remedial treatment have been defined by the National Academy of Sciences, America: "*Rehabilitation:* The land is returned to a form and productivity in conformity with a prior land-use plan with a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values."; "*Reclamation:* The site is hospitable to organisms that were originally present or others that approximate the original inhabitants."; "*Restoration:* The condition of the site at the time of disturbance is replicated after the action.". According to these definitions*:* i) *rehabilitation* usually allows the greatest flexibility in future land use and incurs the least cost; ii) *reclamation* means that the pre- and post-disturbance land uses are nearly the same; and iii) *restoration* allows no land use flexibility and results in the greatest cost (Sahu and Dash, 2011).

In British terminology, "*restoration* means the return of newly mined land to post-mining productivity, whereas *reclamation* means the recovery of derelict land (abandoned industrial land including that from mining) to usefulness. American usage of the word *restoration* has caused it to mean a strict replication of conditions existing before mining." (Saperstein 1990).

According to Del Tredici (2008), "*restoration* has inherent assumptions stating that it is both possible and desirable to establish some portion of the original ecological conditions of a site. People in favor of following strict restoration guidelines have to answer two very difficult questions: i) to what former time period should the site be restored? And ii) how should one deal with the imponderable environmental changes affecting the site? On the other hand, *reclamation*, also referred to as *revitalization*, assumes that there is no ecologic time travel to an earlier state of the site. Instead, to minimize the negative impacts of the site on the surrounding environment and to maximize its aesthetic and ecological functionally are the main objectives of reclamation projects, which are usually large scale and heavily disturbed".

3.2. Aim, importance and necessity of reclamation

A rational reclamation objective should not only aim to create a permanently stable landscape that is both aesthetically and environmentally compatible with surrounding undisturbed lands, but also take into consideration aesthetics, intended use, and versatility when shaping the land in order to construct a land resource with both maximum feasible utility and versatility for future generations. Even though the approximate original contour as a minimum condition is generally required by reclamation regulations, there can be cases where variance from that is allowed as long as desirable results are guaranteed (Jansen and Melsted 1988; Sengupta 1993).

Within the frame of remediation of a contaminated land, either the minimization of actual or potential environment threat, or the reduction of potential risks to acceptable levels are the main goals, which can be accomplished by applying one or more of the following (Wood 1997; 2001):

- elimination of the hazard by removal or treatment/modification of the contaminant,
- control of the hazard by isolation or separation of the contaminant,
- interruption of the pathway of contaminant movement and exposure,
- protection or removal of the receptor (essentially involving an interruption of the pathway).

When viewed in mine reclamation perspective, the fundamental objectives are given as (Cao 2007):

- to eliminate health and safety hazards (i.e., removal of all facilities and structures threatening human health and safety),
- to restore impacted land and water resources (i.e., progressive re-vegetation and stabilization of residues to reduce potential of acid mine drainage or water contamination),
- to eliminate off-site environmental impacts (i.e., cleaning up sites to conform to the community's surrounding landscape),
- to ensure that post-mining land has a feasible self-sustaining future with respect to both environmental and socio-economic benefits (i.e., developing publicly owned land for recreation, historic purposes, conservation purposes, or open space benefits, or for constructing public facilities in communities),
- to encourage better use of energy and natural resources, and to guarantee sustained mining operations.

Mining and land development are closely linked in the dynamic and integrative process addressed by a range of environmental, production, aesthetic, land use, and economic issues related within the reclamation planning objectives. This process, whose outline is briefly given below, starts at the opening of a mine operation and terminates at the closure of the mine, which may take five to fifty years (Bauer, 2000):

- build a mine environment compatible with neighboring land uses during the whole mine operation,
- maximize access to aggregate resources on the site,
- use all unique deposit features created by the mining operation in shaping new landscapes,
- employ non-aggregate earth materials such as overburden, clay deposits, and mine waste in building and shaping land forms,
- use available earth moving equipment and earth moving procedures efficiently for reclaiming the mine site, without interfering with ongoing mining operations,
- develop a coordinated and sequential program of mining, earth moving, land shaping, and landscaping to ensure that lands are prepared for development as mining progresses through the deposit.

3.3. Methods and techniques for reclamation

The process of choosing the most appropriate technique for the reclamation is often a painstaking task, and many economic and operational parameters (i.e., process applicability, effectiveness and costs, process development status and availability and operational requirements) should be taken into account, as well as several additional factors such as process limitations, monitoring needs, potential environmental impact, health and safety needs and post-treatment management requirements (Wood 1997). Additionally, large extend of areas within the mining and industrial structures (i.e., traffic network, electricity grid, pipelines, canalization streams, storage areas, industrial parks etc.) also increase the complexity of rehabilitation works, and restrain the possibilities (Prikryl et al. 2002).

In reclamation of post-mining landscapes, there are generally two basic motives: determinism and contingency, and the processes related with the former are mostly considered. Several factors associated with the latter have also significant role on the success of the reclamation, and these factors are often unpredictable and can be grouped in four categories: i) Initial conditions (natural climate and topography, type and abundance of topsoil); ii) Natural perturbations (droughts, extreme rainfall events, frost periods, pests); iii) Influence of the surrounding ecosystems and people (runoff and sediment flows, grazing, hunting, land uses); and iv) Human contingencies (modification/intermittence of mining operations; mistakes in the performance of reclamation works; changes in legal rules, etc.). Additionally, it is necessary to consider the reclaimed areas as open ecosystems that interact with their surrounding environment, so landscaping schemes and reclamation work must be included in any proposal for the development of a mine that broadly evaluates the impacts of open mine sites on local residents, the landscape and the environment. The following points should be considered to improve the performance of opencast mine reclamation (Bell and Donnelly 2006; Ibarra and de las Heras 2005):

- simultaneous integration of mining and reclamation activities to optimize the opportunities offered by mining operations,
- interactive development of reclamation projects by all actors and to have a consensus on the final objectives for the reclaimed areas,
- specific research to acquire detailed knowledge about the reference ecosystem in order to adopt the general protocols for reclamation to local conditions,
- plan for monitoring and survey to check, improve, or redirect the applied practices.

For achievable and sustainable reclamation, detailed information on various important factors, classified as either natural or cultural, is required during the post-mining land use planning, and they are listed in Table 1 (Ramani et al. 1990):

Naturally, not every mine has the same motives and methods for site rehabilitation, and it is important to point out that it is not feasible to restore all mine sites due to economic and operational considerations. However, even though disturbed by mining activities, all post-mining lands eventually inherit some economic, recreational and esthetic potential. Hence, discovering the unique potential of mined land and choosing appropriate methods and measures, which actually form the core of reclamation, are necessary for the successful transformation of this potential into a sustained capability. In order to obtain satisfactory results in reclamation, special attention must be paid to the post-mining use of the land and its potential functions (i.e., pasture, hayland, recreational areas, wildlife habitat, wetlands, fishing ponds etc.), together with the implementation of environmental conservation and land reclamation programs to minimize the negative environmental effects (Cao 2007; Kavourides et al. 2002; Saperstein 1990).

I. NATURAL FACTORS **A. Topography** 1. Relief 2. Slope **B. Climate** 1. Precipitation 2. Wind-airflow patterns, intensity 3. Humidity 4. Temperature 5. Climate type 6. Growing season 7. Microclimatic characteristics **C. Altitude** **D. Exposure (aspect)** **E. Hydrology** 1. Surface hydrology a. watershed consideration b. flood plain delineations c. surface drainage patterns d. amount and quality of runoffs 2. Ground water hydrology a. ground water table b. aquifers c. amount and quality of ground water flows d. recharge potential **F. Geology** 1. Stratigraphy 2. Structure 3. Geomorphology 4. Chemical nature of overburden 5. Coal characterization **G. Soil** 1. Agricultural characteristics a. texture b. structure c. organic matter content d. moisture content e. permeability f. pH g. depth to bedrock h. color 2. Engineering characteristics a. shrink-swell potential b. wetness c. depth to bedrock d. erodibility e. slope f. bearing capacity g. organic layers	**H. Terrestrial ecology** 1. Natural vegetation, characterization, identification of survival needs 2. Crops 3. Game animals 4. Resident and migratory birds 5. Rare and endangered species **I. Aquatic ecology** 1. Aquatic animals-fish; water birds, resident and migratory 2. Aquatic plants 3. Characterization, use, and survival needs of aquatic life system **II. CULTURAL FACTORS** **A. Location** **B. Accessibility** 1. Travel distance 2. Travel time 3. Transportation networks **C. Size and shape of the site** **D. Surrounding land use** 1. Current 2. Historical 3. Land use plans 4. Zoning ordinances **E. Land ownership** 1. Public 2. Industry 3. Private **F. Type, intensity, and value of use** 1. Agriculture 2. Forestry 3. Recreational 4. Residential 5. Commercial 6. Industrial 7. Institutional 8. Transportation/Utilities 9. Water **G. Population characteristics** 1. Population 2. Population shift 3. Density 4. Age distribution 5. Number of households 6. Household size 7. Average income 8. Employment 9. Educational levels

Table 1. Required information for reclamation and postmining land use planning (Ramani et al. 1990)

Since it is inevitable to have various mutual associates (i.e., companies, state and local agencies, as well as special interest groups and general public) in the planning of surface mines, the major objective is to preserve or enhance the long term use of the land within an integrated mining, reclamation, and land use planning concept that accounts for the interactions that must take place between the various levels of land use planners. A sample framework of such a plan is illustrated in Figure 1 (Ramani et al. 1990).

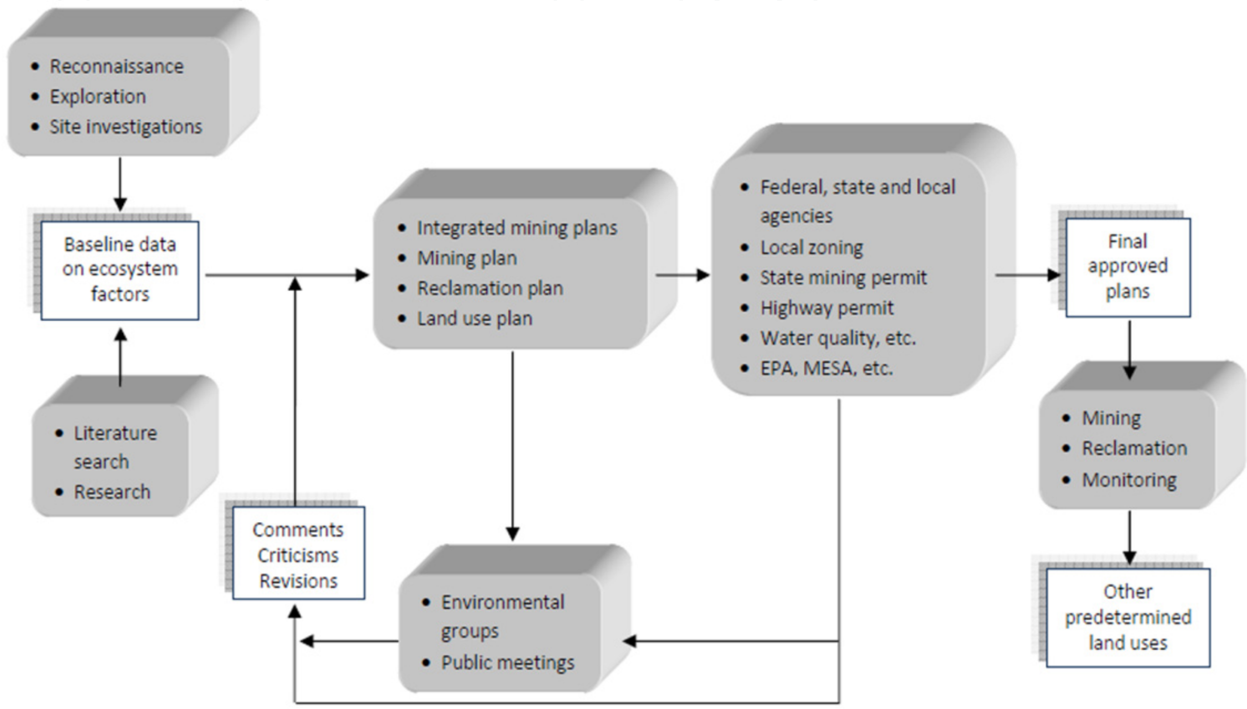

Figure 1. Process of the integration of surface mining, reclamation, and land use planning (Ramani et al. 1990)

Rearrangement and rehabilitation works, which may be either to remove the visual effects of an existing mine site or to reduce the impact of a new mine site to a lowest degree, should be planned before starting operation and carried out in parallel with mining activities. By this way, reclamation can be implemented in a more economical way with minimum cost. During the planning of rehabilitation works, research for land use and purpose of use for the reclaimed land are crucial (Akpınar et al. 1993), and this type of landscape planning should fulfill some or all of the following general conditions (Fanuscu 1999; Görcelioğlu 2002):

- During mining operations:
  - to minimize the visual impact at lowest possible degree,
  - to take the necessary landscape planning measures against noise and dust contamination.
- Subsequent to mining operations:
  - to carry out an effective and economic rehabilitation in order to have an efficient post-mining utilization,
  - to reform the land in accordance with the final scope of use within the frame of available resources,

- to rehabilitate the lower layer material, which has been dug up and is inappropriate for vegetation,
- to take replantation and post-mining land use issues into account.

According to Akpınar et al. (1993), rearrangement and rehabilitation works on degraded areas due to mining activities are carried out in four main steps: i) *post-mining land use planning*; ii) *rearrangement* within the frame of existing land use plan (excavation, dumping, water regime control, removing and laying out of top soil separately etc.); iii) *rehabilitation* (biological reclamation); and iv) *monitoring* and *maintenance*.

One of the main aims of reclamation is to restore the land use capability of disturbed landscape; within this context, reclamation planning is necessary and strictly related to *land use planning*. Substantial deformation of the topographic structure of the landscape, loss of fertile top soil, detriment in the flora and fauna; reduction of such negative effects to a minimum level or complete removal of them are achieved by *landscape use planning*, which is the first stage of the landscape restoration studies.

Landscape use planning, briefly, is to investigate a landscape in point of different aspects and research its availability for the proposed purpose of use. Such plans ensure an optimum utilization of resources by either preservation of environmental values or reducing harmful effects. Re-establishing the balance between ecology and economy in order to decrease the inevitable environmental problems at a minimum level caused by mining, reconstructing the disturbed ecosystem and introducing the possible new uses according to the needs of dwellers are among the main concerns of *landscape use planning*. These studies are part of the reclamation work and begin with planning of all mining activities, then continue during the whole production process. At the beginning, preliminary decisions about the post-mining land use of region are made. This initial plan constitutes the base for detailed decisions to be made later and provides a chance for preliminary evaluation (Akpınar et al. 1993).

Potential future use of the post-mining lands basically depends on the nature of the land, soil conditions, and communal structure of nearby surrounding to be rehabilitated by technical, biological, agricultural means or forestry applications. The followings are the potential land use types that follow successful land reclamation (Görcelioğlu 2002; Topay et al. 2007; Tshivhandekano 2004):

- The original land use,
- Afforestation, forestry,
- Agriculture,
- Nature conservation and wildlife,
- Hydrology,
- Recreation,
- Site improving,
- Special reserve,
- Settlement or industry,
- Solid waste or rubble storage area.

Rearrangement includes excavation and dumping according to the planning, stable design of dump sites and chamfers with proper slope and elevation, laying out of top humus layer and fertile soil right beneath it either directly or later, grading, drainage and water regime control, constructing surrounding drainage channels against floods, and constructing infrastructure and road network; whereas *rehabilitation* comprises improvement of soil conditions and re-vegetation on topographically graded lands (Akpınar et al., 1993).

Factors related to soil and climatic conditions play significant role in the reclamation of post-mining lands. Although it is easy to modify soil factors, it is practically impossible to manipulate the climatic factors except for those related to moisture (i.e., irrigation for water-deficient periods and drainage for water excess periods). Since the climatic adaptation of plants to a certain specific region is one of the major concerns for the fulfillment of reclamation objectives, a special attention must be paid to climate when selecting plants for erosion control and targeted land uses (Powell 1988).

Since there is an urgent need for soil reconstruction and restoration of productive and functional soil plant systems on abandoned and degraded opencast mine sites, soil improvement is an indispensable stage of any reclamation process, where geological substrate, slope and type of reclamation are the key determinants. The whole process consists of a sequence of interrelated stages: i) application of additives, ii) spreading and defraying organic materials, and iii) fertilizing crop rotation. It has also be noted that Mg and Ca amounts, absorption capacity, and available humus forms of the soil horizons should be carefully analyzed in deciding which type of plant is more appropriate (i.e., deciduous or coniferous) (Hendrychova 2008).

Vegetation cover has some significant functions on post-mining landscapes in different ways by i) modifying the surface characteristics, ii) controlling the erosion and reducing slope failures, iii) lessening stream sedimentation, and iv) restoring the beauty and productivity of the land (Schor and Gray 2007; Hutnik and McKee 1990). So, in order to reduce the probability of negative consequences, selection of suitable plant material, which may be either native or introduced plant species, is critical. Additionally, the planners should not only take site specific conditions under consideration, but also pay special attention to those points during vegetation establishment, as will be explained now compactly (Hutnik and McKee 1990; Powell 1988):

- it should be considered as an integral part of the mining and reclamation process,
- appropriate methods should be chosen according to the aim of re-vegetation and the plant species used,
- local variations in climate, geology, and soils should be considered.

Basic knowledge about both biotic and abiotic factors, as well as ecological processes is necessary to reduce the time period needed for creating the favorable soil characteristics required for prosperous biological reclamation. The properties of the reconstructed soils should be analyzed since the structure of future ecosystem highly depends on physical and chemical soil characteristics, which directly affect the amounts of available resources (i.e., nutrient levels), initial species establishment, and long-term successional trends (Hendrychova 2008).

After a proper *rearrangement* and *rehabilitation* work, an additional time is needed to ensure a fertile use of land. At this stage, *monitoring, maintenance* and *controlling* of many environmental and ecologic parameters (i.e., water quality, drainage, vegetation growth, soil condition, erosion etc.) closely associated with the restoration site are essential to improve the quality of the restoration (Akpınar 2005).

Mining activities definitely have long-term impacts on terrestrial ecosystems: i) land degradation, ii) deforestation, iii) loss of fertile topsoil, iv) change in topography and hydrologic conditions, and v) pollution of usable surface and ground water (Tören 2002). So, monitoring and management of post-mining environment are necessary to evaluate the environmental impacts and long term behaviors of post-mining landscapes, and they should be handled with in the perspective of a well-planned environmental policy. Besides, even during any remediation process, adequate quality control measures are also needed to ensure that the methodology conforms to specification or that treatment targets have been achieved. In many cases, environmental monitoring is required while remediation is still in progress. These objectives naturally imply the utilization of scientific methodology, particularly, when field data is unavailable or insufficient (Hancock et al. 2006; Wood 1997).

The basic principles of the environmental management policy for reclamation are given as (Kavourides et al. 2002):

- knowledge of the local environmental conditions,
- selection of the proper methods and techniques of land reclamation,
- general land-planning for the areas under reclamation (land use map),
- systematic realization of the environmental protection and restoration programs according to the environmental terms determined by the Ministry,
- monitoring and evaluation of the environmental restoration results by geographic information systems (GIS).

Reclamation studies often require the integration of multi-source data acquired by different sources of diverse technical and operational characteristics (Kyzeridi et al. 2002). Such data is mostly in both time and spatial domains. So, use of GIS incorporated with remote sensing (RS) technologies provides a suitable platform for the monitoring and the management of reclamation, since it offers unique capabilities for editing, managing, analyzing and automating different kinds of spatial data required for decision making (Bruns and Sweet 2004; Chevrel et al. 2001; Chevrel et al. 2002; Smyth and Dearden 1998; Ganas et al. 2004).

GIS-based decision support systems have many potential applications in reclamation: i) to derive computer-based landscape evolution models for better understanding of geomorphic landscape process in reclamation (Hancock 2004), ii) to evaluate the future development of terrestrial ecosystem under the extreme environmental conditions of post-mining landscapes (Hüttl 1998), iii) to reduce the cost of spoil handling during mining and reclamation (Harwood and Thames 1988), iv) to detect reclamation sites and to measure the impacts of increasing land degradation (Gorokhovich et al. 2003; Hladnik 2005), and v) to increase sophistication of mining industry in rehabilitation practices (Hancock 2004).

3.4. Evaluating the success of reclamation

Restoration of a landscape disturbed by opencast mining operations is mostly viewed in technical or economic perspectives only. Even though the public focused only on the forestry and agricultural aspects of restoration previously, there has been a recent interest in nature conservation and recreation. In order to restore ecological, hydrological, aesthetic, production, recreational and other functions of the post-mining area, a sustainable land use development plan should be prepared through a holistic approach (Sklenicka and Kasparova 2008).

Three basic goals that any restoration plan should reach are given as (Powell 1988):

- stabilization of newly reclaimed lands against accelerated wind and/or water erosion,
- development of target specific re-vegetation programs,
- achievable and sustainable land use by enforcing certain minimum performance standards.

The evaluation of restoration success is a tough issue, since it strictly depends on the character of the post-mining land, inherent features of ecological species involved, and the main objectives of the restoration operation. According to Pecharova et al. (2011), the process should allow spontaneous succession, or use technical restoration by sowing or planting target species and restoring or improving the site conditions.

The *Society for Ecological Restoration International* addresses the same issue by taking 9 ecosystem-related parameters under consideration to measure the restoration success (Hendrychova 2008):

- similar diversity and community structure in comparison with reference sites,
- presence of local species,
- functional groups necessary for long-term stability,
- capacity of the physical environment to sustain viable populations,
- regular functioning,
- integration with the landscape,
- removal of potential threats,
- resilience to natural disturbances,
- self-sustainability.

3.5. Interdisciplinary dimension of reclamation

All mining operations, due to their nature, have negative impacts on the cultural landscape. And opencast mining activities are not an exception, as they drastically change the former dynamic equilibrium of the landscape, leading to the formation of new ecosystems. Only the vegetation establishment by itself is not a proper approach. Instead, sustainable establishment of new ecosystems in the post-mining areas should be seen as an interdisciplinary challenge, in which the active participation of both science and society is highly required (Hüttl and Gerwin 2005).

The negative visual impact of the mining sites unavoidably lowers the aesthetic value of the landscape and its surroundings. So, post-mining landscape planning and rehabilitation activities should strictly consider the previous aesthetic characteristics of the land and their future development within an interdisciplinary approach (Sklenicka and Kasparova 2008).

As important as the interdisciplinary dimension of the issue, all mutual associates such as stakeholders, state officials and laws, environmental groups, engineers, landscape architectures, ecological experts, soil and social scientists should be "creatively" involved in the planning phase (Miao and Mars 2000; Saperstein 1990). By this way, significant social and environmental gains can be obtained by improving the conditions of post-mining landscapes through a relatively small investment (Garavan et.al. 2008).

When building up such a "project team", scale of the project and its complexity, special issues, and the clients' demands are the key factors to get the best results. For projects that require permitting and the preparation of mining and reclamation documents, landscape architects, mine operators, geologists, hydro-geologists, and civil engineers are possible candidates for the team (Bauer 2000).

The involvement of landscape architects in the industry has increased steadily and their role has gone far beyond the "traditional boundaries" of the profession; commonly and mistakenly thought as basic beautification and site planning duties. Based on their education and experiences, landscape architects now can easily deal with more complex sequential mining and reclamation plans, including site analysis, site and land use planning, visual analysis, grading, zoning, re-vegetation, slope stabilization, etc. They also play active roles in the permitting, regulatory, environmental assessment and community relation processes. The form, the function and the purpose of post mine landscape planning should be considered within earth science issues by landscape architects. By this way, they can approach the issue with more systematic and comprehensive manner. Landscape architects should aim to develop integrated multi-scale design approaches not only to be an equal partner in the planning process, but also to be in a position to direct the project team and undertake the responsibility for the success of reclamation planning (Arbogast 2008; Bauer 2000).

For a landscape architecture, a working knowledge on the following three points is essential for the understanding and success of reclamation planning services (Bauer 2000): i) components of mining processes associated with reclamation, ii) geologic complexities and structures within each aggregate deposit, and iii) mechanics and procedures for incorporating the mining procedures with reclamation activities. Table 2 overviews the mine reclamation studies within a multidisciplinary point of view.

Mine Planning Phase	**Planning Activities**	**Areas of Specialization**
Legal requirements analysis	Identification of regulatory constraints related to land use	Land use planner Attorney or paralegal specialist
Land and reserve acquisition	Prepare land use / land cover maps Prepare land ownership map	Land use planner Landscape architect Photogrammetrist/cartographer Plant biologist Photogrammetrist/cartographer Surveyor
Market development	Check market potential of site	Geographer Transportation engineer Land use planner
Financial evaluation	Check if land development potential of the site will justify reclamation to a higher, more costly land use	Engineering economist Land use planner Real estate specialist Fiscal planner
Coal beneficiation studies and plant design	Determine the impact of waste disposal on the Postmining uses of land	Mineral processing engineer Environmental engineer Landscape architect Agronomist Geologist Hydrologist
Environmental impact studies	Evaluate the impact mining will have on the site with respect to capability and productivity	Mining engineer Environmental engineer Forest engineer Agronomist Geologist Hydrogeologist Terrestrial ecologist Plant biologist Agricultural engineer Archeologist Landscape architect Land use planner Social scientist
Preliminary mine planning	Preliminary identification of postmining land uses	Mining engineer Land use planner Landscape architect Agronomist Engineering economist
Permits acquisition	Land use information and postmining land use plan	Mining engineer Land use planner Environmental engineer Agronomist

Mine Planning Phase	Planning Activities	Areas of Specialization
Administrative detail analysis	Submitted / approval of final land use plan	Agricultural engineer Hydrogeologist Plant biologist Engineering economist
Detailed mine planning	Detailed land use plan design	Land use planner (specifically landscape architect) Mining engineer Environmental engineer Civil engineer Agricultural engineer Agronomist Hydrogeologist Plant biologist Engineering economist

Table 2. The areas of technical expertise essential in pre-mining (Adapted from Ramani et.al. 1990; Şimşir et al. 2007)

3.6. Case studies of reclamation

In the 20th century, rapid developments and new innovations in the technology and the machinery used in the mining industry have changed the whole face of landscape modification in all large mining districts of the world. Common problems in such post-mining areas are the increase in water surface area and the acid mine drainage, leading to severe site conditions. Hence, prior to any reclamation study, site specific conditions due to previous mining activities should be taken into account, and the plans toward sustainable ecosystem development should be prepared accordingly. Additionally, soil fauna, mechanisms of plant succession and site specific biocoenosis should be investigated thoroughly for the successful establishment of terrestrial ecosystems on post-mining sites (Hüttl and Gerwin 2005).

Flambeau Mine, located in Wisconsin, is one of the prominent examples for the application of sustainable development principles and implementation of twenty first century materials and engineering technology to reclamation of post-mining landscapes. The implementation of sustainable development at Flambeau Mine has four main pillars: i) economic prosperity, ii) environmental protection, iii) social and community well-being, and iv) governance. The design is based upon a collaborative approach from overlapping disciplines. In addition to traditional engineers and architects, community planners, transportation planners, biodiversity specialists, energy efficiency specialists (e.g. green building) and landscape architects all contribute to the master design. The key to a successful design is to meld the wants and needs of the community with the various ideas and designs from the design team (Cherry 2008).

The study was designed, constructed, operated, and reclaimed in the 1990s. Reclamation of the site began during the fall of 1996 with the initiation of sequential backfilling of the open pit, which was substantially complete by the fall of 1997. During 1998, the contours of the site were reestablished, topsoil replaced, wetlands constructed, and seeding and planting were initiated. The majority of seeding and planting was completed by year and 1999. Additionally the design constructed hiking, biking and equestrian trails for public recreational use. The pre-mining, active mining, and reclaimed site are shown in Figure 2 for a chronological comparison (Fox 2002 ; Cherry 2008).

Figure 2. Flambeau Mine Site: a) before mining (1991), b) during mining (1996), and c) after mining (2002) (Fox 2002)

The reclamation of the Flambeau Mine has included (Flambeau Reclaimed 2012):

- returning the site to its original approximate contours,
- planting clusters of trees to attract and support wildlife habitats,
- creating and restoring over 10 acres of wetland on site,
- creating over 120 acres of grassland habitat,
- constructing four miles of trails for non-motorized recreational activities.

The completion of surface contouring and return of the topsoil in 1998 were followed by the planting of native plant species necessary for the creation of prairie grasslands, woodlands and wetlands. In order to monitor and evaluate the success of the reclamation, 300 locations were randomly selected across the reclaimed Flambeau Mine. At these locations, necessary studies are performed each year in order to observe whether the performance standards (i.e., vegetative cover, planted native species, diversity and woody species survival) are met. In 2001, all necessary standards were met at the reclaimed mine site, which allowed the submittal of the *Notice of Completion to the Wisconsin Department of Natural Resources*. Recent surveys show a fully utilized wildlife at the reclaimed site, which provides unique and critical habitat, particularly for grassland bird species (Flambeau Reclaimed 2012).

Another outstanding example is Jarrahdale in Australia. The mining operations for bauxite at Jarrahdele started in 1963 and continued until 1998. During this period, over 160 million tons of ore was mined. Site rehabilitation studies continued for another 3 years. By 2001, all mined areas, haul roads and building sites were completely rehabilitated (Figure 3) (Alcoa 2012).

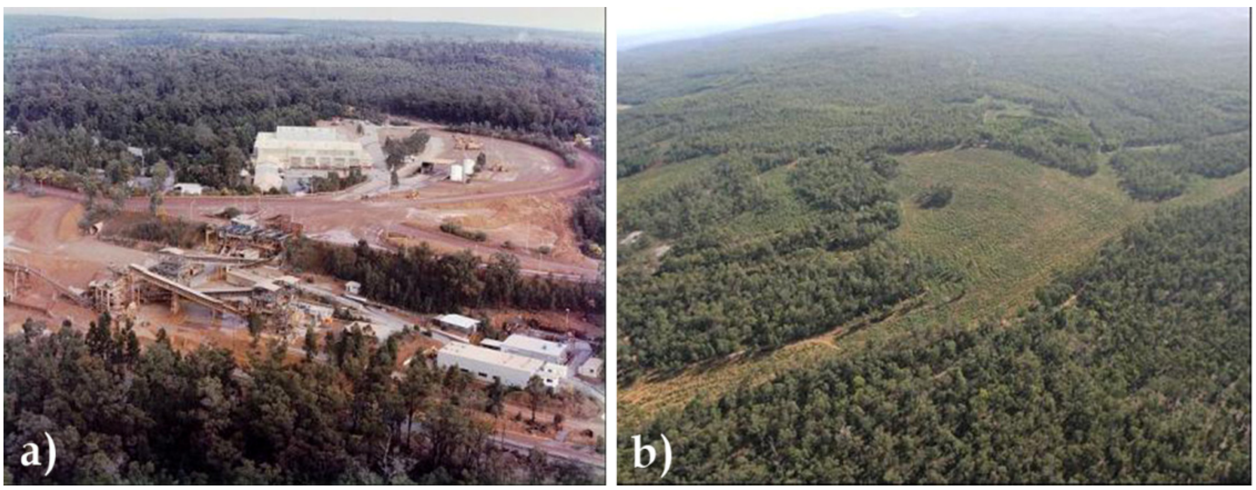

Figure 3. a) The original Jarrahdale crusher circle before its closure in 1998, and b) the same crusher circle site at Jarrahdale, after rehabilitation has been completed (Alcao 2012)

As shown in Figure 4, reclaimed mine sites are returned to productive use in a variety of ways that will serve for future generations.

Figure 4. A site reclaimed by Starvaggi Industries in West Virginia is developed into the Star Lake Amphitheater: a) post-mining landscape, b) after the reclamation (Mineral Information Institute 2012)

In Turkey, reclamation of abandoned mine sites is generally carried out in the form afforestation (Figure 5 and 6).

Figure 5. Afforestation operations in Şile, İstanbul (Şile Forestry Operation Directorate 2012)

Figure 6. Afforestation in Ağaçlı, İstanbul (Kutorman 2012)

Rehabilitation and restoration operations in most of the abandoned coal mine areas are conducted by Turkish Coal Enterprises (TKİ). According to General Directorate of Turkish Coal Enterprises (2011), between 1991 and 2011, nearly 7.3 million trees in various species [stone pine (*Pinus pinea*), black pine (*Pinus nigra*), red pine (*Pinus brutia*), cypress (*Cupressus* sp.), cedar (*Cedrus* sp.), horse chestnut (*Aesculus hippocastanum*), black locust (*Robinia pseudoacasia*), tree of heaven (*Ailanthus altissima*), oak (*Quercus* sp.), maple (*Acer* sp.), ash (*Fraxinus* sp.), etc.] were planted on 4455 hectares of post-mining lands in various establishment directorates of TKİ (Figure 7).

Figure 7. Afforestation of soil waste dumps by the establishment directorates of TKİ (General Directorate of Turkish Coal Enterprises 2011)

3.7. Legislative and regulatory issues in mine reclamation

Since the late 20th century, reclamation has been widely accepted by both developed and developing countries as a desirable and necessary remedy in order to: i) reestablish the environmental conditions in post-mining landscapes at an acceptable level, and ii) increase their economic value to an optimum level (Cao 2007).

The law plays a critical role in reclamation of the post-mining landscape. It does not only define the legal status of the issue, but also reveals the outlook and approach of individual governments, which differ significantly in their attempts to mitigate the effects of mining disturbance.

For many of the developing countries, mining has a significant contribution to economy, which often puts a certain pressure on policy makers in order to establish an appropriate balance between national economic growth and environmental protection. Generally speaking, developing countries do not have strict environmental regulations and effective enforcement programs, and they usually address the issue within mining and environmental acts, or related national laws. Additionally, these countries mostly consider the reclamation and pollution control after the mine operations end (Cao 2007).

On the other hand, the approach in developed countries is more comprehensive and they have more stringent and effective regulations. Besides, restoration is regarded as a continuous process during mining, and mining companies have to prepare detailed environmental management plans and use expensive environmental technologies.

At this point, it would be wise to basically give examples of legislations related to mining and reclamation in several developed countries. The situation in Turkey is also overviewed briefly.

USA

With both the foundation of the *Soil Conservation Service* in the early 1930s and increasing local and state concerns about the degradation of land due to surface mining operations, protection of land resources became a publically important issue after World War I. This movement evolved into surface mine legislation, first in West Virginia in 1938, and then, in Indiana (1941), Illinois (1943), Pennsylvania (1945), and in Ohio (1947). Parallel to the increase in surface mining activities due to the energy crisis in the 1970s, the protection of environment gained more public interest (Doll 1988).

In the first half of the 1970s, many states asked mine operators to provide methods for certain mine operations and requirements for reclamation. During the late 1970s and early 1980s, more compulsive regulations were imposed by the states with coal mining activities and the federal government. In this period, under the influence of Congress and pending legislation, public education campaigns by local mining associations and new research efforts by the industry to reduce the economic impact of legislated reclamation gained speed. Today, all surface mining in the US is regulated by federal or state laws (Harwood and Thames 1988).

The reclamation for the surface effects of coal mining activities (including underground operations) on public and private lands in the US is based on the *Surface Mining Control and Reclamation Act* (*SMCRA*) of 1977 (Micsak, 2008).

This principle law (i.e., *SMCRA/PL 95-87*) defines the federal standards for the reclamation of surface mine sites. Within the guidelines and regulatory procedures set by this law, the industry was pinned for the reclamation of surface-mined lands, which has led to major changes in mining practices and reclamation techniques. By this way, many surface-mined lands have been successfully reclaimed (Doll 1988).

Section 101(c) of *SMCRA* states: "Many surface mining operations result in disturbances of surface areas that burden and adversely affect commerce and the public welfare by destroying or diminishing the utility of land for commercial, industrial, residential, recreational, agricultural, and forestry purposes, by causing erosion and landslides, by contributing to floods, by polluting the water, by destroying fish and wildlife habitats, by impairing natural beauty, by damaging the property of citizens, by creating hazards dangerous to life and property by degrading the quality of life in local communities, and by counteracting governmental programs and efforts to conserve soil, water, and other natural resources." Section 101(e) of *SMCRA* says: "Surface mining and reclamation technology are now developed so that effective and reasonable regulation of surface coal mining operations by the States and by the Federal Government in accordance with the requirements of this Act is an appropriate and necessary means to minimize so far as practicable the adverse social, economic, and environmental effects of such mining operations." (Office of Surface Mining Reclamation and Enforcement 2012).

Canada

Each Canadian provincial government has the authority to make laws related to property, contracts, natural resources, employment, land use and planning, education, health care and municipalities. So, most laws in respect of commercial nature are enacted by provincial governments. Mining activities are mainly governed by the laws of the province or territory where a mine is physically located. Additionally, the federal government has overlapping jurisdiction in a number of areas such as taxation and the environment. The federal *Canadian Environmental Assessment Act* (*CEAA-2012*) constitutes the main legislative frame for all environmental assessment processes. It requires an environmental assessment when a federal authority proposes the mining project, provides financing or lands for the project, or issues certain permits or approvals for the project. In general, a federal environmental assessment is required for most major mining projects. Federal and/or provincial environmental impact assessments are required prior to commencing or expanding operations or even conducting exploration in order to decide whether or not a proposed mining project should proceed based on its environmental and social impacts. The government generally has the authority to require a public hearing and the discretion to accept a proposed mining project or reject it (Davies 2011).

Australia

The first Australian mining law dates back to 1851. Legal dimension of environmental issues associated with mine operations are defined within the various sections of *Mining Act* and the *Environmental Protection Act*, which was enacted in 1986. According to the act, any project proposal, which may potentially have a significant impact on the environment, is referred to the *Environmental Protection Authority*. The *Environmental Protection Authority* evaluates the proposal and prepares a report on whether the proposal should proceed. In relation to the minerals and the environment, four important points are always kept under consideration: i) assessment and recommendation on the environmental management related to exploration and mining proposal, ii) collaboration with the industry and the community on the environmental management of the mining industry, iii) compliance with environmental conditions during exploration and mining, and iv) cooperation with other governmental agencies in order to keep lands of high conservation under protection, and not to exclude land unnecessarily from exploration and development activity (Hunt 2009).

Germany

German mining law dates back to 1865, when the *Allgemeines Berggesetz* (*AGB*) was established. The first reclamation amendments to the mining law were enacted in 1929. Due to the increase in demand for coal after World War II, reclamation was ignored. However, beginning in 1950, reclamation efforts increased and new laws with more precise requirements were put into force in Germany (Knabe 1964). The act has been amended several times and was replaced in 1980 by the *Federal German Mining Act* (*BGBl. IS. 1310*). This act was set into force in January 1982 and revised on December 9, 2006, through slight revision to provisions of *Article 11* (*BGBl. IS. 2833*) (Anderson 2012; Betlem et al. 2002).

United Kingdom

The main laws related to the mining and the environment in UK are i) *Coal Mines Regulation Act* (1908), ii) *Mining Industry Act* (1920), iii) *Coal Act* (1938), iv) *The Town and Country Planning Act* (Scotland) (1947), v) *Coal Industry Act* (1949), vi) *Mineral Workings Act* (1951), vii) *Mines and Quarries Act* (1954), viii) *Opencast Coal Act* (1958), ix) *Mines Act* (Northern Ireland) (1969), and x) *Environmental Protection Act* (1990) (Legislation.gov.uk 2012). English mining law operates primarily by public (administrative) law rather than by private (civil) mechanisms. The central administrative body is the *Coal Authority* and it was established under the *Coal Industry Act* (1994) during the privatization of the industry. There are lots of acts in the area of mining regulation; however, the *Coal Industry Act* (1994) and the *Coal Mining Subsidence Act* (1991) are the most pertinent ones (Betlem et al., 2002). *Environmental*

Protection Act was amended by *Environment Act* in 1995, and *Part IIA* of this amendment defines a detailed framework for the identification and the compulsory remedial action for contaminated land (Legislation.gov.uk 2012).

France

The *French Mining Code* (*Code Minier*) was enacted on 21 April 1810. The old *Mining Code* was amended by *Law No. 94- 588* of 15 July 1994, which organizes existing case law and aims at a better protection of the environment, and can be seen as revisions to bring the *French Mining Code* in conformity with relevant European regulations. During the development of the French environmental law in the past three decades, mechanisms for financial sanctions for those causing environmental damage have been incorporated without proper coordination in enforcement. With the *Environmental Code* enacted in 1999 (*Code de l'Environnement*), a more coherent regime was aimed by the Government. The *Code* addresses to several environmental issues in more than 975 articles over six chapters, combining liability clauses (Betlem et al. 2002). The central government representatives (*préfets*) can legislate for promoting the conservation of the habitat of listed protected species, according to a decree adopted in 1977 for the implementation of the *Act* (Groombridge 1992).

Turkey

In Turkey, there have been several efforts to designate the principle legal guidelines for the reclamation of post-industrial landscapes. "*The Regulation on Reclamation of Lands Disturbed by Mining Activities*" is an important landmark for mine closure planning in Turkey. It basically aims to establish the basic requirements for this purpose, and was published on 14th of December, 2007, and amended on 23rd of January, 2010. According to this regulation, reclamation plans for mining projects must be appended to the *Environmental Impact Assessment* (*EIA*) reports. A summary of related laws and regulations is given in Table 3.

Laws and Regulations	**Effective Date**	**Repealed by**	**Valid**
General Hygiene Law No. 1593	1930	-	General Hygiene Law No. 1593 (1930)
Forest Law No. 6831	1956	-	Forest Law No. 6831 (1956)
The Constitution of the Republic of Turkey	1982	-	The Constitution of the Republic of Turkey (1982)
Environmental Law No. 2872	1983	-	Environmental Law No. 2872 (1983)
National Parks Law No. 2873	1983	-	National Parks Law No. 2873 (1983)
Regulation on Unhealthy Institutions	1983	Regulation on Unhealthy Institutions (1995) Regulation on Repealing of Unhealthy Institutions Regulation (2005)	Repealed (2005)
Mining Law No. 3213	1985	-	Mining Law No. 3213 (1985)

Laws and Regulations	**Effective Date**	**Repealed by**	**Valid**
Regulation on Protection of Air Quality	1986	Regulation on Air Quality Assessment and Management (2008)	Regulation on Air Quality Assessment and Management (2008)
Regulation on Noise Control	1986	Regulation on Assessment and Management of Environmental Noise (2005; 2008; 2010)	Regulation on Assessment and Management of Environmental Noise (2010)
Regulation on Water Pollution Control	1988	Regulation on Water Pollution Control (2004)	Regulation on Water Pollution Control (2004)
Regulation on Control of Solid Wastes	1991	-	Regulation on Control of Solid Wastes (1991)
Regulation on Environmental Impact Assessment	1993	Regulation on Environmental Impact Assessment (1997; 2002; 2003; 2008)	Regulation on Environmental Impact Assessment (2008)
Regulation on Allocation of Forest Lands	1995	Regulation on Permissions in Forest Lands (2007) Regulation on Implementation of 17th and 18th Articles of the Forest Law (2011)	Regulation on Implementation of 17th and 18th Articles of the Forest Law (2011)
Regulation on Control of Hazardous Wastes	1995	Regulation on Control of Hazardous Wastes (2005)	Regulation on Control of Hazardous Wastes (2005)
Regulation on Control of Soil Pollution	2001	Regulation on Control of Soil Pollution (2005) Regulation on Control of Soil Pollution and Point-Source Contaminated Fields (2010)	Regulation on Control of Soil Pollution and Point-Source Contaminated Fields (2010)
Regulation on Noise	2003	-	Regulation on Noise (2003)
Regulation on the Implementation of Mining Law	2005	Regulation on the Implementation of Mining Activities (2010)	Regulation on the Implementation of Mining Activities (2010)
Regulation on Permission of Mining Activities	2005	-	Regulation on Permission Mining Activities (2005)
Regulation on Reclamation of Lands Disturbed by Mining Activities	2007	Regulation on Reclamation of Lands Disturbed by Mining Activities (2010)	Regulation on Reclamation of Lands Disturbed by Mining Activities (2010)
Regulation on Protection of Groundwater against Pollution and Deterioration	2012	-	Regulation on Protection of Groundwater against Pollution and Deterioration (2012)

Table 3. The main laws and regulations related to mining and reclamation in Turkey (Official Gazette of Republic of Turkey 2012; Republic of Turkey Prime Ministry 2012; Republic of Turkey Ministry of Justice 2012; Chamber of Mining Engineers of Turkey 2012)

4. Concluding remarks

One of the human footprints that cause drastic changes on environment is mining. Although it has a significant contribution to world economy and an indisputable social influence on the life of communities, its devastating negative impacts on environment cannot be disregarded. Particularly, opencast mining activities severely alter the topography and the physical conditions of the atmosphere, and inversely affect plant life, soil conditions, wildlife habitats, and water resources in the mining area and in its immediate surroundings.

As a result of above mentioned factors, post-mining landscapes lose their previous aesthetic, ecological and socioeconomic values. If effective mitigation measures are not taken to decrease the adverse environmental impacts, environmental degradation due to opencast mining operations may be irreversible.

As addressed within the chapter, the ultimate goal of reclamation is two-fold: i) to sustainably establish the aesthetic and ecological conditions of the post-mining landscape so that it become as much compatible as with surrounding undisturbed lands, and ii) to regain or enhance the productive capacity and stability of the land so that it contributes to community's economic and social welfare in a more efficient way.

Due to rapid industrialization and economic growth, the size and the content of the problems arising from negative impacts of mining activities have been changed and become more complicated than ever. So, in order to achieve successful results in reclamation studies, multidisciplinary approach enriched with the latest technological means is highly required. Of course, there is no "*unique*" and "*magical*" reclamation plan that can be directly applied on all post-mining areas, since major determinants in each reclamation study highly differ and depend on the specific characteristics of the site. Additionally, collaborative and creative involvement of all concerned parties (i.e., state and company officials, local authorities and non-governmental organizations, scientist, engineers and specialists, environmental groups etc.) is crucial for the development of permanently stable landscape use and reclamation plans. It is also necessary to emphasize that reclamation studies should begin at the earliest stages of project development, continue during mining, and proceed after the operation is completed.

The role of landscape architects in such studies has recently gone far beyond the "classical" borders of the profession. Instead of routine beautification and site planning tasks, now they often involve in large-scale complex reclamation and rehabilitation projects, and they even serve as the leader of the project team by taking the advantage of their education and practical experiences, which enables them to develop more innovative, consolidative and comprehensive approaches toward the optimum solution.

Legislative issues in mining and reclamation studies are mostly contingent to the visions of the governments. However, in order to foster efficiency and sustainability of post-mining landscapes, and to protect our valuable natural resources, much stricter global standardization on legal measures is needed in our rapidly changing world.

Our future depends on what we do today and how we interact with nature. So, it is essential to sustainably reclaim mine-disturbed lands through comprehensive and collaborative planning that considers all key aspects. Because we borrow the nature that we live in from future generations, which is a fact that we should always recall.

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