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MINING OPERATION & ENVIRONMENT IMPACT ASSESSMENT (EIA) IN PUNGAR WATER-SHED BAGESHWAR UTTARAKHAND, HIMALAYA

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Mining and Physical Landscape Alteration (Topography, water quality, soil quality, etc.)

The mining area of Pungar watershed in Lesser Himalayan Region is well known for soapstone mining. Soapstone is extracted by surface mining. It is used as filler in paper, textile, rubber, insecticides and fertilizer industries. Pure soapstone after calcination, called 'Lava' is used in the manufacture of low-loss ceramic materials essential for radio, radar, television, etc. In roofing products, such as tar paper, asphalt shingles and roll roofing, talc acts as a fire retardant and increases weather resistance. Body and face powders (talcum powder) are prepared from the finest quality talc after adding deodorant and perfumes. Massive steatite when cut into panels is used for switchboards and acid proof table tops in laboratory, laundry and kitchen sinks, in tubs and tanks as well as for lining alkali tanks is paper industry. Due to its high melting point (1630 °C), soapstone can be used in refractories and fireplaces. It is also quite useful in sculpturing. Mining activity in this region has been going on for the past 40 years.

The Himalayan ecosystem is fragile and diverse. It includes over 51 million people who practice hill agriculture and remain vulnerable. The Himalayan ecosystem is vital to the ecological security of the Indian landmass, through providing forest cover, feeding perennial rivers that are the source of drinking water, irrigation, and hydropower, conserving biodiversity, providing a rich base for high value agriculture and spectacular landscapes for sustainable tourism. The Himalayan ecosystem is vulnerable and susceptible to the impacts and consequences of:

i. Changes on account of natural causes,
ii. Climate change resulting from anthropogenic emissions and

iii. Developmental paradigms of the modern society.

With the onset of growth and development people living in an area seek access to developmental choices. These choices include the exploitation of the natural resources found in that region.

Extraction of minerals for various purposes from the earth's crust is one of the most destructive activities of human beings. Mining is the processes of extraction of minerals from the earth's crust by removing the vegetative cover, the top soil and rocks lying above the required mineral. The process of mining not only destroys the original ecosystem but also replaces it with empty pits and sterile wasteland.

The main impacts of mining are on physical landscape of the concerned region. These include changes in the structure, fertility and fertility of the soils, the quality of air, the quantity and quality of water and removal of the vegetative cover which also results in loss of fauna. Topographic deformation in the form of mining pits, cavities and heaps of overburden can also be seen in the mining regions. The quarrying sector's primary impact on biodiversity is through the removal of surface features during the extraction of minerals. Through this process, habitats can be altered or destroyed. Secondary effects of the quarrying process, such as noise, dust, pollution and waste removal can also impinge on plants and animals. Usually these effects include a combination of changing land forms and disturbance, for instance through sedimentation which may arise through excavation and disturbance to land or water through the activities themselves. The Table 1.1 gives a detailed account of physical landscape alteration owing to mining operation in Pungar watershed. It is evident that mining activities are concentrated only in Valley zone (below 1200 m) and mid altitude zone (1200-1400 m). This is due to maximum inhabited area.

Table 1.1: Pungar Watershed: Impact of mining operation on physical Landscape.

Altitudinal zone (m)	Name of Mining site and villages	Total Lease Area (ha)	Topographical alteration (Based on field observation)
Below 1200 (Valley zone)	Jharkot Mine:	29.28	
	Jharkot		➢ The river bed is rising because of deposition of waste material (soil and stones) derived from mining. This deposition is responsible for the diversion of river channel. ➢ The waste material deposited due to mining is accelerating the soil erosion. ➢ This mining area falling under reserve forest is also causing decrease in forest cover resulting into landuse change in the region.
	Biladi		➢ In this area mining is along the slope and waste material is being thrown towards the foot hill as a result agriculture area and non-mining area is also effected. ➢ In this village a slope which was convex as converted into concave.
	Gurughucha		➢ This mine also situated very close to the stream in the valley area. ➢ As this mine is very close to stream, waste material is being deposited directly in the main river. ➢ In this area gully development has taken place. ➢ Due to this mine there are landslides along the road.
1200-1400 (Mid altitude zone)	Surkali	139.37	➢ Agricultural terraces are under mining operation and its original shape. ➢ Due to mining nearby agricultural land is losing its fertility. ➢ The area is under gullying process/ gully erosion due to mining operation.
	Kiroli	101.98	➢ In this mining area agriculture land is highly affected. ➢ The waste material of mining is deposited in the nearby streams ➢ This area is also influenced by soil erosion.

Source: Executive summary for public hearing regarding environment clearance of Kiroli soapstone mine

6.1.1. Water Quality Information of Pungar Watershed

Water quality information is collected from executive summary for public hearing regarding environment clearance prepared by Kirai Soapstone Mine. As per the Report water sample are collected from rivers hand-pumps and springs spread over the study area. The detailed characteristics of water are given in Table 1.4.

Table 1.2 Pungar Watershed: Description of Surface Water Sampling Locations.

Station No.	Location	Project Area		Project area/study area
		Distance (km)	Direction	
SW1	Pungar river Up stream	0.9	SW	Buffer Zone
SW2	Pungar river downstream 100 Meter away	1.2	SW	Buffer Zone
SW3	Upstream side of Loharket nalla	-	N of M.L area	Adjacent to area zone
SW4	Upstream side of Pachar Ka nalla	-	N of M.L area	Adjacent to area zone
SW5	Downstream of Loharket nalla & Pachar ka nalla nalla, Abhay gadera nalla	-	S of M.L area	Adjacent to area zone

Source: Executive summary for public hearing regarding environment clearance of Kiroli soapstone mine

Table 1.3 Pungar Watershed: Description of Ground Water Sampling Locations.

Station No.	Location	Distance & Direction From project area	Study area	Environmental setting
DW1	Rima Village	3.0	N	Buffer zone from public water supply system line
DW2	Khatigaon Village	1.5	W	Buffer zone from public water supply system
DW3	Kirai Village	0.3	W	Buffer zone from public water supply system
DW4	Oliya Village	1.0	W	Buffer zone from public water supply system

Source: Executive summary for public hearing regarding environment clearance of Kiroli soapstone mine

Table 1.4 Pungar Watershed: Water Quality Information.

S. No.	Parameters	Test Method Reference	Unit	Pungar River Up stream	Pungar River Downstream 100 meter away	Upstream of Loharket nalla	Upstream of Pachar ka nalla	Downstream of Loharket, Pachar & Abhay Gadera / Nallah	Hand pump Water (Rima Village)	Khati Village spring water	Kirai Village spring water	Oliya Village spring water	Limits IS: 10500
1	pH	IS:3025(Pt11)1983	-	8.0	7.75	7.5	7.78	7.8	8.10	7.65	7.85	7.90	6.5 to 8.5
2	Conductivity	IS:3025-1964	µS/cm	233	296	296	285	290	104	109	148	113	-
3	Color	IS:3025(Pt4)1983	Hazen	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4	Total Dissolve Solid	IS:3025(Pt16)1984	mg/l	168	204	180	186	170	68	48	74	52	500
5	Hardness Total (As $CaCo_3$)	IS:3025(Pt21)2009	mg/l	110	120	110	112	114	40	40	70	30	300
6	Calcium (as Ca^{2})	IS:3025(Pt40)1991	mg/l	16.8	17.6	16.8	17.6	16.8	8.0	10.4	11.2	8.8	75
7	Magnesium (as Mg^{2+})	IS:3025(Pt46)1994	mg/l	16.32	18.24	16.32	16.32	17.28	4.8	3.36	10.08	1.92	30
8	Alkalinity (as $CaCo_3$)	IS:3025(Pt23)1986	mg/l	118	120	110	108	118	36	42	68	42	-
9	Chlorides (as Cl^{-})	IS:3025(Pt32)1988	mg/l	5.0	5.0	5.0	5.0	5.0	9.0	5.0	6.0	5.0	250
10	Mineral Oil	IS:3025(Pt39)1991	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.01
11	Chromium (as Cr^{6+})	IS:3025(Pt52)2003	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.05
12	Copper as Cu	IS:3025(Pt42)1992v	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.05
13	Fluoride (as F)	IS:3025(Pt60)2008	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	06 to 1.2
14	Sulphate (as SO_4)	IS:3025(Pt24)1986	mg/l	3.50	9.50	4.43	5.8	6.5	9.8	4.62	5.33	5.24	150

Soil Characteristics of Pungar Watershed

Soil characteristics are given using the information collected from Executive Summary for Public Hearing Regarding Environment Clearance prepared by Kirai Soapstone Mine. Report is based on soil samples collected from three villages, namely, Kirai, Sirala and Karuli. The detailed chemical characteristics are given in Table 1.6.

Table 1.5 Pungar Watershed: Soil Quality Monitoring station.

S.No.	Location	Station Code	Zone
1	(Top soil) Kirai Village	S1	Core
2	(Top soil) Kirauli Village	S2	Buffer
3	(Top soil) Sirala Village	S3	Buffer

Table 1.6 Pungar Watershed: Chemical Properties of Soil.

S.No.	Parameters	Unit	Result		
			Top Soil (Kirai Village)	Top Soil (Kirauli Village)	Top Soil (Sirala Village)
1	pH	-	4.8	6.5	5.5
2	Colour		Brown	Reddish	Brown
3	Electrical Conductivity	Us	32.00	56	48.00
4	Bulk Density	gm/cc	1.176	1.15	1.11
5	Particle Density	gm/cc	2.48	2.52	2.49
6	Porosity	%	52.58	54.36	55.43
7	Moisture	%	15.80	14.5	16.5
8	Iron as Fe	%	02.67	2.95	3.19
9	Aluminium as Al	%	2.82	0.62	0.56
10	Organic Matter	%	0.708	2.85	2.73
11	Sulphate	%	0.622	0.65	0.502
12	Chloride	%	0.009	0.008	0.006
13	Calcium Carbonate	%	1.8	2.5	4.0
14	Calcium as Ca^{++}	%	0.72	1.0	1.6
15	Magnesium as Mg^{++}	%	0.36	0.408	0.84
16	Sodium as Na	%	0.00494	0.0056	0.0051
17	Available Phosphorus	kg/ha	80	210	192
18	Available Potassium	kg/ha	400	540	440
19	Available Nitrogen	kg/ha	392	509.6	492

Source: Executive summary for public hearing regarding environment clearance of Kiroli soapstone mine

Mining and Cultural Landscape Alteration (Socio-Economic Scenario)

Five sample villages were selected for studying the impact of mining operations on socioeconomic status of the people residing in these villages. These villages are chosen for study because the important mines of the study region are located in these villages, and therefore, they are also named after these villages. An extensive household survey was done in these sample villages to understand the impact of mining in the socio economic status of the people living there. A brief description of this is as follows:

Jadkot

Jadkot is a valley village having an area of 32.18 ha. According to 2001 Census, the village has a population of 268 persons living in 48 households. Mining is also an important economic activity in Jadkot village. Presently only three household of the village are engaged in the mining operations in the village. Table 1.7 shows the detail of these households. A total of 0.14 ha land of these households is under mining practices while remaining 1.5 ha land is used for cultivation. The income from mining is significantly high (₹44000/month) as compared to that from agriculture (₹ 9000/month).

Guruguchha

Guruguchha is a valley village having an area of 8.76 ha. According to 2001 Census the village has a population of 26 persons living in 5 households. Mining is also an important economic activity in Guruguchha village. Presently only four households of the village are engaged in the mining operations in the village. Table 1.7 shows the details of these households. A total of 0.26 ha land of these households is under mining practices while remaining 2.0 ha land is used for cultivation. The income from mining is significantly high (₹43000/month) as compared to that from agriculture (₹9600/month).

Bidali

Bidali is a valley village having an area of 16.42 ha. According to 2001 Census the village has a population of 70 persons living as 10 households. Mining is also an important economic activity in Bidali village. Presently only five households of the village are engaged in the mining operations in the village. Table 1.7 shows the details of these households. A total of 0.27 ha land of these households is under mining practices while remaining 1.7 ha land is used for cultivation. The income from mining is significantly high (₹74000/month) as compared to that from agriculture (₹12800/month).

Surkali

Surkali is a mid-altitude zone village having an area of 47.56 ha. According to 2001 census the village has a population of 181 persons living in 20 households. Mining is also an important economic activity in Surkali village. Presently only eight household of the village are engaged in the mining operations in the village. Table 1.7 shows the detail of these households. A total of 0.92 ha land of these households is under mining practices while remaining 4.64 ha land is used for cultivation The income from mining is significantly high (₹120000/month) as compared to that from agriculture (₹33000/month).

Kiroli

Kiroli is a mid-altitude zone village having an area of 47.56 ha. According to 2001 Census the village has a population of 132 persons living in 20 households. Mining is also an important economic activity in Kiroli village. Presently only eleven household of the village are engaged in the mining operations in the village. Table 1.7 shows the detail of these households. A total of 1.62 ha land of these households is under mining practices while remaining 6.76 ha land is used for cultivation The income from mining is significantly high (₹197000/month) as compared to that from agriculture (₹81000/month).

Thus there are five villages under mining, out of them three villages comes under valley zone (below 1200 m) and the remaining two villages comes under mid altitude zone (1200-1400 m). A total of 3.21 ha land of the village households is under mining practices while remaining 16.6 ha land is used for cultivation. The income from mining is significantly high (₹478000/month) as compared to that from agriculture (₹231000/month.)

Table 1.7 Pungar Watershed: Socio Economic status of Sample Village.

Village name	Total area (ha)	Total HH	Total population	Mining households					
				No of HH	Population	Total agricultural land (ha)	Total mining land (ha)	Income from agriculture(per month)	Income from mining (per month)
Jadkot	32.18	48	268	3	17	1.5	0.14	9,000	44,000
Guruguchha	8.76	5	26	4	25	2	0.26	96,00	43,000
Bidali	16.42	10	70	5	39	1.7	0.27	12,800	74,000
Surkali	47.56	20	181	8	60	4.6	0.92	33,000	1,20,000
Kiroli	46.80	20	132	11	74	6.76	1.62	81,000	1,97000
Total	**151.72**	**103**	**677**	**31**	**215**	**16.6**	**3.21**	**2,31,000**	**4,78,000**

Source: Field work, 2011

Environmental Impact Assessment

Geographers have had a continuing interest regarding man's impact upon the natural environment. They have devoted considerable attention to environmental impacts associated with the human use of resources. Numerous publications have appeared from time to time which present rationales method and technique of Environmental Impact Assessments (Dilton and Goodale, 1992 Stover, Bruchell and Listokin, 1975, Crowin *et al*., 1975, Rosen 1976, Canter 1977, Cheremisinoff and Morresi 1977). With this proliferation of books and manuals, many definitions have been offered for ecological for ecological impact assessment. A synthesis of many views indicates that it represents a legislative or policy-based concern for positive-negative and short-long term effects on our total environment attributable to be proposed or existing projects and activities (Mitchell and Turkheim, 1977).

Various techniques have been devised and evolved in order to access the impact of human activities on the natural ecological system. However, there is no uniform and universally applicable method of environmental impact assessment as yet. The aspects of nature and human society affected by economic development must be taken into account very carefully when preparing a correct and comprehensive environmental statement. This is usually achieved by checklists in the form of a matrix. Such a checklist presents a specific list of environmental considerations to be investigated. It does not require the establishment of direct cause - effect links to human activities (Dee *et al* 1972, Ahmad 1990). Besides, numerous matrices have been developed for ecological impact assessment analysis (Schlesinger and Daetz, 1973). Many of these build upon earlier studies which sought to develop frameworks to incorporate the ecological dimension into environmental planning and management (Hills, 1961). Matrices differ in sophistication, ranging from extensions of checklist to others involving several stage or multiple dimensions. They emphasize consideration of the impact of each aspect of activity for range of environmental concerns, and they consider both the magnitude and importance of impacts (Mitchell, 1979).

The pioneering efforts with matrices was done by Leopold (1971) and his colleagues in US Geological Survey. The Leopold matrices are well known and often used for large and open systems where only qualitative information is available and social and human perception are to be taken into account. The Leopold matrix is composed of 100 rows listing eleven categories and 88 columns giving the various possible impacts grouped in different categories. This leads to 100 x 88 arrays in which the possible impact of human action of interference can be entered at the intersections in scales of magnitude and importance, generally in arbitrary numbers from 1 to 10.

Such as matrix enables alternative to be studied and choices made. However, the 8800 intersections make the Leopold matrix cumbersome and still leave out important relevant environmental conditions (Chaudhari, 1983). The Leopold matrix has also been criticized as being biased towards physical and biological effects rather than socioeconomic and aesthetic factors. In spite of some of these shortcomings the Leopold matrix remains the most exhaustive of qualitative assessment of environmental impacts due to human actions and is often used partly or wholly or through simpler variants, and enables decisions to be taken on choices and alternative actions that are possible.

An attempt was made in present investigation to assess the environmental impact of various human activities with the application of Leopold matrix of Environmental Impact Assessment (EIA).

The parameters selected for present research work from Leopold Matrix (1971) are highlighted by bold and (√**)** tick mark and demonstrated with the help of data matrix (Fig. 6.1). The matrix is used here in a slightly modified and simplified from. In this matrix the impact of mining, transport, development projects, on the environmental components of flora, fauna, land and water was analysed with the help of rank no. The rank no. indicates the magnitude of impact, range between minimum 1 and maximum 10 (Fig No. 1.2). The assessment of the magnitude of impact of a particular activity on different environmental component and allotment of different rang no. was done by researcher through experience gained during the field survey. In the Fig. 1.1 out of the total 88 environmental characteristics along the vertical axis of Leopold matrix 40 variables were found to be applicable in Pungar watershed while 23 variables were studied along the horizontal axis out of Leopold's 100.

There are a total of 374 boxes in the matrix. After properly analysing this matrix the Table 6.8 was prepared and described below:

Table 1.8: Categorization of the relative magnitude and relative importance scores of boxes.

Category	Number of Boxes	Number of Boxes (%)
1-2 (Very Poor)	15	4.01
3-4 (Poor)	107	28.61
5-6 (Moderate)	181	48.61
7-8 (High)	66	17.65
9-10 (Very High)	5	1.34
Total	**374**	**100**

Table 6.8 reveals the categorization of the relative magnitude and relative importance scores of boxes. It is found that moderate category (5-6 scores) scores maximum boxes indicating that maximum part of the study region is moderately affected by mining operation. Minimum boxes are covered by very high magnitude category which imply that mining operations are highly affecting a very few part of the region.

Fig. 1.1: Leopold matrix having environmental characteristics likely to be affected by project actions (Part A) and project actions and their impacts (Part B)

Part A	Environmental 'Characteristics' and 'conditions' likely to be affected by project actions (these variables are arranged vertically in the matrix)	Part B	Project actions (these variables are arranged horizontally in the matrix)
(A)	Physical and chemical characteristics	(A)	Modification of Regime
(1)	Earth	**(a)**	**(√) Exotic flora or fauna introduction**
(a)	**(√) Mineral resources**	(b)	Biological controls
(b)	Construction materials	(c)	**(√) Modification of habitats**
(c)	**(√) Soils**	(d)	**(√)Alteration of ground cover**
(d)	**(√) Landform**	**(e)**	**Alteration of groundwater hydrology**
(e)	Force fields and background radiation	**(f)**	**(√) Alteration of drainage**
(f)	**(√) Unique physical features**	**(g)**	**(√) River control and flow modification**
(2)	**(√) Water**	(h)	Canalization
(a)	Surface	**(i)**	**(√) Irrigation**
(b)	Ocean	(j)	Weather modification
(c)	Underground	(k)	Burning
(d)	**Quality**	(l)	Surface of paving
(e)	Temperature	**(m)**	**(√)Noise and vibration**
(f)	Recharge		
(g)	Snow, ice and permafrost	**(B)**	**Land Transformation and Construction**
(3)	**(√) Atmosphere**	(a)	Urbanization
(a)	**Quality (gases, particulates)**	(b)	Industrial sites and buildings
(b)	Climate (micro, macro)	(c)	Airports
(c)	Temperature	(d)	Highways and bridges
(4)	**Processes**	**(e)**	**(√) Roads and trails**
(a)	**(√) Floods**	(f)	Railroads
(b)	**(√) Erosion**	(g)	Cables and lifts
(c)	**(√) Deposition (sedimentation, precipitation)**	**(h)**	**(√)Transmission lines, pipe lines and corridors**
(d)	Solution	(i)	Barriers including fencing
(e)	Sorption (ion exchange, complexing)	(j)	Channel dredging and straightening
(f)	Compaction and settling	(k)	Channel revetments
(g)	**(√) Stability (slides, slumps)**	(l)	Canals
(h)	**(√) Stress-strain (earthquake)**	(m)	Dams and impoundment's
(i)	Air movements	(n)	Piers, seawalls, marinas and sea terminals
(B)	**Biological Condition**	(0)	Offshore structures
1	**Flora**	(p)	Recreational structures
(a)	**(√) Trees**	**(q)**	**(√) Blasting and drilling**
(b)	**(√) Shrubs**	**(r)**	**(√)Cut and fill**
(c)	**(√) Grass**	(s)	Tunnels and underground structures
(d)	**(√) Crops**	**(C)**	**(√) Resource Extraction**
(e)	**(√) Micro flora**	**(a)**	**(√) Blasting and drilling**
(f)	**(√)Aquatic plants**	**(b)**	**(√) Surface excavation**
(g)	Endangered species	(c)	Subsurface excavation
(h)	Barriers	(d)	Well drilling and fluid removal
(i)	Corridors	(e)	Dredging
(2)	**Fauns**	(f)	Clear cutting and other lumbering
(a)	**(√) Birds**	(g)	Commercial fishing and hunting
(b)	**(√) Land animals including reptiles**	**(D)**	**Processing**
(c)	**(√) Fish and shellfish**	**(a)**	**(√) Farming**
(d)	Benthic organisms	(b)	Ranching and grazing
(e)	**(√) Micro fauna**	(c)	Feed lots
(f)	Endangered species	(d)	Dairying
(g)	Barriers	(e)	Energy generation
(h)	Corridors	(f)	Mineral processing
(C)	Cultural Factors	(g)	Metallurgical industry
(1)	**Land use**	(h)	Chemical industry
(a)	**(√) Wilderness and open spaces**	(i)	Textile industry
(b)	Wetlands	(j)	Automobile and aircraft
(c)	**(√) Forestry**	(k)	Oil refining
(d)	**(√) Grazing**	(l)	Food
(e)	**(√) Agriculture**	(m)	Lumbering
(f)	**(√) Residential**	(n)	Pulp and paper
(g)	**(√)Commercial**	(o)	Product storage

(h)	Industrial	**(E)**	**Land Alteration**
(i)	**(√) Mining and quarrying**	**(a)**	**(√) Erosion control and terracing**
(2)	Recreation	**(b)**	**(√) Mine sealing and waste control**
(a)	Hunting	**(c)**	**(√) Strip mining, rehabilitation**
(b)	**(√) Fishing**	**(d)**	**(√) Landscaping**
(c)	Boating	(e)	Harbour dredging
(d)	Swimming	(f)	Marsh fill and drainage
(e)	Camping and hiking	**(F)**	**Resource Renewal**
(f)	Pick nicking	**(a)**	**(√) Reforestation**
(g)	Resorts	(b)	Wildlife stocking and management
(3)	**Aesthetic and Human Interest**	(c)	Groundwater recharge
(a)	**(√)Scenic views and vistas**	(d)	Fertilization application
(b)	**(√) Wilderness qualities**	(e)	Waste recycling
(c)	**(√) Open space qualities**	(G)	Changes in Traffic
(d)	**(√) Landscape design**	(a)	Railways
(e)	Unique physical features	(b)	Automobiles
(f)	Parks and reserves	**(c)**	**(√) Trucking**
(g)	Monuments	(d)	Shipping
(h)	Rare and unique species or ecosystems	(e)	Aircraft
(i)	Historical and archaeological sites and objects	(f)	Pleasure boating
(j)	Presence of misfits	(g)	Trails
(4)	**Cultural status**	(h)	Cables and lifts
(a)	**(√) Cultural patterns (life style)**	**(i)**	**(√) Communication**
(b)	**(√) Health and safety**	**(j)**	**(√) Pipe line**
(c)	**(√) Employment**	(H)	Waste Emplacement Treatment
(d)	Population density	(a)	Ocean dumping
(5)	**Man-made Facilities and Activities**	**(b)**	**(√) Landfill**
(a)	**(√) Structures**	(c)	Emplacement of tailings, spoil and overburden
(b)	**(√) Transportation network**	(d)	Underground storage
(c)	**(√) Utility networks**	(e)	Junk disposal
(d)	Waste disposal	(f)	Oil well flooding
(e)	Barriers	(g)	Deep well emplacement
(f)	Corridors	(h)	Cooling water discharge
(6)	Ecological Relationships	(i)	Municipal waste discharge including spray irrigation
(a)	Stalinization of water resources	(j)	Liquid effluent discharge
(b)	Eutrophication	(k)	Stabilization and oxidation ponds
(c)	Disease-insect vectors	(l)	Septic tanks
(d)	Food chains	(m)	Stack and exhaust emission
(e)	Salinization of surficial material	(n)	Spent lubricants
(f)	Brush encroachment	(I)	Chemical Treatment
	Others	(a)	Fertilization
		(b)	Chemical deicing of highways etc.
		(c)	Chemical stabilization of soils
		(d)	Weed control
		(e)	Insect control (pesticides)
		(J)	Accidents
		(a)	Explosions
		(b)	Spills and leaks
		(c)	Operational failures
		(d)	Others

Source: L.S. Leopold,*et al.*, 1971: A Procedure for Evaluating Environment Impact, United States Geological Survey.

Fig 1.2 Data Matrix

Environmental Characteristics and conditions - Likely to be affected by Project Action	Exotic Flora or fauna introduction	Modification of habitats	Alteration of ground cover	Alteration of drainage	River control and Flow modification	Irrigation	Noise and Vibration	Road and Trails	Transmission lines pipe lines and corridors	Blasting and Drilling (Land Transformation and Construction)	Cut and Fill	Blasting and Drilling (Resource Extraction)	Surface excavation	Farming	Erosion control and terracing	Mine scaling and waste control	Strip mining, rehabilitation	Landscaping	Reforestation	Trucking	Communication	Pipe line	Land fill
Mineral Resources		7/7	10/10	10/10	3/3	2/2	8/8	4/4	3/3	7/7	8/8	9/10	3/4	7/7	6/6	3/4		6/5	4/4	8/8	6/6	3/3	6/6
Soil	6/6	6/5	8/8	2/2	1/2			7/7	5/6	2/2	6/6	2/2	5/6	8/8	5/5		3/4	3/4	3/4	1/2		5/6	5/6
Landform	4/4	7/7	7/8	5/6	3/4	5/5		7/8	6/6	5/6		7/8		6/6	6/6	6/5	6/5	6/6	5/6	6/6			5/6
Unique Physical features		1/1						1/2							5/6								
Water Quality	5/5	3/4	7/7	7/7	5/5	4/4		5/5	5/6	¾	4/4	5/5		4/4		5/5	3/3		5/5	4/4			
Atmospheric Quality	4/3	5/6	7/7							5/6		6/6							7/7	8/8			
Floods	7/7		5/5		3/4			3/4															
Erosion	8/7	5/6	7/7	5/6	5/6			7/7	5/6	¾	5/5	7/7		5/5	3/4	5/6	5/5	4/4	5/5	5/6			4/4
Deposition – sedimentation	8/7	5/6	6/6	6/6	5/6			5/6			7/7			5/6	6/6	3/4	4/4	4/4					5/6
Stability (Slides, slumps)	7/7	5/6	7/7	6/5	5/6					5/6	7/7	7/8			5/6	5/6			6/5				4/4
Stress Strain (earthquake)	4/4	6/6	3/4	1/2				4/4															
Trees	5/6		3/4	3/4							6/5				4/4		6/6	5/6	7/7				
Shrubs	7/7		2/2	3/4		3/4		4/4			5/5				5/5	8/5	3/4	1/2	6/6				
Grass	7/8		3/3	3/4		5/6		3/3			5/5				6/5	5/6	3/3	3/4	6/6				
Crops	6/5	7/7	4/4	2/2		7/8								8/8	6/6								
Micro flora	8/8		3/4	2/2	3/4	3/4		5/6			6/6			5/6	5/5	5/6	2/3	5/6	5/6				
Aquatic Plants	3/4			5/6	5/6	6/6																	
Birds	6/5																		4/4				
Land animal including reptiles	5/5		3/3								3/4								5/5				

		Exotic Flora or fauna introduction	Modification of habitats	Alteration of ground cover	Alteration of drainage	River control and Flow modification	Irrigation	Noise and Vibration	Road and Trails	Transmission lines pipe lines and corridors	Blasting and Drilling (Land Transformation and Construction)	Cut and Fill	Blasting and Drilling (Resource Extraction)	Surface excavation	Farming	Erosion control and terracing	Mine scaling and waste control	Strip mining, rehabilitation	Landscaping	Reforestation	Trucking	Communication	Pipe line	Land fill
	Fish and Shellfish	5/6		3/4		5/6																		
	Micro-fauna	4/4		2/2	3/3		5/5		5/6			3/3			5/5	3/4	3/4			4/4				
	Wilderness and open spaces		6/5						3/4			6/6				6/6	3/4		3/4	5/5				
	Forestry	6/5	6/5	6/5					3/4			5/5				5/5		6/6	3/3	5/5				
	Grazing	6/5		5/5					3/4			3/4				4/4		5/5		5/5				
	Agriculture	4/3	7/8	7/7	3/4	4/4	7/8		5/5			5/6			8/8	7/8	7/8	7/7	5/5	4/4				5/5
	Residential		7/7	3/4				5/5	5/6	3/4					6/5	3/4			5/6			6/6		
	Commercial		6/6						5/6	5/6									3/4		5/5	6/5		
	Mining and querying	5/6	7/7	8/8	3/4	5/5		6/6	3/4	3/4	6/6	7/7	8/8		4/4	5/6	10/10	6/6	3/4	3/4	8/8			5/5
	Fishing	3/4		4/3	5/6	5/6																		
	Scenic views and vistas								3/4							5/6	7/7	3/4	6/5	6/5				
	Wilderness qualities			3/4		4/4			3/4			5/5				5/6	5/6	3/4		6/5				
	Open space qualities			5/5					3/4			4/4					5/5	3/4		5/5				
	landscape design	3/4	7/7	7/7	5/5	7/7			7/7	5/5	5/6	8/8			5/6	6/5	8/8	6/6		6/6				5/6
	Cultural patterns (lifestyle)	7/	8/8	7/7					5/5						5/5							6/6		
	Health and Safety	3/4	5/6					7/7	6/6		6/6		7/7							4/4	4/4	4/4		
	Employment		3/4	5/5					5/6			5/6			6/6		6/6	3/4			6/6	5/5		
	Structure		5/5	5/6					5/5	5/5	4/4	5/6	5/5		4/4	5/5	8/8	5/5		5/5	4/4			5/6
	Utility network		4/4	3/4					7/7	5/6					5/5						8/8	7/7		
	Transportation network	1/2	5/6	6/5					8/8	5/6					4/4						10/10	5/5		