INDIA
CHATTISGARH
RAIGARH DISTRICT

Confidential
(For Official Use Only)

KELO MAJOR IRRIGATION PROJECT

VOLUME-I

ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN

Prepared for
Department of Water Resources
Government of Chattisgarh
RAIPUR

MARCH 2008

AGRICULTURAL FINANCE CORPORATION LTD

203, Subhansirisampada
Apartments
Somajiguda, Rajbhavan Road
HYDERABAD.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - 1

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - I
GENERAL

I
INTRODUCTION

BACK DROP

1.01 Inspite of remarkable progress in the areas of water resources development after the independence, India is experiencing several issues primarily due to severe climate variations, rapid population growth, urbanization and industrialization. India, with only four percent of the Gobal fresh water resources to support 16 percent of the worlds' population, is hard pressed to maintain the dedicated balance between the demand for and supply of this vital resource.

1.02 The south-west monsoon brings four-fifths of the annual rainfall, generally between June and September. However, this rainfall is not distributed evenly during that period. While one-eighth of India's area has been assessed as flood-prone, a third of India is considered as drought-prone. Devastating floods have become a recurring annual feature in some parts of India while devastating droughts have also made the nation vulnerable to disasters of another kind. On an average 7.6 million hectares of land in India is affected annually of which 3.6 million ha are cropped area. It is noted that dams with reservoirs are among measures most resorted to as long term solution to mitigate flood losses as well as to prevent drought situations.
In multipurpose reservoirs, their interests of the various components like irrigation, power generat ion and flood control are often at variance one another.

HISTORY OF IRRIGATION

1.03 In the nineteenth century British colonialism introduced technical and hydraulic principle by introducing perennial irrigation in the sub-continent. The system evolved gargantuan projects which made a dramatic hike in cropping intensity, fuelled the commercial farming, and spread of mono cropping system. A third wave in hydraulic manipulation emerged in 1930s with new technologies put into operation to effect the virtual industrialization of river control. Now the entire river basin became the focus for water planners and engineers. This facilitated to train the river through interconnected dams, reservoirs and diversions all the way to its estuary by harnessing its waters simultaneously for navigation, irrigation flood control and power generation.

1.04 In recent years India's water crisis has become cancerous and fatal. The supply side approach fact carned off the bend and crashed noisily against economical limits. Large dams particularly have been singled out for causing catastrophic environmental damage. This rapid development is causing a serous concern in providing and maintaining pollution free environment. Keeping in view the biotic stress in the recent past, protection of natural environment has been gaining highest priority while planning for any developmental projects like Thermal and Hydro power generation units, Irrigation projects, Road projects, Industrialization, etc.

1.05 It is an established fact that natures stability is dependent on bio-diversity and environmental sustenance. Therefore, during the last couple of decades there has been a spurt in the awareness on the need for environmental protection and environmental management for improving the Global ecology. Serious efforts are therefore, being put into conserve and regenerate the nature as the poor live in by "Gross nature Product" and the bio-mass developed in various forms in different regions along the hills, plains, rural areas and in other parts with dense human habitation. To meet the challenges of environmental pollution, the developed countries in the world have taken concrete steps and have established separate Departments/Ministries exclusively for this purpose. Falling in line with them, the Govt. of India has established an exclusive Ministry for Environment and forests (MOEF) for taking care of environmental protection needs. Safeguarding the interest of environment is done through suitable identification of environmental impacts and preparing suitable environmental management plans while sanctioning the establishment of Industries,Rreservoirs/ Dams, Railways, Thermal power plants, etc., In other words , any project involved in interference with the environment is governed by the Environmental Protection Act Enacted by the Government of India. The Ministry of Environment and Forests (MOEF), Government of India is therefore the nodal agency for sanctioning the Environmental clearance for developmental projects. While clearing the projects, the MOEF is taking care of the environmental needs within and around the areas of different developmental projects/schemes in the country.

NATIONAL PERSPECTIVES

1.06 In the year 1980 the then Union Ministry of Irrigation and the Central Water Commission formulated the national perspectives for Water Resources Development which comprises two main components. They are,

1. Himalayan Rivers development,
2. Peninsular rivers development.

1.07 Himalayan rivers development envisages construction of storage reservoirs on the main Ganga and Brahmaputra and their tributaries along with inter - linking canal systems to transfer surplus flows of the eastern tributaries of the above rivers. Peninsular river development includes inter-linking of major rivers flowing in the Peninsular India including the southern tributaries of Yamuna. The perspectives envisage construction of storage reservoirs at potential sites and canal systems to mitigate the hardship of farmer community in the drought prone areas.

Present proposal

1.08 Chattisgarh state is situated in the core of India. Kelo is one of the main river in the area. The

river is perennial in nature but nearly dries up in summer. The major chunk of the total population in the villages are schedule tribes. The infrastructure facilities are poor in the area. The main source of water for domestic and drinking purposes are dug wells and pumps, tanks and local nallas. The area is economically under developed. The state possesses fertile soil, good rainfall and substantial water resources and also endowed with rich mineral and forest wealth. To harness the water resources and to meet the irrigation and drinking water and other demands in this backward area of Raigarh district, the Government of Chattisgarh has proposed to construct a dam across Kelo river near Danote(v) which is 8 Km north of Raigarh, the district head quarters. Kelo river is one of the main tributaries of Narmada River flowing in the state.

Objectives and Scope

1.09 The main objective of the study is to assess the environmental impacts due to the proposed Kelo project on land, water, Flora & Fauna, public Health; Climate and socio-economic conditions. Also, the study evolves a suitable environment management plan for minimizing/ eliminating the negative impacts likely to occur due to the construction of the project in the area.

1.10 Thus the scope of the study comprises of the following components;

(i) Assess the impact of the project on land environment;

(i) Assess the impact on water environment;

(i) Assess the impact on biological environment; such as flora, fauna, aquatic life, migratory birds, endangered species etc;

(i) Assess the public health hazards during the construction period;

(i) Assess the impact of the project involving involuntary displacement of population, morbidity etc;

(i) Conducting socio economic surveys related to project affected persons and formulation of resettlement and economic rehabilitation plan for the PAPs. This includes in identification of suitable locations for the resettlements, infra structural needs, feasibility of compensating land for land and assessment of training needs.

(i) Prepare a detailed catchment area treatment plan for reducing soil erosion, ensuring sediment free flows to the reservoir;

(i) Make necessary proposals for Command Area Development based on soils, soil capability, irrigability, slope, etc;

(i) Formulate a detailed environmental management plan (EMP) for ensuring healthy environmental cover in the project area including monitoring of different components;

(i) Suggest suitable organization for implementation of the EMP;

(i) Estimate the project cost for allocation of required budget for implementation of EMP

TEAM COMPOSITION

1.11 Keeping in view of the technical needs of the various components of the study, the AFC constituted a study team consisting of experts drawn from several disciplines as below:

THE TEAM

S.No.	Name	Designation
1	Shri M. Dharma Reddy	Team Leader and M & E Expert
2	Dr. K.B. Reddy	Environmental Sciences. Bio Diversity Expert
3	Shri A. Srinivasarao	Hydrologist and Irrigation Specialist
4	Sri U.M. Lal	Environmental Specialist
5	Shri Mohammad Siddiqui	Soil Scientist
6	Dr. Smt. T. Rajya laxmi	Fisheries Expert
7	Dr. R. Sudheer	Environmental Engineer
8	Dr. G. Gopal Reddy	Sociology Expert
9	Shri Venkata Naresh Kumar	Geology Specialist
10	Shri Datta Shivani	Hydro geologist
11	Dr. K.K.E. Namboodiri	Economist
12	Dr. J.P. Rao	System Analist
13	Ms. K. Padma	R.S. and GIS Specialist
14	Shri V. Malleshwar	Agricultural Specialist
15	Shri C. Manohara	Rand R Expert
16	Shri V. Rammohan	Logistic Support
17	Shri K. Rameshwar	Forest Expert
18	Mrs. I. Manjulatha	Computer Programmer
19	Mrs. G. Rajyalakshmi	Computer Operator

1.12 The above experts and specialists are assisted by technical supervisors and investigators at field level.

APPROACH AND METHODOLOGY

1.13 The impacts due to the proposed project on different envi ronmental components are assessed.

The following environmental components are considered for such assessment.

- Land Environment;
- Water environment;
- Biological Environment;
- Climatological Environment;
- Public Health;
- Socio-Economic Environment; and
- Risk Assessment.

1.14 The above components are studied in detail through various means by conduct of detailed ground level investigations buy collection of primary data, discussions with officials and non officials at state, district and project levels, collection of s econdary sources of information from various relevant line departments and also through application of sophisticated GIS and Remote sensing technologies.

1.15 The primary data were collected from the affected households through conduct of detailed socio-economic survey of each household, group discussions with the officials, non officials and affected population, collected village level information on various infra structural facilities that are likely to get effected due to submergence.

1.16 The study utilized the SOI toposheets of 1:50,000 for studying the catchment area and command area and the toposheets were also utilized for studying the submergence area, identifying the land use land cover, slope and soil etc. The satellite based cloud fee remote sensing imageries are procured from NRSA for image analysis for deriving the land use land cover, slope soils, surface drainage etc and also for preparation of catchment area treatment plan based on sediment yield index method.

Report Structure

1.17 The study report consists of two volumes. Volume - I is divided into four parts. Part I deals with General information , Part - II with Baseline Data, Part - III with Impact prediction and Part - IV with Environmental Management plan. Volume - II of the report focuses on the socio economic aspects of the project affected people under the reservoir submergence villages needing to Resettlement and Rehabilitation through formulation of Project Affected Families Economic Rehabilitation Plan (PAFERP).

Chapterisation

1.18 As already mentioned, the report is prepared in two volumes. The chapterisation of each of volume of the report is presented below:

CHAPTERISATION **VOLUME - I** **ENVIRONMENTAL IMPACT ASSESSMENT** **AND** **ENVIRONMENTAL MANAGEMENT PLAN**	
Chapter No.	Part - I General
	Part - I General
I	INTRODUCTION

II	PROJECT AREA
III	POLICY, LEGAL & ADMINISTRATIVE FRAME WORK
	Part - II Baseline Data
IV	GEOLOGICAL, GEOPHYSICAL & HYDROLOGICAL ASPECTS
V	BIOLOGICAL RESOURCES
VI	AIR & NOISE ENVIRONMENT
VII	SOCIO-ECONOMIC ASPECTS IN COMMAND AND CATCHMENT AREA
VIII	REMOTE SENSING & GIS STUDIES IN THE CATCHMENT & COMMAND
	Part - III Impact Prediction
IX	AIR ENVIRONMENT
X	NOISE ENVIRONMENT
XI	WATER & PUBLIC HEALTH ENVIRONMENT
XII	LAND ENVIRONMENT
XIII	ECOLOGY
XIV	SOCIO-ECONOMIC CONDITION IN THE CATCHMENT & COMMAND AREAS
	Part - IV Environment Management Plan
XV	CATCHMENT AREA TREATMENT PLAN
XVI	CONSERVATION OF BIO-DIVERSITY
XVII	COMMAND AREA DEVELOPMENT PLAN
XVIII	FISHERIES DEVELOPMENT PLAN
XIX	LAND ENVIRONMENT MANAGEMENT PLAN
XX	WATER QUALITY AND PUBLIC HEALTH MANAGEMENT PLAN
XXI	AIR & NOISE MANAGEMENT PLAN
XXII	ENVIRONMENT MONITORING PLAN
XXIII	DAM BREAK STUDY & DISASTER MANAGEMENT PLAN
XXIV	COST OF EMP
VOLUME –II RESETTLEMENT & REHABILITATION PLAN	
I	INTRODUCTION
II	SOCIO-ECONOMIC ENVIRONMENT
III.	RESETTLEMENT AND ECONOMIC REHABILITATION PLAN
IV.	TRAINING
V.	ORGANISATION AND MANAGEMENT
VI.	MONITORING AND EVALUATION
VII	IMPLEMENTATION
VIII	PROJECT COST
IX	EMERGING ISSUES

Introduction

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume - 1

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - I
GENERAL

II

PROJECT AREA

Introduction

2.01 Chattisgarh is one of the backward states of India, situated in the heart of country. It has a total Geographical area of 137798 sq.km and is bordered by six states namely Uttar Pradesh, Jharkhand, Orissa, Andhra Pradesh, Maharashtra and Madhya Pradesh. The state possesses fertile soil, plentiful rainfall precipitation and substantial water resources. Inspite of its existence in Mahanadi river basin, Raigarh district experiences frequent droughts due to large variations in the annual and seasonal rainfall rendering the rain fed crops uncertain. Assured irrigation is meager and is only about 0.95 per cent of the total study area. Unirrigated agricultural land occupies major share of 56.14 percent. The situation emphasizes the need for certain major irrigation schemes for the benefit of the farmer community of the area and development of overall economic growth. Accordingly, the Govt of Chattisgarh has proposed a major irrigation project on Kelo river in Raigarh district.

2.02 The Kelo project is contemplated to irrigate an area of 22,800 ha with an annual gross irrigation of 26,800 ha in Raigarh and Janjgir – Champa districts. Thus the intensity of irrigation is 117.54 percent, besides providing water supplies for domestic and industrial purposes.

Location of the Project

2.03 The proposed Kelo Project is locatedin Raigarh district, across Kelo river which is a tributary of Mahanadi River. The dam site is situated at 8 km north of Raigarh town

near Danote village. The site is approachable from Raigarh – Ambikapur state highway road. The nearest railway station is Raigarh on Raipur – Bilaspur – Jharsuguda railway line which is 8 km from the dam site. The site is about 268 km by road from the state capital Raipur on NH 200. The geo coordinates of the project site are 83^0 – 23' – 20"East longitude and $21^0$5'71" North latitude. The project area and its location and vicinity within radius of 10 km are shown in Fig. II.1 & Fig II.2.

2.04 The area in the vicinity of the project has a network of district roads. The Raigarh – Bilaspur (via Kharsia) road runs across the command area for a length of about 15 km. The Raigarh – Saragarh district road also passes though the command area for about 20 km. The proposed dam site is well connected by the Raigarh – Ambikapur (via Ghargada) state high way. The Howrah – Mumbai broa d gauge (via Nagpur) railway line of SE & SC Railway also bifurcates the command area.

2.05 Seventy five villages of Ghargoda Tahsil in Raigarh district in the study area are benefited by the Kelo Project. The list of villages is furnished in Annexure II.1.

Selection of Site

2.06 The proposal of Kelo Project dates back to the year 1964 when it was in Madhya Pradesh state. Since then surveys and investigations were carried out. Four alternatives for the dam location of the project were studied. They are as follows:

(i) Laking site near Lakha Tussar silk centre

(ii) Milupara site near village Milupara

(iii) Urdana site near village Urdana

(iv) Danote site C – C axis near Danote (v)

2.07 The alignment along the C axis i.e., Danote site has been selected out of the above four alternative sites surveyed for this project. The other three alternatives were rejected after due consideration on the basis of Geologists reports. Danote site is found a better selection as the dam site with respect to geological formations. This site is preferred due to lower area of submergence, in view of the fact that the entire water spread area of the dam between two small hillocks on either sides of the proposed dam.

Inter State Aspects

2.08 Mahanadi river is an interstate basin and its catchment area lies in Maharashtra., Madhya Pradesh, Chattisgarh, Jharkhand and Orissa states. The total drainage area of the river is assessed to be 141589 sq. km and is distributed between the states as in Table – 2.1.

Table – 2.1 : KELO PROJECT DISTRICTWISE DISTRIBUTION OF CATCHMENT AREA OF MAHANADI RIVER			
Sl.No	**State**	**Area (sq.km)**	**Percentage**
1	Maharashtra	238	0.17
2	Chattisgarh	74997	52.95
3	Madhya Pradesh	139	0.10
4	Jharkhand	635	0.45
5	Orissa	65580	46.32
	Total	**141589**	**100.00**

2.09 Chattisgarh state is entitled to use 26542 Mm^3 of water of Mahanadi basin as presented in Table – 2.2.

Table - 2.2 : KELO PROJECT : RAINFALL & RUNOFF YIELD DETAILS				
Sl.No	**Particulars**	**U/s of Hirakud Dam**	**D/s of Hirakud Dam**	**Total**
1	From Av. Annual rainfall (cm0	133	140	-
2	Surface water @ 75% dependability (Chattisgarh) (Mm^3)	30,077	929	31006
3	Water use committed to Orissa (as per April 83 agreement. Mm^3)	-	-	654
4	Water available from Orissa (as per April '83 Agreement Mm^3)	-	-	198
5	Water available to Chattisgarh after deducting above water use by Orissa	-	-	30550
6	Proposed water use in Chattisgarh Mm^3	28828	714	26542

2.10 The water use in Mahanadi basin through the completed and ongoing major schemes of Chattisgarh state has been worked out to be 7300 m cum approximately. The water utilization including the now proposed Kelo project (9173 Mcum) would be 7473 Mm^3 which is only about 28.15 % of available yield from Mahanadi river basin. Hence the current project does not violate any interstate aspects of river water sharing.

Project components

2.11 The project comprises the following main components :

a) Earthen dam 1270 m long main earth dam across Kelo river with a maximum height of 24.22 m and RL of +233.00m.

b) Earthen saddle dam I of length 282 m and with a maximum height of 14.81 m above ground level

c) Earthen saddle dam II of length 910 m. with maximum height of dam above ground level of 9.16 m.

d) Masonry dam with spill way for a length of 142 m and maximum height of 3 m above foundations. It is proposed with 8 radial gates to pass a maximum flood discharge of 9688 cumecs. This will be situated from Rd 70 m to RD 212 m of the dawdle number I.

e) Non over flow portion of masonry dam of length 50 m and height 16 m above foundation

f) 26.62 km length of main canal proposed to take off at RD 12.40 m the right flank of the Kelo river to provide irrigation to 22800 ha. CCA.

2.12 Salient features of the project are presented in Annexure II.2.

Reservoir and Submergence

2.13 Reservoir is created by construction of dam across Kelo river a tributary of Mahanadi River. Maximum Reservoir level as well as FRL is proposed as + 233.0 m, with lowest sill at + 227.0 m. The gross storage created will be 60.785 m cum whereas the live storage of the reservoir will be 46.607 M cum duly providing a dead storage capacity 14.178 M .cum. The maximum height of the dam will be 24.22 m only. The water spread area at full reservoir level is assessed to be 1206.38 ha.

2.14 Due to the creation of the reservoir, about 1320 ha of land will be under submergence at FRL. The classification of the lands coming under submergence is as presented in Table 2.3.

Table – 2.3 : KELO PROJECT
CLASSIFICATION OF LANDS UNDER SUBMERGENCE

Sl.No	Details of Land	Extent (ha)
1	Culturable private land	750.399
2	Govt. land (waste land, revenue, roads and river)	260.814
3	Forest Land	
	a) Belonging to Forest Department	139.53
	b) Belonging to Revenue Department	169.136
	Total	**1319.879 ha**

2.15 It is also assessed that about 5 or 1320 ha land from 20 villages pertaining to Raigarh district will be partially affected. The details of the assets that are likely to be submerged are dealt with in volume II, R&R plan. The share of cultivable area under submergence in the CCA of the project is about 0.05 which is within permissible limits.

Historical and Archeological Monuments

2.16 No a archeological monuments of significant historical importance is going under the submergence area of the Kelo Reservoir.

Meteorology

2.17 The only meteorological observatory station in the project area is at Raigarh, the district head quarters and is taken as the representative for the entire project area. Gauging of Kelo river has been done just about 250m downstream side of the proposed Kelo dam near Danote village and about 4.0 km downstream of the proposed dam site for nearly 5 years. The gauging were done at hourly basis during monsoon. The gauging at Danote site and Kelo bridge at Raigarh were done for hourly gauging as per the suggestion of Central Water Commission.

Climate

2.18 The project area has a sub-tropical climate. There are considerable variations in the rainfall, temperature and humidity. The climate is characterized by oppressive hot summer, a mild winter, and well distributed rainfall during south west monsoon. The year can be divided into four seasons. Summer season lasts from March to middle of June, Monsoon season from middle of June to September, post monsoon season from October to November and cold season from December to February.

Rainfall

2.19 The project area is influenced by south west monsoon and at times by North East monsoon also during winter. The South west monsoon generally sets in the second week of June and lasts upto the second week of October. The rainfall in the catchment area varies from a maximum of 2044 mm to a minimum of 703 mm. The average annual rainfall is 1373.50 mm in the catchment area and it is 1429 mm in the command area, as per the Raigarh rain gauge station. The south west monsoon accounts for 90% of the total rainfall. The following Rain gauge stations influence the project area.

a) Raigarh
b) Ghargoda
c) Pathalgam
d) Buldega
e) Himagir

2.20 In addition to the above two new rain gauge stations were installed at Danote (proposed dam site) and Tamar during the years 1982 and 1985 and rainfall data is being recorded.

Temperature

2.21 Modest heat is experienced in the project area during summer and it is cool during winter. Maximum temperature touches 49.6^0c in May during summer as recorded at Raigarh IMD station. The observed minimum temperature is 6.8^0c during January in the midst of winter.

Relative Humidity

2.22 Relative humidity in the morning varies from 38 percent during April to 86 percent in August. In the evenings it varies from 20 per cent in April to 78 per cent in August. Thus the humidity surcharge is low in dry weather and is very high during the monsoon.

Wind Velocity

2.23 As per the observations, predominant wind direction is form NE during winter season and SW during summer during morning hairs. In the evening hairs the direction is predominant from NE (between October and January) , to NW between February and May. It is SW between June and September. The general wind speed ranges from 1 to 5 km per hour through out the year during both the tones. How ever winds in the speed ranges of 6 to 12 km ph also occur, particularly during late summer and early monsoon periods.

Topography and Drainage

2.24 Chattisgarh state lies between latitude $21^0$58' 0" North and 74^0 to 83^0 23'20" East longitude. The main Geographical dispositions of the Satpura range form the watershed of the plain legging in North and South of them i.e, Narmada and Ganga basin in the North. The Godavari basin and Chattisgarh plains of Mahanadi basin are in the south and south East. The Chattisgarh plains extending along the eastern face of Satpura range form a part of Mahanadi basin. The proposed dam on Kelo river is located in Raigarh district of the lower Mahanadi basin (Kelo sub basin. The basin is saucer shaped constituting Chattisgarh state. The basin is bounded on North by the Raghalkhan platinum, Central India hills on the South, East by the Dandakaranya platinum and Eastern gnats and on west by Satpura Maikala Ranage .

2.25 The general elevation of Satpura range is 610 m above MSL. The higher level in this Northern Platen is about 1220m. but most of the area is at elevation of about 600 m. The Chattisgarh plains one of fan shaped and lie between elevations of 200 m to 400m. There are small hill ranges evenly distributed in this region.

2.26 In general the command area of Kelo Project is broad plains. The upper pediments are sloping. The area to the right of Kelo river is leveled plain comprising of deep clayey soils. Relief of the area is normal.

2.27 The area in general is moderately undulating slopes and general topography is generally with gentle slopes and partly hills. The general slope of the area is towards south. The study area can be distinguished as follows.

a) North Eastern part comprising valley formed by Kelo river and its tributaries as well as high hills

b) South western part mainly concerned by Taraimal R.F, Raigarh RF and Parjipathara RF.

c) Central part is general flat and region of agricultural track.

d) North western part is region of agricultural track and falls in the valley formed by Diyanala and panther nadir and its tributaries.

2.28 The general topography of the Kelo command area is broadly plain with elevations of 213 m to 244 m above MSL. The slope direction in general is form north to south. The command area of the project is circumscribed by a number of natural drains, nalas, streams and Kelo river which collect the run off from the surface and drain effectively. The Kelo river rises at an elevation of about 710 m above MSL about 40 km North of Ghargoda (v) in Raigarh district. The river is about 113km long upto the point of its confluence with Mahanadi river in sambalpur district of Orissa state. During in course it is joined by number of major and minor streams and rivulets forming the drainage area of in catchment area of 920 sq.km upto the proposed dam site. The surface drainage is shown in Fig. II.3

Regional Geology

2.29 Mahanadi basin is on the south eastern side of Chattisgarh. The basin contains rocks belonging to age ranging from Pleistocene to archons represented by late rites , basalt,Lim stones, Sand Stones , Dolamitegnesis, schist's, phylistes, quartzite's, granite etc alluvial deposits however belong to the recent age.

2.30 The Kelo river valley coal fields represents the South-Western extremely of the major Gondgana basin aligned in NW-SE direction. The trend of this basin bears parallelism to the structural gain of the pre-Cambrian basement rocks. Regionally the Kelo Valley coal fields forms part of the inter connected hosed (korba) Mand and Ibb river coal fields, the southern boundary if these basins locally marks a faulted contact. This follows an alignment of NW-SE alignment, which possibly limits the southern part of Mahanadi graben.

2.31 The basin floor in the Kelo valley appears to be irregular and Achaean upland alignment is in a general NW-SE West of Lakha upto Chairapani, the lower Godwana formations but against the Cuddapah and the pre-Cambrian, thereby indicating a faulted contact. The Kelo river basin occurs as broad and open syncline and the synclinal core lies along Bhainsgarhi and Raraimal in a NW-SE direction. Along the basional fringe, the beds dip at 10 – 12 degrees toward NE, whereas the general dip is low (2 to 5 degrees) towards NE, south of axis and SE towards both of fold axis. Near the synclinal core the dips are almost horizontal.

2.32 Another set of fault in NE-WE direction is developed across the basin fringe near Danote-Lakha. Apart from these features the Kelo River coal fields appears to be free from major structural disturbances.

Seismicity

2.33 The project area falls in zone II of the seismological map of India (IS: 1897 – 79). The fracture pattern prevailing in the area has dose relationship with the intrusive activity. The basic dykes and vein quartz though following primary structural trend of the bed rock in the NW-SE direction have shown intense, fracturing/shattering. These are

also displaced along NE-SE to NNE – SSW cross faults. The GSI feels that these faults may not be active in the present day period and would only present cursed zones for local foundation treatment. The Geological conditions of the project area revealed that the selected dam site lies in a very stable region.

Soils

2.34 The soil in the command area is generally alluvium and clay. The top soil crest is generally deep. The colour of the soil is grayish brown changing to darker shades at lower depths. On the basis of texture of topsoil, the following is the classification of the soils in the command area.

1) Sandy Loam----------15.38%

2) Salty Loam ----------53.85%

3) Loam----------23.08%

4) Clay Loam----------7.69%

2.35 The soil texture is normal and likely to provide conditions for normal drainage.

Agriculture

2.36 One paddy crop dependent as timely rains is being grown in the area. Besides, sugarcane is also grown in small parches of land where there are irrigation facilities in the form of wells or tanks. Rabi crop is uncertain in view of lack of adequate soil moisture. The details of the existing cropping pattern in the project area is furnished in Table – 2.4.

Table – 2.4 : KELO PROJECT
EXISTING CROPPING PATTERN IN THE COMMAND AREA

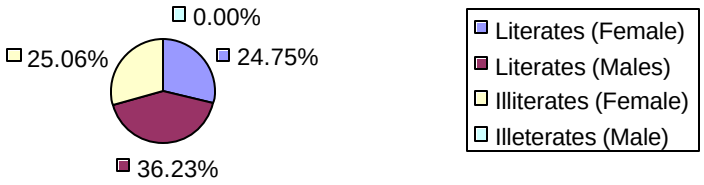
Sl.No	Name of Crop	% of cultivable Area
1	Paddy (Local)	80.97
2	Sugarcane	0.58
3	Other Kharif Crops	13.62
4	Wheat (Hy)	3.67
5	Other Rabi Crops	1.16
	Total	**100.00**

Demography

2.37 The project area comprises of 75 inhabited revenue villages. Out of these 4 fall in Lailunga tahsil and the rest in Ghargoda tahsil of Raigarh district. The total population in these villages as per 2001 census is 56989. Out of the above 50.19 per cent are male and 49.81 per cent are female. Schedule cast population are 9.17% and schedule tribes are 50.87%. Total literates account for 60.99 percent. Among females the literacy rate is

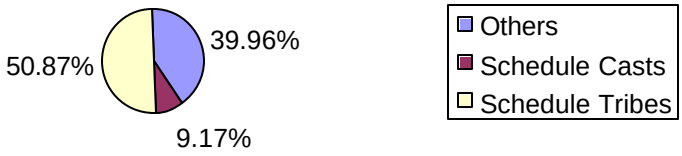
49.69 percent and the rate among males is 72.19 percent. The literacy level in the study area is presented in Chart – 2.1.

Chart – 2.1 : Literacy Level in the Study Area



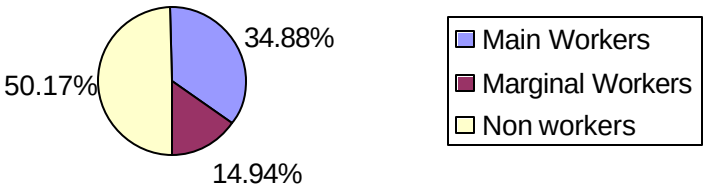
The castewise composition of the population in the command area indicated the area is predominantly tribal area with tribal population accounting for about 51 per cent of total population. The break-up of SC & ST population in the study area is presented in Chart – 2.2.

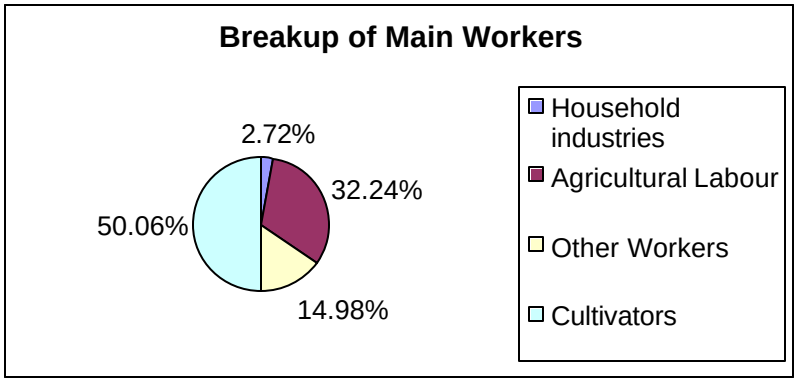
Chart - 2.2 : Breakup of SC&ST population in the Study Area



2.38 Employment pattern and occupation are the two main indicators of economic profile. Pie diagram showing the employment pattern and occupation are shown in Chart – 2.3 and Chart 2. 4 below respectively.

Chart - 2.3 : Employment Pattern





2.39 The total main workers in the study area are 19879 (34.88%) as per census 2001. Marginal workers are 8517 (14.98%) and Non workers are 28593 (50.17%). \thus the Proposed Kelo Project creates employment to the non workers in the study area to a major extent which go a long way in uplifting the socio economic status of many house holds.

Summary of the amenities available in the study area villages are as below:

➢ Education Facilities	74 Primary Schedules 2 High Schedules 1 Adult Literacy Centre
➢ Drinking Water	54 villages – Hand pumps 59 Villages – Well water 12 Villages – River Water 2 Villages - Canal Water 12 Villages – Tank Water
➢ Power Supply	34 Villages – Domestic Purpose 2 Villages – Agricultural Purpose
➢ Communications	14 Villages - Post Offices 1 Villages – Telegraphic Offices 2 Villages – Telephone Facility 7 Villages – Pucca roads 67 Villages – Kutch roads 3 Villages – footpaths

2.40 Aquatic resources are limited. Most of the tanks dry up during summer. There are 7 major industries available in the study area. There are no places of historical/tourist/religious/archeological importance in the study area. Some villages consist of local worship places.

Mines and Minerals:

2.41 Chattisgarh district is endowed with several minerals such as a) Coal, (b) Iron ore, c) Limestone, d) Bauxite, (e) Dolemite and (f) Tin.

The mineral sources available in the project area are as below:

1. **Coal:** After deep dirking activities, coal was found at an average depth of 100 metres . The coal deposits one of inferior quality and thus the resources are of no economical importance.

2. **Lead:** A minor occurrence has been recorded and it is of little importance .

Copper and Zinc are also available but in very minute quantities.

Project Benefits

- The project provides annual irrigation benefits to 26,800 hectares in the most backward Raigarh tahsil of Raigarh district.
- Sustainable increase in agricultural production
- Provides water supply for drinking Industria l and domestic use in the command area
- Creates job potential to the local work force during construction as well as in the post construction period.
- Accelerates the industrial growth and agricultural development of the district and the state in general.
- Creates possibilities for development of the pisciculture as commercial scale in the reservoir area.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - I
GENERAL

III

POLICY, LEGAL AND ADMINISTRATIVE FRAME WORK

Introduction

3.01 The water resources department of the Govt. of Chattisgarh (part of east while Madhya Pradesh) has proposed an irrigation project across Kelo River to cater the needs of farmer community to bring 22,800 ha. under assured irrigation, besides providing drinking water to Raigarh town and to other industries. Such projects have become imminent need for the development and economic growth in the backward area. Though there are large benefits that may accrue after assuring irrigation they are out weighed by social, environmental and economic costs. The chapter focuses on the coverage of the irrigation projects under various acts and regulations set up by the Govt. of India.

National Perspectives

3.02 In the year 1980 the then Union Ministry of Irrigation and the Central Water Commission formulated the national perspectives for Water Resources Development which comprises two main components. They are as follows,

- Himalayan Rivers development,
- Peninsular rivers development.

3.03 Himalayan rivers development envisages construction of storage reservoirs on the main Ganga and Brahmaputra and their tributaries along with inter - linking canal systems to transfer surplus flows of the eastern tributaries of the above rivers. Peninsular river development includes inter-linking of major rivers flowing in the Peninsular India including the southern tributaries of Yamuna. The interlinking of these rivers will envisage construction of storage reservoirs at potential sites and canal systems for transferring waters from surplus to deficit basins/areas. The canals also include tunnel and lifts, wherever necessary.

National Water Policy

3.04 The National Water Policies is being adopted by the Government of India since, 1987. It emphasizes the need for interlinking of rivers by inter-basin transfer of waters. It states 'Water should be made available to water short areas by transfer from other areas including transfer from one river basin to another 'based on a national perspective' after taking into account the requirements of the areas/basins.

Environmental Policy of India

3.05 To meet the challenges of environmental pollution, falling in line with the developed countries, Government of India (GOI) has established an exclusive ministry for Environment and Forests (MOEF) for taking care of environmental protection needs. Any project involved in interference with the environment is governed by the Environmental protection act enacted by the GOI, Environment (Protection) act promulgated in 1986 under Environmental Policy has been amended from time to time covering various implications arising new and then. Clearance to the present Kelo Project is needed under the latest notification of 14th September 2006 and circular dated 8th December 2006.

Forests (Conservation) Act, 1980 and Rules 1981

3.06 The Forest Conservation Act (FCA) was adopted in 1980 to protect and conserve forests. The Act restricts the powers of the state in respect of de-reservation of forests and the use of forest land for non forest purposes. An advisor committee has been created to oversee the implementation of the statute. The FCA is relevant for the irrigation sector also for the setting guidelines for river valley projects where submergence for the reservoir and land acquisition for the canals are involved use of forest land for "Non-Forest" purposes.

3.07 According to Section 2 of the Act "Not with standing any thing contained in any other law for the time being in force in a state, no state Government, or other authority shall, except with the prior approval of the Central Government, make any order directing. De-reservation of a reserved forest".

- Use any forest land for any non forest purpose
- Assign any forest land to any private person or entity not controlled by the Government.
- Clear any forest land of naturally grown trees for the purpose of using it for reforestation.

3.08 The term 'Non forest Purpose' includes clearing any forest land for formation of reservoirs impounding water, excavation of canals and any purpose other than afforestation. The act applies to any forest land irrespective of whether or not it has been declared reserved. It covers the extended meaning of a tract of land covered with trees; shrubs, vegetation and undergrowth intermingled with trees and pasture.

3.09 Be it of natural growth or man-made forestation, such extended meaning is justified in order to make the Act effective to preserve forest land from deforestation, to maintain ecology and to prevent environmental degradation. The forest (conservation) Rules, 1981 empower the central government to constitute a committee to advice the central government on this policy.

3.10 The Kelo Project across Kelo river submerges forest land of 361.90 ha. As per the act double the

area has to be remarked towards compensatory afforestation. As informed by the proponents, required compensation has been paid to the forest department. Clearance from the forest department is yet to be obtained.

The Wildlife (Protection)Act, 1972 (WPA)

3.11 The wildlife (Protection) Act, 1972 provides for protection of listed species of flora and fauna and establishes a network of ecologically important protected areas. The WPA empowers the central and state Governments to declare any area to be a wildlife sanctuary, National park or a closed area. There is a blanket ban on carrying out any process or activity inside any of these protected areas in case.

3.12 If forest land within the protected areas network is to be diverted for other than wildlife use, a no objection certificate has to be obtained from the Indian Board of Wildlife and the state legislature, before the final consideration by MoEF.

Environmental Permits required for the proposed Irrigation Project

3.13 Techno-economic clearance of the proposal is required from the CWC. As per the policies and legal framework, following approvals/clearances are required for an irrigation project.

I. Clearance from CWC under the following. directorates .

1. C & MDD (NW&S) for DPR clearance
1. Design directorate for barrage and canals
1. Machinery consultancy directorate for plant aspects
1. FE &SA directorate for foundation clearance
1. Hydrology directorate
1. Interstate matters directorate
1. Central Ground water board
1. Approval obtained from the above directorates.

II **Ministry of Coal and Mines - Department of Coal**

3.14 No objection certificate given stating that no potential coal seam having workable thickness of 1.2 m and above is likely to occur in the area upto depth of as much as 385 m in their letter dated 07.10.2004.

III Ministry of Agriculture Department of Agriculture and Cooperation

3.15 The Department expressed no objection and in fact supported the proposal in their letter dated

30.01.2006.

IV Cost appraisal directorate (Irrigation)

3.16 Approval at price level of 2007 (by using CSR for 2003) in letter 04.05.2007 was accorded for the project.

V Resettlement and Rehabilitation Policy

3.17 National policy on Resettlement and Rehabilitation to be followed keeping in view of the state policy of Chattisgarh state regarding the R&R of displaced people due to the construction of Kelo Project. The National R & R Policy stipulates that the State Policy in this regard can be adopted, only if the same is more beneficial to Project Affected Families that of National Policy.

VI Archeology and Museums Department

3.18 Necessary no objection certificate is to be obtained from the Archaeological and Museums department as no such monuments are going to be submerged in the proposed reservoir.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume – I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART- II
BASELINE DATA

IV

GEOLOGICAL, GEOPHYSICAL AND HYDROLOGICAL ASPECTS

Introduction

4.01 Chattisgarh Government has proposed a major river valley Project across Kelo River to meet the irrigation demands in the backward Raigarh district. The Kelo river is one the main tributaries of Mahanadi River. The river originates from Dongbra Reserve forests near Hirapur village in Raigarh district. After traversing about 113 km it confluences with Mahanadi River near the state boundary between Chattisgarh and Orissa, 51 km downstream of the proposed Kelo dam site. The Kelo river flows in a sinuous course towards North - South direction through a gently undulating country, largely draining through the lower Gondwana formations. It enters the Archean terrain near Danote (V), the proposed site of Kelo Dam. The river gorge is fairly open in general but in the Barakar and kamthi formations it is narrow with step faces of low height.

Regional Geology

4.02 The Barakar occurs as thin strip across Kelo River because of truncated sequence through it, consisting of a nearly 200m. thick pile of sediment in the main basin portion. The sub-arkosic character of the sandstone with calcareous and ferruginous cement resembles the known Barakar formation of the Mand Valley in the West and Ibb Valley in the East - South- East.

4.03 The Kamthi formation has wide extent towards NW-SE and rests over the Barakar just North of Danote-Lakha belt along the Kelo Valley. The lithological character of this member resembles the Kamthi of Hingir and Ibb valley. In the Kelo valley the thickness of this unit may not be appreciable and will be approximately 50-60 m.

4.04 Irregular patches of recent gravel and conglomerate occur over the ground especially on the higher contours in the proximity of Kelo River. The area in the vicinity of Raigarh has not shown any igneous emplacement.

GEOLOGICAL STRUCTURE

4.05 The Kelo river valley coal fields represents the South-Western extremity of the major Gondwana basin aligned in NW- SE direction. The trend of this basin bears parallelism to the structural grain of the pre-Cambrian basement rocks. Regionally, the Kelo Valley coal fields forms part of the inter-connected Hasdo (Korba), Mand and Ibb river coal fields, the southern boundary of these basins locally marks a faulted contact. This follows an alignment of NW-SE alignment, which possibly limits the southern part of Mahanadi graben.

4.06 The basin floor in the Kelo Valley appears to be irregular and the Archean upland alignment is in a general NW- SE West of Lakha upto Chiraipani, the lower Gondwana formations abut against the Cuddapah and the pre-Cambrian, thereby indicating a faulted contact. The Kelo river basin occurs as broad and open syncline and the synclinal core lies along Bainsagahi and Taraimal in a NW - SE direction. Along the basin fringe, the beds dip at10-12 degrees towards NE, whereas the general dip is low (2 to 5 degrees)towards NE, south of axis and SE towards both of fold axis. Near the synclinal core the dips are almost horizontal.

4.07 Another set of fault in NE-WE direction is developed across the basin fringe near Danote-Lakha. Apart from these features the Kelo River coal fields appears to be free from major structural disturbances.

4.08 The Geological Sequence of the Kelo River basin is given in Table – 4.1.

Table – 4.1
GEOLOGICAL SEQUENCE OF THE KELO RIVER BASIN

Sl. No	Formation	Group	Possible Age
1	Alluvium, Recent Gravel and Conglomerate some laterite	-	Recent
2	Ferruginous sandstone and shale	Lower Gondwana	Upper Permian
3	Current bedded feldspathic sandstone, fine to medium grained sandstone and coal seam.	Lower Gondwana	Upper Permian
4	Light green to grey silt stone, fine to medium grained sandstone and coal seam.	Lower Gondwana	Lower Permian

Table – 4.1
GEOLOGICAL SEQUENCE OF THE KELO RIVER BASIN

Sl. No	Formation	Group	Possible Age
5	Lower Coal formation Karhabari	Lower Gondwana	
6	Talchir	Unconformity	Permian
7	Quartzite, Sandstone and shale	Cuddapah	Proterozoic
8	Unconformity	-	-
9	Granite gneiss, schist & quartzite	Basement Complex	Archaean

GEOLOGY OF THE BASIN AND RESERVOIR

4.09 Construction of main earth dam for a length of 1270 m with two dykes on left side of Kelo river, one proposed about 8 km North of Raigarh in the district of Chattisgarh. As per the information indicated in the reports of officials of Geological Survey of India, Quartzite, sandstone and Phyllite, shale belonging to Chandrapur series of Cuddapah age are resting on Archaean Gneiss and amphibolites associated with quartzite and vein quartz. The Chandrapur series rocks are massive sandstones, bedding planes being 0.3 to 2.0 m apart. The colour varies in shades of brown. These are hard and compact, medium to coarse grained rocks. The beds dip at 10° to 50° South West. Rocks are open jointed.

4.10 Another isolated hillock forming the right flank of saddle dam I of main earth dam is also composed of the same formations as described above.

4.11 Insitu exposures are not seen. Left flank of the saddle dam 1, composed of the same rock formation and forms an isolated hillock NW of village Belwatikra. At the top of this ridge, shale inter bedded with sandstones are seen tending E - W dipping 50° North.

4.12 Archaean Rocks are well exposed at isolated patches both upstream and downstream of the C-C axis (Danote) up to a distance of 2 km. The rocks are also exposed along the axis in the side nala joining the Kelo River from the left flank. Scanty exposures of Granite gneiss rocks are also found in the alluvial cover on either flank of the river but are slightly weathered. In the river channel, however, the rocks are comparatively fresh, hard and compact. In the side nala flowing on the left flank along the C-C axis (Danote) Granite gneiss have 1.0m thick quartz vein which is highly jointed. The vein trends N-S and closely spaced joints 10 to 20 cms apart.

GEOLOGY OF DAM SITE & RESERVOIR BASIN

4.13 Thus the Geological investigation of Kelo Dam across Kelo River revealed the presence of Granite gneiss, quartizitic Sandstone around the proposed alignment. Archaean Granitegneiss, Hornblende gneiss and amphibolites associated with quartz-vein form the foundation rock along the major portion of the C-C dam axis of Danote site. Chandrapur Sandstone- shale hillocks along the C-C axis and isolated hill features are existing on the left flank of Kelo River.

GEOLOGY OF THE RESERVOIR AREA

4.14 Archaean Granite gneiss forms the foundation, with Quartzitic Sandstone and Shale under the abutments. The reservoir will be spread over the Archaean, Cuddapah and Gondwanas with unconformable interface between the major units and porous Sandstones occupying major portion of the basin.

SEISMICITY

4.15 The entire project site features on the proposed Danote C - C axis across Kelo River, are located in the vicinity of Cuddapah-Archaean boundary which has both unconformable and faulted contact in NW-SE direction. The present status of the boundary fault and other gross faults, mentioned above, were not known in the absence of historic seismological data. However, GSI feels that these faults may not be active in the present day period and would only present crushed zones for local foundation treatment. The project area falls in zone-II of the seismological map of India For which suitable seismic factors are given in the ISI code IS: 1897 – 79.

4.16 The fracture pattern prevailing in the area has close relationship with the intrusive activity. The basic dykes and Quartz veins follow primary structural trend of the bed rock. Earthquakes in this region are largely associated with the tectonics of the Narmada - Tapti - Sone Rift, the Brahmin fault and the Godavari fault. In the revised Seismic zoning map of India prepared by a committee of experts from various scientific institutions including India Meteorological Department (IMD) under the Bureau of Indian standards (BIS Code: IS 1893 - part I; 2002), the area of Raigarh and its neighborhood lies in zone III. The seismic intensity is broadly with seismic intensity of VII on the MMI Scale.

4.17 It may be mentioned here that the seismic intensity VII on MMI scale corresponds to horizontal ground acceleration range of 18 - 140 cm/sec^2 or an average acceleration of 67 cm/sec^2 in any direction. The ground acceleration and hence the intensity of an earthquake at a place depends on magnitude of earthquake, the distance from the focus, duration of earthquake, type of underlying soil and its damping characteristics. The damage to the buildings founded on soft soil or filled up earth will be higher than that in the similar type of buildings having their foundation on hard bedrock. Also, the damage will be higher for higher magnitude and long duration earthquake, less epicenter distance, poor underlying soil conditions and areas with high liquefaction potential.

MODIFIED MERCALLI INTENSITY SCALE (ABRIDGED)

Intensity / Grade	Description
I	Not felt except by a very few under specially favorable circumstances.
II	Felt only by a few persons at rest, especially on upper floors of buildings; and delicately suspended objects may swing.
III	Felt quite noticeably indoors. specially on upper floors of buildings but many people do recognize it as an earthquake; standing motor cars may rock slightly; and vibration may be felt like the passing of a truck.
IV	During the day felt indoors by many, outdoors by a few, at night some awakened; dishes, windows, doors disturbed; walls make creaking sound, sensation like heavy truck striking the building; and standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened; some dishes, windows, etc. broken; a few instances of cracked plaster; unstable objects overturned; disturbance of trees, poles and other tall objects noticed sometimes; and pendulum clocks may stop.
VI	Felt by all, many frightened and run outdoors; some heavy furniture moved; a few instances of fallen plaster or damaged chimneys; and damage slight.
VII	Everybody runs outdoors, damage negligible in buildings of good design and construction; slight to moderate in well built ordinary structures; considerable in poorly built or badly designed structures; and some chimneys broken, noticed by persons driving motor cars.
VIII	Damage slight in specially designed structures; considerable in ordinary but substantial buildings with partial collapse; very heavy in poorly built structures; panel walls thrown out of framed structured; falling of chimney, factory stacks, columns,monuments, and walls; heavy furniture overturned, sand and mud ejected in small amounts; changes in well water; and disturbs persons driving motor cars.

IX	Damage considerable in specially designed structures; well designed framed structures thrown out of plumb; very heavy in substantial buildings with partial collapse; buildings shifted off foundations; ground cracked conspicuously; and underground pipes broken.
X	Some well built wooden structures destroyed; out masonry and framed structures with foundations destroyed; ground badly cracks; rails bent; landslides considerable from river banks and steep slopes; shifted sand and mud; and water splashed over banks.
XI	Few, if any, masonry structures remain standing; bridges destroyed; broad fissures in ground, underground pipelines completely out of services; earth slumps and land slips in soft ground; and rails bent greatly.
XII	Total damage; waves seen on ground surfaces; lines of sight and levels distorted; and objects thrown upward into the air.

HISTORY OF PAST EARTH QUAKES IN THE AREA

4.18 Historical and instrumentally recorded data on earthquakes show that the area of Kelo Major Project in district Raigarh (Chattisgarh) and its neighborhood fall within the Narmada - Sone lineament zone which passes through central India from west to east and is seismically active. This region has experienced earthquakes up to magnitude 6.5. The prominent amongst these are:

I. The earthquake of May 1846 near Damoh (magnitude = 6.5 on Richter Scale),
II. The Sone valley earthquake of June 2, 1927 (Mag=6.5),
III. The Satpura Earthquake of 14th March 1938(Magnitude = 6.3),
IV. The Balaghat earthquake of Aug. 25, 1957 (Magnitude = 5.5), and
V. The Jabalpur earthquake of May 22, 1997 (Magnitude = 6.0).
VI. Earthquake on 6-4-2000 around Bilaspur (Magnitude 4.0)

4.19 The Jabalpur earthquake of 22nd May 1997 was severely felt in the region. According to an official estimate, it took a toll of 39 human lives and caused extensive damage to property in the epicentral area. The damage was maximum in Jabalpur and Mandla districts. Due to this earthquake the area of Raigarh and its neighborhood experienced seismic intensity V on the Modified Mercalli Intensity (MMI) scale (description of MMI scale enclosed). The earthquake was followed by a number of after shocks some of them had magnitude > 3 on Richter scale.

4.20 The region has also experienced fringe effects of moderate earthquakes originating in the peninsular shield region and the great earthquakes originating in the Himalayan belt.

4.21 In recent past 06.04.2000 an earthquake shock of slight intensity (Mag = 4.0) occurred in the region and it was reported felt in and around Bilaspur (Chattisgarh). The maximum seismic intensity at the epicenter due to this earthquake was estimated to be IV on MMI scale.

4.22 Besides, a list of significant earthquakes from IMD catalogue occurred in the region bounded by latitude 19.0^0 to 25.0^0N and longitude 80.4^0 to 86.4^0 E upto October 2005 is listed in Table - 4.2. Some of these earthquakes could have been experienced in the region.

Table – 4.2 : KELO PROJECT

List of Earthquakes from IMD catalogue occurring between Latitude 19.00 to 25.00 Deg. N and Longitude 80.40 to 86.40 Deg. E for the period 1505 to October 2005

Date	O-Time		Latitude	Longitude	Depth	Mag
30.09.1868	0-0	0	24.00	85.00	0.00	5.0
02.06.1927	16-37	24.00	24.00	82.30	0.00	6.5
05.08.1979	1-18	36.6	22.12	85.97	33.00	4.7
17.02.1985	23-6	55.00	24.67	85.48	11.00	4.7
06.05.1985	20-59	45.5	24.43	82.37	42.00	4.7
18.01.1986	5-42	18.2	20.94	84.90	33.00	4.4
19.01.1986	6-52	59.7	21.01	85.22	0.00	4.4
17.03.1986	3-3	35.1	22.87	85.16	33.00	4.3
05.04.1989	9-40	34.4	24.12	82.60	33.00	.0
20.01.1991	8-2	47.0	24.20	82.20	33.00	.0
16.05.1991	8-22	35.0	24.80	84.30	33.00	.0
29.07.1991	7-57	22.0	24.20	82.90	10.00	.0
10.08.1991	8-7	52.00	24.90	84.00	33.00	.0
08.10.1991	11-27	57.00	23.50	84.30	10.00	.0
15.10.1991	7-13	42.0	24.30	82.60	33.00	.0
17.12.1991	8-16	48.0	24.10	83.00	33.00	.0
01.11.1993	9-23	14.00	21.00	85.10	0.00	3.8
27.03.1995	7-52	13.0	21.70	84.60	33.00	4.5
26.05.1995	13-58	23.00	19.20	83.30	33.00	4.5
21.06.1995	18-35	38.1	21.80	85.30	33.00	4.5
18.01.1996	8-5	35.00	24.90	82.80	33.00	.0
22.05.1998	23-13	32.0	22.53	85.28	33.00	4.3
23.05.1998	9-3	52.00	24.36	82.95	162.00	2.8
05.02.1999	16-24	37.9	23.38	81.06	15.00	.0
12.04.1999	8-37	19.0	24.11	82.44	33.00	2.9
25.05.1999	16-16	40.7	23.52	84.53	33.00	4.0
09.11.1999	7-51	55.6	19.53	84.24	10.00	3.4
27.02.2000	11-42	58.0	22.23	82.88	33.00	4.0
06.04.2000	4-34	32.5	22.34	82.43	15.00	4.0
29.09.2000	5-3	38.8	23.55	81.52	33.00	3.1
10.10.2000	6-11	32.6	23.06	82.92	5.00	3.5
20.11.2000	8-12	29.8	22.44	83.67	82.00	3.0
05.12.2000	8-55	50.8	22.18	81.46	33.00	2.6
29.12.2000	8-40	32.3	24.28	83.16	10.00	3.3
17.02.2001	8-11	32.8	24.11	82.17	9.00	.0

Table – 4.2 : KELO PROJECT

List of Earthquakes from IMD catalogue occurring between Latitude 19.00 to 25.00 Deg. N and Longitude 80.40 to 86.40 Deg. E for the period 1505 to October 2005

17.05.2001	9-27	41.9	24.57	84.86	15.00	3.2
08.06.2001	7-34	43.5	24.24	82.65	5.00	3.1
10.06.2001	1-12	18.8	23.03	83.15	16.00	3.6
12.06.2001	12-41	4.3	22.25	84.03	33.00	4.7
17.10.2001	9-6	16.4	24.00	80.82	10.00	3.7
03.11.2001	15-2	26.8	19.70	82.79	15.00	3.7
14.04.2002	10-5	46.0	22.32	54.72	38.00	.0
21.09.2002	6-7	37.6	21.06	80.79	10.00	3.0
21.09.2002	10-26	18.00	19.43	84.11	15.00	3.7
07.10.2002	4-52	37.9	19.01	83.66	10.00	2.1
28.02.2003	9-15	23.9	22.27	81.04	10.00	.0
17.03.2003	21-48	24.40	22.45	86.04	10.00	3.6
30.07.2003	17-15	32.6	21.80	84.31	25.00	3.4
25.12.2003	9-15	13.7	21.65	81.15	5.00	2.7
12.01.2004	9-2	39.7	23.33	81.97	20.00	3.3
25.08.2004	0-11	32.6	23.19	85.90	35.00	3.6
10.02.2005	6-20	5.4	22.92	85.42	39.00	3.3
16.02.2005	8-54	17.1	23.15	81.66	5.00	2.8
05.06.2005	11-45	39.1	21.42	81.16	5.00	2.7
08.08.2005	16-12	50.5	23.36	85.87	5.00	3.8

HYDROLOGY

Mahanadi River System

4.23 The river Mahanadi is an inter-state river system between Maharashtra, Chattisgarh, Bihar and Orissa. The total length of the river is 851 km and the area of the drainage is 11.42 lakh sq.km. The river rises in Raipur district of Chattisgarh at on elevation of 442 m above MSL near Nagiri (v). The river Mahanadi has 25 major tributaries with catchment area exceeding 250 sq.km. Out of the above 18 tributaries lie wholly in Chattisgarh and six lie partly in Chattisgarh and in Orissa. The largest tributary sheonath is partly in Madhya Pradesh and partly in Maharashtra. The Mahanadi basin in Chattisgarh can be broadly divided into three distinct zones.

(i) Upper Mahanadi : Basin excluding that of Sheonath river up to its confluence with Mahanadi . Mostly in Bastar and Raipur districts;

(ii) Sheonath: The sub basin of Sheonath river, covering area in Durg, Raipur and Bilaspur.

(iii) Lower Mahanadi: Remaining Mahanadi Basin in Chattisgarh district covering areas in Raipur , Bilaspur, Raigarh and Surguja districts.

Mahanadi - Basin

4.24 The Mahanadi River Basin spreads over an area of 11.42 lakh sq.km. Out of the above 53.86 percent is in Chattisgarh, 46.32 percent in Orissa, 0.17 percent in Maharashtra and 0.45 percent in Bihar. Seven districts of Chattisgarh state are covered under the Mahanadi basin. Details are shown in Table - 4.3..

Table - 4.3
BASIN AREAS COVERAGE IN THE DISTRICTS OF CHATTISGARH

Sl.No	District	Total area of the District (sq.km)	area of Basin lying in the district (sq.km)	Percentage of district are lying in basin (%)
1	Bastar	3906.00	266.60	6.82
2	Raipur	2127.30	2123.40	99.82
3	Durg	857.00	839.00	97.87
4	Rajnandgaon	1109.70	814.90	73.43
5	Bilaspur	1190.50	1095.90	95.25
6	Raigarh	1281.00	1067.00	82.65
7	Surguja	2223.70	492.90	22.07
	Total	**12695.00**	**6699.70**	**52.77**

4.25 The basin is bounded by Raghalkhan plateau (surguja, shedol) on North, central India hills on the south, Dandakaranya plateau and the Eastern ghats on East and Satpura Maikala Range on west. The rainfall pattern within the basin indicates decreasing trend towards central portion compared to North and Southern Regions. In the entire basin the rainfall varies from 1000 km to 1500 mm which is fed by both south west and North East monsoons. Monsoon sets in the second week of June and continues till the end of September. About 90 percent of the rainfall occurs in the monsoon period. Based on the rainfall - run off relationship, the surface water availability has been assessed as below:

Table - 4.4
WATER ASSESSMENT IN THE BASIN

Sl. No	Basin	CA (sq.km)	75% dependable yield Mm^3	MAF
1	Upstream of Hirakud Dam	72629.00	29933.00	24.27
2	Downstream of Hirakud Dam	2507.00	929.00	0.75
	Total	**75,136.00**	**30,862.00**	**25.02**

KELO RIVER

4.26 The Proposed Kelo dam is located in Raigarh District of the lower Mahanadi Basin. i.e., Kelo sub-basin. The Kelo River across which the Kelo dam will be located, rises at an altitude of 710.36m above Mean Sea Level about 40 km North of Gharghoda in Raigarh District. The river is about 112.60 km long and joins Mahanadi, directly on its left bank near village Mahanadi in Sambhalpur district (Orissa).

4.27 It has a well defined course from village Amapali, located at latitude 83^0 - 29' - 0" and longitude 22^0 - 22' - 0",9.00 km downstream of its origin up to its confluence with the Mahanadi River.

4.28 It starts in the westernly direction, as a small rivulet and traverses in this direction (Latitude 23^0 - 29' - 25" and longitude $82^0$23' - 0") for about 4.0 km from its origin and after which it is deflated in the Southernly direction. It leaves the hilly tract and enters plains near village-Milupara (latitude 22^0 - 11' - 0" and longitude $83^0$31'35") 34.60 km from its origin. In plains its length is 78.0 km.

Catchment Area

4.29 The Catchment Area of Kelo river up to the proposed dam site near Danote (v) is 920.21 sq.km Ninety five percent of the catchment area lies in Chattisgarh state only. A marginal area of 5 percent lies in Orissa state.

Drainage Area

4.30 The area is Characterized by dendritic pattern of drainage and mainly controlled by Kelo river and its tributaries. The project area is drained by Kelo river, Pajhar nadi,etc., The general topography of the Kelo command is broadly plain with elevation from 213.0 m to 243.0 m above MSL and slope direction is generally from North to South. The area is covered with several major and minor streams which collect the run off from the surface into the reservoir. Drainage pattern is shown if Fig.IV

Water Availability and Utilization

4.31 The 75% dependable yield from Kelo catchment area as approved by CWC, is 388.23 M cum and yearly water utilization proposed for the project is 172.88 M cum (173 Mm^3) only. The water use in Mahanadi basin from completed and ongoing major, medium and minor schemes of Chattisgarh state has been worked out to about 730 M cum. With the proposed utilization under Kelo project of 173 Mm^3, the total utilization works out to 7473 Mm^3 which is about 28.15% of available yield of 6,542 Mm^3 in Mahanadi water as per the share of Chattisgarh, proportionate to its catchment area.

HYDRO METEOROLOGY

4.32 The project area has a tropical climate. There are considerable variations in the rainfall.

Rainfall

4.33 The Catchment area is influenced by seven rain gauge stations including "Danote" at dam site..

Rain gauge stations influencing the catchment area.

A.	Raigarh	Out side periphery of CA but within the command
B.	Ghargoda	At the periphery of CA
C.	Pathalgaon	Outside the CA
D.	Buldega	Outside the CA
E.	Himgir	Outside the CA
F.	Danote (dam site)	At dam site within CA(installed in 1982)
G.	Tamnar	Within catchment area periphery (Installed in the year 1985)

4.34 Considering the rainfall recorded at the RG station at dam site, Raigarh, the maximum annual rainfall occurred in the year 2003 which is 23.7% more than the normal rainfall . The minimum rainfall was recorded in the year 2006 which is 42.4 per cent less than the normal rainfall .

Gauge Discharge Data

4.35 The months discharge data of Kelo river observed by the Hydro meteorology division No. 4, Raipur at Kelo bridge at Raigarh during the years from August 2001 to 2007 are shown in Table - 4.5. The observed annual run-off with peak and lean flows are tabulated in Table - 4.6.

Table - 4.6 : KELO PROJECT : ANNUAL RUNOFF				
Sl. No	Year	Annual run off (MCM)	Peak observed discharge (cumecs)	Lowest observed discharge (cumecs)
1	2001 - 2002	409	160 (22-08-2001)	7.94 (03.02.2002)
2	2002 - 2003	589	114 (12-09-2002)	8.47 (31.07.2002)
3	2003 - 2004	969	180(08.09.2003)	8.23 (08.07.2003)
4	2004 - 2005	911	394 (12.08.2004)	10.6 (30.04.2005)
5	2005 - 2006	928	180 (06.08.2005)	12.7 (26.05.2006)
6	2006 - 2007	653	218 (30.07.2006)	0.49 (11.04.2007)
Average		**743.17**	**207.67**	**8.07**

4.36 The mean annual run off considering the last six years worked out to 743.17 Mcm. The mean peak and lowest observed flows in the Kelo river are 207.67 cumecs and 8.07 cumecs respectively. Graphical representation of annual run off versus annual rainfall is presented in Drawing 1.

Temperature

4.37 The project area experiences modest heat during summer and is very cool during winter. The highest temperature as recorded at Raigarh observatory station touches a maximum in May. The minimum temperatures touch in January.

Relative Humidity

4.38 It is observed that the relative humidity is higher during other months. The variation of mean relative humidity in percentage in different months is graphically represented in Drawing 2.

Wind flow Pattern

4.39 The monthly mean wind speed and direction for the period 2001-2002 to 2006-2007 have been studied as per the data procured from IMD station Raigarh. The predominant wind direction during morning hours is from NE during winter season and SW during summer and monsoon seasons. The predominant wind direction in the evenings is from NE between October and January, NW between February and May and SW between June and September. The general wind speed ranges from 1 to 5 km/hr throughout the year during both morning and evening tones. However winds in the speed ranges 6 kmph to 12 kmph also occur occasionally.

CATASTROPHIC EVENTS
FIRES IN FOREST

4.40 Forest fires are a common feature in forested mountain areas. In the project area of Kelo Project there is no evidence indicating extensive fire causing damages to habitats in the recent historical period. The people in the villages who will be deputed for construction purpose in the project area will be provided with adequate knowledge about the pre cautions and preventive measures.

Land Slides

4.41 Land slides are rare events in the area especially during high intensity monsoon rains. Present topography of the ground in the vicinity of dam is not vulnerable to land slides in view of flatter slopes of about 1:10. Before start of the construction activities, areas prone to land slides, if any will be identified to implement suitable measures for slope stabilization.

Floods

4.42 No catastrophic events due to floods have occurred in the project area. The Project area does not fall under very heavy rainfall area. The Kelo river catchment comprises mostly forest areas with steep slopes which do not allow the flood waters to inundate the areas causing damages. Hitherto no record of evidence available as to the damages due to floods in the area.

Earth Quakes

4.43 The Project area falls within seismic zones III as per Seismic zoning map of India. Historically and instrumentally recorded data on earth quakes show that the area of Kelo major project in Raigarh district and its neighborhood falls within the Narmada – one lineament zone which passes through the central India from west to East and is seismically active. The region experienced earthquakes up to a magnitude of 6.5. The list of prominent amongst these is tabulated below. (Table - 4.7).

Table - 4.7 : KELO PROJECT
LIST OF PROMINENT EARTHQUAKES

Sl.No	Location	Magnitude	Damages
1	Damoh in May 1846	6.5	Not felt in the region
2	Stone valley Earthquake of 2nd June 3, 1927	6.5	Not felt in the region
3	Satpura Earth quake of 14th March 1938	6.3	Not felt in the region
4	Balaghat Earthquake of 25th August 1957	5.5	Not felt in the region

Table - 4.7 : KELO PROJECT LIST OF PROMINENT EARTHQUAKES			
Sl.No	Location	Magnitude	Damages
5	Jabalpur Earthquake of 22nd May 1997	6.0	Severally felt. Took a toll of 359 human lives and caused extensive damage to property in the epicenter area. No. of aftershocks =3 followed.
6	Earth quake on 6th April 2000 around Bilaspur	4.0	Fringe effects only.

4.44 Suitable seismic design parameters adopted for designing Hydro electric projects.

Sedimentation

4.45 The water available in Kelo River is free from any in hygienic solvents considered harmful for irrigation and domestic water supply purpose. The catchment area of 920.21 sq.km up to dam site has been considered for sedimentation studies. For calculation of silt reserve, rate of silting has been adopted as 0.52 ha. M /sq.km of catchment area per year (1.0 acre ft per sq. mile of CA per year) according to silt observations conducted at Harkin dam as suggested by CWC duly taking the life of the reservoir as 100 years. The zero elevation of the dam has been worked out at +219.51 m and the MDDL has been fixed at +227.0 m. The sediment distribution has been worked out for the period of 50 years and 100 years by need's method. Sediment distribution up to + 23933 m has been done. The abstract of sediment study are shown in Table - 4.8 computations of gross sediment deposits for 50 years and 100 years has been made in the studies.

Table - 4.8 ABSTRACT SEDIMENT STUDY				
Sl.No	Particulars	Unit (Acre ft.)	Life in years	Quantity of Sediment deposits in acre ft
1	Total Silt	Acre ft.	50/100	35545.00
2	Zero elevation	Acre ft.	50/100	
3	Silt below zero elevation	Acre ft	50/100	1396.00
4	Silt above zero elevation	Acre ft	50/100	34149.00
5	Silt below 229.00 m	Acre ft	50/100	15433.00
6	Silt above 229.00 m	Acre ft	50/100	20112.00

4.46 Keeping in view of the command level in view, the MDDL is fixed at RL 227.00 m. The silt sediment trapped by the upstream projects have not been considered in this computation, being very marginal or negligible quantity.

Water use and Water Availability

4.47 The project aims at making optimum use of water resources of Kelo River and its tributaries. Besides It has been estimated that upstream of Kelo Dam water requirement for irrigation by Minor Schemes and that of domestic and industrial supply of Water may be of the order of 0.0073800 M.ham. (67.20 thousand acres ft). this, the use of water from the Project itself would be 0.03115 M.ham (253.249 Thousand Ac.ft.) Against this, the water available at Kelo dam, Danote site C-C axis, without deduction of the upstream use, will be of the order of 0.038714 M.ham on the basis of the annual inflow i.e., (314.748 thousand acre ft) 0.03606 M.ham (293.172 thousand acre ft) on the basis of monsoon inflow from June to October at 75% dependability. The water available at the project site after deduction for the upstream use would be 0.027795 M.ham. (225.972 thousand acre ft) based on the monsoon inflows. Therefore some carry over storage s provided for this project taking into account the requirement anticipated from the water use on the upstream of the project. Table 4.9 gives the idea of the water available and that proposed to be used for irrigation and other purposes.

Table - 4.9
WATER AVAILABILITY AND REQUIREMENT

Sl.No	Item	Quantity of Water requirement	
		M.ham	Macre ft
1	Water available	0.0387140	0.314
2	Upstream Utilisation	0.0073800	0.067
3	For Kelo Project Irrigation	0.0311500	0.25325
4	Water Supply for domestic and industrial purposes	0.0068856	0.0072
	Total	**0.0454156**	**0.32745**

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume – I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART- II
BASELINE DATA

V

BIOLOGICAL RESOURCES

Introduction

5.01 Biological diversity cures our ills. It also feeds us and provides raw materials for industry" - WWF International.

5.02 The biological resources of the Kelo project include natural protection forests, timber, pulp wood, fire wood, fodder, fruit, medicinal and crop plants. Tropical dry deciduous type of forests occurs in the catchment area of the river Kelo. Close to the dam site and in the area of submergence, the forests are highly degraded due to biotic pressure. Away from the area of submergence in the catchment area, relatively thick mixed Sal forests are found in isolated pockets. Forests cover an area of about 110 Km^2 accounting for about 28% of the total catchment area & Forest Cover. As per the local classification, reserved forests occupy 88 Km^2, protected forests cover about 10 Km^2 while the revenue forests are found in 12.22 Km^2. Besides the above, there are also agro-forests and social forests of Sal, Teak and *Eucalyptus* within the catchment area including the area of submergence. Open forests (<40% canopy cover) occupy about 65% of the total forest area. Thick forests (>40% canopy cover) occur in about 18% of the area and the rest (17%) is a bush land.

Flora and Fauna

5.03 Survey of the flora and fauna of the Kelo irrigation Project was undertaken between April 2007 and February 2008. Data was collected separately from the catchment area, reservoir and the command area. Comprehensive lists of flora and

fauna are prepared for the catchment, reservoir and the command areas based on extensive survey made covering the entire study area. Random stratified sampling techniques were used for the collection of information about the floristic composition, density, frequency and other quantitative features from stratified natural forests. A total of 100 quadrts of 50 m X 2 m were used for assessment of the relative importance of different species of trees and shrubs and the quantitative data thus generated was used for calculation of Shannon – Wiener Indices of Diversity (H') by using PAST programme. For the assessment of the indices of diversity of herbaceous species, 100 random quadrts of 1x1m were taken during the three different seasons. Shannon – Wiener Indices of Diversity (H') were calculated based on the average cover of different species per hectare. Modified line intercept method was used for estimation of cover of structural species. In order to estimate the cover, 10 line transects of 100 m each running across different types of communities were used. The area in term of distance intercepted, overlaid or under- laid by the canopy of dominant species along the lines was measured and expressed as the percent cover. Canopy cover was used for trees and ground cover was used for herbs and bushes.

5.04 These quantitative data were used for calculation of indices of diversity by making use of PAST programme. Both the structural and interstitial species are collected from the study area are included in the list of species while the average number of taxa found in each hectare and their percent cover were used for calculation of indices of diversity. Number of taxa and the Shannon – Wiener Indices of Diversity for different seasons for the three different areas are shown in Table 5.1.

Table – 5.1 : KELO PROJECT
SHANNON – WIENER INDICES OF DIVERSITY OF THE CATCHMENT, RESERVOIR AND COMMAND AREAS DURING THE RAINY, WINTER AND SUMMER SEASONS

Season	Area	No. of Taxa	Shannon–Wiener Indices
Summer 2007	Command	18	0.75
	Catchment	98	1.86
	Reservoir	127	1.65
Rainy season 2007	Catchment	164	2.27
	Reservoir	152	3.10
Winter 2007 / 2008	Command	94	1.15
	Catchment	112	2.16
	Reservoir	96	2.04

5.05 Perennial plant resources of the catchment area and the reservoir area are given in Table 5.1. Except for differences in dominance, there were no floristic differences between the catchment area and the area of submergence since it is mostly a plain land without much variation in topography, climate, altitude, drainage, rainfall and soils. The relative differences in distribution are indicated in Table 5.2.

5.06 List of trees and shrubs found in the catchment and reservoir areas throughout the year (in all seasons) are given in Table 5.2. The common use of the plant resources is also given in Table - 5.2..

Table – 5.2: KELO PROJECT
LIST OF TREE RESOURCES OF THE CATCHMENT AREA
INCLUDING THE AREA OF SUBMERGENCE.

Legend: T= timber; Fr=Fruit trees; Fw= Fire wood; P = Pulp wood; M=Medicinal; F=Fodder; CP= Crop plant ; L=Leaf; R= reservoir area; CA= catchment area

S.No	Name of plant species	Relative importance	Resource
1.	*Acacia caesia*	Scattered in R &CA	M,T &Fw
2.	*Acacia catechu*	Scattered in R &CA	M,T &Fw
3.	*Acacia nilotica*	Occasional in CA	M,F, T , Gum & FW
4.	*Acacia sinuata*	Occasional climber in CA	M & sheeka kai
5.	*Ailanthus excelsa*	Widespread	M & Fw
6.	*Alstonia scholaris*	Widespread	M & Fw
7.	*Alstonia venenata*	Occasional	FW
8.	*Anogeissus latifolia*	Occasional in R&CA	T &Fw
9.	*Azadiracta indica*	Scattered in R &CA	M,T , neem oil & Fw
10.	*Bambusa arundinacea*	Prominent in CA	Bamboo
11.	*Buchanania lanzan*	Predominant	T,Fr
12.	*Butea superba*	Climber in CA	M
13.	*Butea monosperma*	Common to R&CA	M & F w
14.	*Careya arborea*	Occasional in CA	M,T &Fw
15.	*Carissa spinarum*	Common in R & CA	Fr & Fw
16.	*Ceiba pentandra*	Occasional in CA	Fibre & Fw
17.	*Cochlospermum relogio sum*	Occasional in CA	M, Gum & Fw
18.	*Combretum albidum*	Occasional climber in CA	M
19.	*Cordial dichotoma*	Occasional in R & CA	M, Fr & Fw
20.	*Couropita guinensis*	Occasional in R	M, Flowers & Fw
21.	*Dalbergia sissoo*	Very Common in R & CA	M,T, Fw &F
22.	*Delonix elata*	Occasional in R & CA	Ornamental avenue tree
23.	*Dendrocalamus strictus*	Common in R & CA	Bamboo
24.	*Diospyros melanoxylon*	Abundant in R	Beeri Leaf & Fw
25.	*Erythrina stricta*	Common to R&CA	M & Fw
26.	*Erythrina suberosa*	Prominent in CA	M & Fw
27.	*Erythrina vriegata*	Scattered in R &CA	M & Fw
28.	*Ficus benghalensis*	Common in R & CA	Shade, shelter & food for birds
29.	*Ficus hispida*	Common in R & CA	Fr & Fw
30.	*Ficus racemosa*	Occasional in R & CA	M, Fw & shade
31.	*Ficus relogiosa*	Common in R & CA	Shade, shelter & food for birds
32.	*Givotia moluccana*	Scattered in CA	W & wood for toys
33.	*Gmelina arborea*	Common in CA	Timber
34.	*Helecteris isora*	Common to R&CA	M & Fw

S.No	Name of plant species	Relative importance	Resource
35.	*Holoptelia integrifolia*	Common to R&CA	M, Fibre & Fw
36.	*Jatropha curcas*	Abundant in R	M & Biodiesel
37.	*Jatropha glandulifera*	Common in R & CA	M
38.	*Lagerstroemia parviflora*	Common in R & CA	T &Fw
39.	*Mangifera indica*	Scattered in R &CA	Fr, T &Fw
40.	*Manilkara hexandra*	Occasional in CA	M, T &Fw
41.	*Phyllanthus emblica*	Occasional in CA	M, T &Fw
42.	*Plumeria alba*	Occasional in R	M & ornamental
43.	*Pongamia pinnata*	Common in R & CA	M & Biodiesel
44.	*Pterocarpus marsupium*	Occasional in CA	T &M
45.	*Rauvolfia serpintina*	Occasional in CA	M
46.	*Semecarpus anacardium*	Occasional in CA	M & marking nut
47.	*Shorea robusta*	Predominant	T
48.	*Shorea tumbaggaia*	Occasional in CA	M, resin & T
49.	*Strebulus asper*	Abundant in R	Fr & Fw
50.	*Strychnos potatorum*	Occasional in CA	M & Clearing nut
51.	*Syzygium cumini*	Scattered in R &CA	Fr, M, T &Fw
52.	*Tamarindus indica*	Scattered in R	Fr, tamarind & Fw
53.	*Tectona grandis*	Occasional in R & CA	Timber
54.	*Terminalia arjuna*	Common to R&CA	T
55.	*Terminalia bellirica*	Occasional large trees in R&CA	Seed & Fw
56.	*Terminalia chebula*	Occasional in R&CA	M & Fw
57.	*Terminalia pallida*	Occasional in CA	M & Fw
58.	*Terminalia tomentosa*	Common to R&CA	T & Fr
59.	*Wrightia tinctoria*	Scattered in R &CA	M &Fw
60.	*Ziziphus marutiana*	Scattered in R &CA	Fr &Fw
61.	*Ziziphus nummularia*	Scattered in R &CA	Fw & minor timber
62.	*Ziziphus rugosa*	Scattered in R &CA	Fr &Fw

5.07 But in the command area, trees were restricted to road sides, vacant lands, residential areas and field bunds. *Acacia nilotica* was the most predominant tree along the field bunds in the whole area from Raygarh to Bilaspur.

5.08 Besides the above trees, there were a number of perennial and annual shrubs, climbers and herbs. Their occurrence and distribution in the reservoir, catchment and command areas are given in Table – 5.3.

Table 5.3 : KELO PROJECT
LIST OF PLANT RESOURCES RECORDED DURING DIFFERENT SEASONS
BETWEEN MAY 2007 AND FEBRUARY 2008
R = rainy season, W= winter and S= summer.Ecologically dominant species are indicated by *

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Abelmoschus esculentus	Malvaceae	R&W		R&W
Abelmoschus moschatus	Malvaceae	R&W		
Abrus precatorius	Fabaceae	R&W	R,W &S	
Abutilon crispum	Malvaceae	R&W	R&W	
Abutilon graveolens	Malvaceae	R&W	R&W	
Acalypha indica	Euphorbiaceae	R &W		
Acanthus ilicifolius	Acanthaceae	R,W&S		R,W&S
Achyranthes aspera	Amaranthaceae	R&W	R&W	R&W*
Achyranthes bidentata	Amaranthaceae	R&W	R&W	
Adiantum caudatum	Adiantaceae		R&W	
Adiantum incisum	Adiantaceae		R&W	
Adiantum lunulatum	Adiantaceae		R&W	
Aeluropus lagopoides	Poaceae	R&W	R&W	
Aerva javanica	Amaranthaceae	R&W	R&W	
Aerva lanata	Amaranthaceae	R&W	R&W	
Aerva tomentosa	Amaranthaceae	R&W		R&W
Aeschynomene aspera	Fabaceae	R&W		R&W
Aeschynomene indica	Fabaceae	R&W		R&W
Agave Americana	Agavaceae	Perennial	Perennial	Perennial
Ageratum conyzoides	Asteraceae	R&W	R&W	
Allamania nodiflora	Amaranthaceae			R&W
Allmania longipedunculata	Amaranthaceae	R&W		R&W
Alloteropsis cimicina	Poaceae	R&W	R&W	
Alocasia decipiens	Araceae	R&W		R&W
Alternanthera pungens	Amaranthaceae	R&W	R&W	R&W
Alternanthera sessilis	Amaranthaceae	R&W	R&W	R&W*

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Alysicarpus monilifer	Fabaceae	R&W	R&W	
Amaranthus caudatus	Amaranthaceae			R&W
Amaranthus hybridus	Amaranthaceae			R&W
Amaranthus spinosus	Amaranthaceae	R&W	R&W	R&W
Amaranthus viridis	Amaranthaceae			R&W
Ammannia baccifera	Lythraceae	R&W		R&W
Ammania multiflora	Lythraceae	R&W		R&W
Amorphophallas bulibifer	Araceae	R&W	R&W	
Andrographis echinoides	Acanthaceae	R&W		R&W
Andrographis paniculata	Acanthaceae	R&W	R&W	R&W
Anisomeles malabarica	Lamiaceae	Perennial	Perennial	
Apluda mutica	Poaceae	R&W	R&W	
Arachis hypogaea	Fabaceae			R&W
Argemone mexicana	Papaveraceae			R&W
Aristida adscensionis	Poaceae			R&W
Aristida funiculata	Poaceae	R&W	R&W	R&W
Aristida hystrix	Poaceae			R&W
Aristida setacea	Poaceae	R&W	R&W	R&W
Aristolochia bracteolata	Aristolochiaceae			R&W
Aristolochia indica	Aristolochiaceae	R&W	R&W	
Arundinella purpurea	Poaceae	Perennial	Perennial	
Asclepias curassavica	Asclepiadaceae	Perennial	Perennial	
Asparagus racemosus	Liliaceae	Perennial	Perennial	
Asystasia gangetica	Acanthaceae	R&W		R&W
Bacopa floribunda	Scrophulariaceae	R&W		R&W
Barleria prionitis	Acanthaceae			R&W
Bidens biternata	Asteraceae	R&W		R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Biophytum nervifolium	Oxalidaceae			R&W
Blepharis maderaspatensis	Acanthaceae			R&W
Blepharis repens	Acanthaceae	R&W		
Blumea amplectens	Asteraceae	W	W	W
Blumea membranacea	Asteraceae	W	W	W
Blumea solidaginoides	Asteraceae	W	W	W
Boerhavia diffusa	Nyctaginaceae			R&W
Boerhavia erecta	Nyctaginaceae	R&W	R&W	
Borreria articularis	Rubiaceae			R&W
Borreria hispida	Rubiaceae			R&W
Bothriochloa pertusa	Poaceae	R&W	R&W	
Brachiaria distachya	Poaceae	R&W	R&W	
Brachiaria ramosa	Poaceae			R&W
Brachiaria reptans	Poaceae			R&W
Brassica juncea	Brassicaceae			R&W
Brassica nigra	Brassicaceae			R&W
Breynia vitis-ideae	Euphorbiaceae	Perennial	Perennial	Perennial
Bulbostylis barbata	Cyperaceae	R&W		R&W
Cajanus cajan	Fabaceae			R&W
Canavalia gladiata	Fabaceae	R&W		R&W
Canscora decussata	Gentianaceae	R&W	R&W	
Canscora diffusa	Gentianaceae	R&W	R&W	
Capparis brevispina	Capparidaceae	Perennial	Perennial	
Capparis zeylanica	Capparidaceae	Perennial	Perennial	
Caralluma indica	Aristolochiaceae	Perennial	Perennial	
Caralluma umbellata	Aristolochiaceae	Perennial	Perennial	
Cardiospermum halicacabum	Sapindaceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Carissa carandas	Apocyanaceae	Perennial	Perennial	Perennial
Carissa spinarum	Apocyanaceae	Perennial	Perennial	Perennial
Cassia pumilo	Caesalpinaceae	Perennial	Perennial	Perennial
Cassia sophera	Caesalpinaceae	R&W		R&W
Cassia montana	Caesalpinaceae		R&W	
Cassia occidentalis	Caesalpinaceae			R&W
Cassia tora	Caesalpinaceae	R&W	R&W	R&W
Cassytha filiformis	Lauraceae	Perennial	Perennial	
Catharanthus roseus	Apocyanaceae			R&W
Celosia argentea	Amaranthaceae			R&W
Centaurium centaurioides	Gentianaceae	R&W		
Centranthera indica	Scrophulariaceae			R&W
Ceratophyllum demersum	Ceratophyllaceae	R&W		
Cereus pterogonus	Cactaceae	Perennial	Perennial	
Ceropegia bulbosa	Aristolochiaceae	R&W	R&W	
Ceropegia hirsuta	Aristolochiaceae	R&W	R&W	
Cestrum nocturnum	Solanaceae			R&W
Chenopodium album	Chenopodiaceae			R&W
Chloris barbata	Poaceae			R&W
Chloris gayana	Poaceae	R&W	R&W	R&W
Chloris montana	Poaceae	R&W	R&W	R&W
Chloris virgata	Poaceae	R&W	R&W	R&W
Chlorophytum arundinaceum	Liliaceae	R&W	R&W	
Chlorophytum tuberosum	Liliaceae	R&W	R&W	
Chrozophora rottleni	Euphorbiaceae			W &S
Chrysopogon aciculatus	Poaceae	R&W	R&W	
Chrysopogon fulvus	Poaceae	R&W	R&W	
Chrysopogon verticillatus	Poaceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Cissampelos pareira	Menispermaceae	Perennial	Perennial	
Cissus quadrangularis	Vitaceae	Perennial	Perennial	Perennial
Citrullus colocynthis	Cucurbitaceae			R&W
Clematis gouriana	Ranunculaceae	R&W	R&W	
Cleome angustifolia	Capparidaceae			
Cleome chelidonii	Capparidaceae	R&W		R
Cleome gynandra	Capparidaceae			R
Cleome monophylla	Capparidaceae			R
Cleome viscosa	Capparidaceae	S	S	S&R
Clitoria ternatea	Fabaceae	R&W	R&W	R&W
Coccinia indica	Cucurbitaceae			W&S
Colocasia esculenta	Araceae	R&W		R&W
Commelina benghalensis	Commalinaceae			R&W
Commelina cristata	Commalinaceae	R&W		
Commelina diffusa	Commalinaceae			R&W
Commelina paludosa	Commalinaceae		R&W	
Conyza cineraria	Asteraceae	R&W	R&W	R&W
Conyza stricta	Asteraceae	R&W	R&W	R&W
Corchorus aestuans	Tiliaceae			R&W
Corchorus capsularis	Tiliaceae			R&W
Crinum asiaticum	Amaryllidacea	R&W	R&W	
Crinum defixum	Amaryllidacea	R&W	R&W	
Crinum latifolium	Amaryllidacea	R&W	R&W	
Crossandra infundibuliformis	Acanthaceae			R&W
Crotalaria calycina	Fabaceae	R&W	R&W	
Crotalaria ferruginea	Fabaceae	R&W	R&W	
Crotalaria hirsuta	Fabaceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Crotalaria juncea	Fabaceae			R&W
Crotalaria linifolia	Fabaceae			R&W
Crotalaria medicaginea	Fabaceae	R&W	R&W	R&W
Crotalaria prostata	Fabaceae			R&W
Crotalaria ramosissima	Fabaceae	R&W	R&W	
Crotalaria verrucosa	Fabaceae		R&W	R&W
Cryptolepis grandiflora	Periplocaceae	Perennial	Perennial	
Cryptolepis sinensis	Periplocaceae	Perennial	Perennial	
Cucumis callosus	Cucurbitaceae			R&W
Cucumis melo	Cucurbitaceae			R&W
Cucumis sativus	Cucurbitaceae			R&W
Curcuma longa	Zingiberaceae			R&W
Cymbopogon citratus	Poaceae	R&W	R&W	
Cymbopogon coloratus	Poaceae	R&W	R&W	
Cymbopogon flexuosus	Poaceae	R&W	R&W	
Cymbopogon martinii	Poaceae	R&W	R&W	R&W
Cymbopogon nardus	Poaceae	R&W	R&W	R&W
Cynodon barberi	Poaceae	R&W	R&W	R&W
Cynodon dactylon	Poaceae	R&W	R&W	R&W
Cyperus brevifolicus	Cyperaceae	R&W	R&W	R&W
Cyperus compressus	Cyperaceae	R&W		R&W
Cyperus diffusus	Cyperaceae	R&W		R&W
Cyperus esculentus	Cyperaceae	R&W		R&W
Cyperus iria	Cyperaceae	R&W		R&W
Cyperus rotundus	Cyperaceae	R&W	R&W	R&W
Cyperus sanguinolentus	Cyperaceae			R&W
Cyperus squarrosus	Cyperaceae	R&W		R&W
Cyperus triceps	Cyperaceae	R&W		R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Dactyloctenium aegyptium	Poaceae			R&W
Datura innoxia	Solanaceae			R&W
Datura metel	Solanaceae	R&W		R&W
Datura stramonium	Solanaceae	R&W		R&W
Desmodium gangeticum	Fabaceae			
Desmodium heterocarpon	Fabaceae		R&W	
Desmodium triangulare	Fabaceae	R&W	R&W	R&W
Desmodium triflorum	Fabaceae	R&W	R&W	R&W
Desmodium triquetrum	Fabaceae	R&W	R&W	R&W
Dichanthium annulatum	Poaceae	R&W	R&W	R&W
Dichanthium aristatum	Poaceae	R&W	R&W	R&W
Digera arvensis	Amaranthaceae			R&W
Digera muricata	Amaranthaceae			R&W
Digitaria ciliaris	Poaceae	R&W	R&W	R&W
Digitaria longiflora	Poaceae	R&W	R&W	R&W
Digitaria sanguinalis	Poaceae			R&W
Dinebra retroflexa	Poaceae			R&W
Dioscorea anguina	Dioscoriaceae	Perennial	perennial	
Dioscorea glabra	Dioscoriaceae	Perennial	perennial	
Dioscorea hispida	Dioscoriaceae	Perennial	perennial	
Dioscorea oppositifolia	Dioscoriaceae	Perennial	perennial	
Dioscorea pentaphylla	Dioscoriaceae	Perennial	perennial	
Dioscorea tomentosa	Dioscoriaceae	Perennial	perennial	
Dioscorea.bulbifera	Dioscoriaceae	Perennial	perennial	
Dolichos trilobus	Fabaceae			R&W
Echinochloa colona	Poaceae	R&W		R&W*
Echinochloa crusgalli	Poaceae			R&W
Eclipta prostrata	Asteraceae	R&W		R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Eichhornia crassipes	Pontederiaceae	R&W		R&W
Eleusine coracana	Poaceae			R&W
Eleusine indica	Poaceae			R&W
Emilia sonchifolia	Asteraceae	W	W	W
Enteropogon monostachyos	Poaceae	R&W	R&W	
Eragrostis aspera	Poaceae			R&W
Eragrostis ciliata	Poaceae	R&W	R&W	R&W
Eragrostis coarctata	Poaceae			R&W
Eragrostis maderaspatana	Poaceae			R&W
Eragrostis pilosa	Poaceae	R&W	R&W	R&W
Eragrostis tenella	Poaceae	R&W	R&W	R&W
Eragrostis viscosa	Poaceae	R&W	R&W	R&W
Eriochloa procera	Poaceae			R&W
Euphorbia chamaesyce	Euphorbiaceae			R&W
Euphorbia dracunculoides	Euphorbiaceae	Perennial	Perennial	
Euphorbia heterophylla	Euphorbiaceae	R&W	R&W	
Euphorbia hirta	Euphorbiaceae	R&W	R&W	R&W
Euphorbia indica	Euphorbiaceae	R&W	R&W	R&W
Evolvulus alsinoides	Convolvulaceae	R&W	R&W	R&W
Evolvulus nummularis	Convolvulaceae	R&W	R&W	R&W
Exacum pedunculatum	Gentianaceae	R&W		
Exacum tetragonum	Gentianaceae		R&W	
Fimbristylis dichotoma	Cyperaceae	R&W		R&W
Fimbristylis miliacea	Cyperaceae	R&W		R&W
Fimbristylis ovata	Cyperaceae	R&W		R&W
Fimbristylis umbellata	Cyperaceae	R&W		R&W
Fleurya interrupta	Urticaceae	R&W	R&W	

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Flacourtia indica	Flacourtiaceae	Perennial	Perennial	
Galactia longifolia	Fabaceae			R&W
Galactia tenuiflora	Fabaceae	R&W	R&W	R&W
Galactia villosa	Fabaceae	R&W	R&W	R&W
Gentelbua urens	Acanthaceae	R&W	R&W	R&W
Glinus lotoides	Aizoaceae	R&W		R&W
Glinus oppositifolius	Aizoaceae		R&W	R&W
Gloriosa superba	Liliaceae	R&W	R&W	
Glycine wightii	Fabaceae			R&W
Glycosmis mauritiana	Rutaceae	R&W		R&W
Glycosmis pentaphylla	Rutaceae	Perennial	Perennial	
Gnaphalium polycaulon	Asteraceae			R&W
Gomphrena globosa	Amaranthaceae			R&W
Halophila beccarii	Hydrocharitaceae	R&W		R&W
Halophila ovalis	Hydrocharitaceae	R&W		R&W
Hedyotis affinis	Rubiaceae		R&W	R&W
Hedyotis auricularia	Rubiaceae	R&W	R&W	
Hedyotis corymbosa	Rubiaceae		R&W	R&W
Hedyotis diffusa	Rubiaceae	R&W		R&W
Hedyotis herbacea	Rubiaceae			R&W
Hedyotis racemosa	Rubiaceae	R&W	R&W	R&W
Hedyotis umbellate	Rubiaceae	R&W	R&W	R&W
Helicteres isora	Sterculiaceae	R&W	R&W	R&W
Hemidesmus indicus	Periplocaceae	Perennial	Perennial	Perennial
Hemigraphis hirta	Acanthaceae	R&W	R&W	
Hemigraphis latebrosa	Acanthaceae	R&W	R&W	
Hemigraphis venso	Acanthaceae			R&W
Heteropogon contortus	Poaceae	R&W	R&W	R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Heylandia latebrosa	Fabaceae			R&W
Hibiscus lobatus	Malvaceae	Perennial	Perennial	Perennial
Hisbiscus panduriiformis	Malvaceae	Perennial	Perennial	Perennial
Holarrhena pubescens	Apocyanaceae	Perennial	Perennial	
Hybanthus enneaspermus	Violaceae			R&W
Hydrilla verticillata	Hydrocharitaceae	R&W		R&W
Hygrophila auriculata	Acanthaceae	R&W		R&W
Hygrophila heinei	Acanthaceae	R&W		R&W
Hygrophila salicifolua	Acanthaceae	R&W		R&W
Hyptis sauveolens	Lamiaceae	R&W*	R&W*	R&W*
Ichnocarpus frutescens	Apocyanaceae	R&W	R&W	
Imperata cylindrica	Poaceae	R&W	R&W	
Indigofera astragalina	Fabaceae	R&W	R&W	
Indigofera ennaephylla	Fabaceae	R&W	R&W	R&W
Indigofera hirsuta	Fabaceae			R&W
Indigofera linifolia	Fabaceae	R&W	R&W	R&W
Indigofera linnaei	Fabaceae	R&W	R&W	R&W
Indigofera oblongifolia	Fabaceae			
Indigofera tinctoria	Fabaceae	R&W		
Indigofera trifoliata	Fabaceae			R&W
Indigofera trita	Fabaceae		R&W	R&W
Indigofera wightii	Fabaceae	R&W	R&W	R&W
Iphigenia indica	Liliaceae	R&W	R&W	
Ipomoea aquatica	Convolvulaceae	Perennial	Perennial	Perennial
Ipomoea carnea	Convolvulaceae	Perennial	Perennial	Perennial
Ipomoea hederifolia	Convolvulaceae	Perennial	Perennial	Perennial
Ipomoea obscura	Convolvulaceae	Perennial	Perennial	Perennial
Ipomoea pes-caprae	Convolvulaceae	Perennial	Perennial	Perennial

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Ipomoea sepiaria	Convolvulaceae	Perennial	Perennial	Perennial
Ipomoea turbinata	Convolvulaceae	Perennial	Perennial	Perennial
Ipomoem alba	Convolvulaceae	Perennial	Perennial	Perennial
Ischaemum ciliare	Poaceae	R&W	R&W	
Ischaemum indicum	Poaceae	R&W	R&W	
Ischaemum laxum	Poaceae	R&W	R&W	
Iseilema laxum	Poaceae	R&W		R&W
Iseilema prostratum	Poaceae			R&W
Jacquemontia paniculata	Convolvulaceae			R&W
Jasminum angustifolium	Oleaceae	Perennial	Perennial	Perennial
Jasminum arborescens	Oleaceae	Perennial	Perennial	
Jasminum brevilobum	Oleaceae	Perennial	Perennial	Perennial
Justicia adhatoda	Acanthaceae	R&W	R&W	R&W
Justicia diffusa	Acanthaceae			R&W
Justicia glabra	Acanthaceae			R&W
Justicia procumbens	Acanthaceae			R&W
Justicia trinervia	Acanthaceae	R&W		R&W
Justicia vahlii	Acanthaceae	R&W	R&W	
Kalanchoe laciniata	Crassulaceae	Perennial	Perennial	
Kalanchoe pinnata	Crassulaceae	Perennial	Perennial	
Kyllinga nemorales	Cyperaceae	R&W	R&W	R&W
Lablab purpureus	Fabaceae			R&W
Lemna gibba	Lemnaceae	R&W		R&W
Lemna perpusilla	Lemnaceae	R&W		R&W
Lepidagathis cristata	Acanthaceae	R&W	R&W	
Lepidagathis cuspidata	Acanthaceae	R&W	R&W	
Leucas biflora	Lamiaceae			R&W
Leucas indica	Lamiaceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Leucas lamifolia	Lamiaceae			R&W
Limnophila indica	Scrophulariaceae	R&W		R&W
Lindernia anagallis	Scrophulariaceae	R&W		R&W
Lindernia anagallis	Scrophulariaceae	R&W		R&W
Lindernia antipoda	Scrophulariaceae	R&W		R&W
Lindernia parviflora	Scrophulariaceae	R&W		R&W
Lindernia procumbens	Scrophulariaceae	R&W		R&W
Lindernia viscosa	Scrophulariaceae	R&W		R&W
Lippia javanica	Verbenaceae	R&W		R&W
Ludwigia octovalvis	Onagraceae	R&W		R&W
Ludwigia perennis	Onagraceae	R&W		R&W
Ludwigia prostrata	Onagraceae	R&W		R&W
Luffa acutangularis	Cucurbitaceae			R&W
Luffa cylindrical	Cucurbitaceae			R&W
Lycopersicon esculentum	Solanaceae			R&W
Malvastrum coromandelianum	Malvaceae	R&W	R&W	R&W
Marsilea quadrifolia	Marsileaceae			R&W*
Mazus pumilus	Scrophulariaceae	R&W		R&W
Melochia corchorifolia	Sterculiaceae	R&W		R&W
Merremia gangetica	Convolvulaceae			R&W
Merremia tridentata	Convolvulaceae			R&W
Millettia auriculata	Fabaceae	R&W	R&W	
Millettia recemosa	Fabaceae	R&W	R&W	
Mollugo cerviana	Aizoaceae			R&W
Mollugo disticha	Aizoaceae			R&W
Mollugo nudicaulis	Aizoaceae	R&W		R&W
Mollugo pentaphylla	Aizoaceae	R&W		R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Momordica charantia	Cucurbitaceae			R&W
Momordica dioica	Cucurbitaceae			R&W
Mucuna pruriens	Fabaceae	R&W	R&W	
Mukia maderashpatana	Cucurbitaceae			R&W
Murdannia nudiflora	Commalinaceae			R&W
Nelumbo nucifera	Nelumbonaceae	R&W		R&W
Neodistemon indicum	Urticaceae	R&W	R&W	
Neptunia triquetra	Mimosaceae		R&W	R&W
Nicotiana tabacum	Solanaceae			W
Nymphaea nauchali	Nymphaeaceae	R&W		R&W
Nymphaea sellata	Nymphaeaceae	R&W		R&W
Ocimum americanum	Lamiaceae			R&W
Ocimum basilicum	Lamiaceae			R&W
Ocimum canum	Lamiaceae	R&W	R&W	R&W
Ocimum sanctum	Lamiaceae			R&W
Optuntia stricta	Cactaceae	Perennial	Perennial	Perennial
Opuntia elatior	Cactaceae	Perennial	Perennial	Perennial
Orobanche cernua	Orobanchaceae			R&W
Oryza sativa	Poaceae			Extensive *
Ottelia alismoides	Hydrocharitaceae	R&W		R&W
Oxalis corniculata	Oxalidaceae	R&W	R&W	R&W
Panicum brevifolium	Poaceae	R&W	R&W	R&W
Panicum maximum	Poaceae	R&W	R&W	R&W
Panicum psilopodium	Poaceae	R&W	R&W	R&W
Panicum repens	Poaceae	R&W	R&W	R&W
Parthenium hysterophorus	Asteraceae	R&W*	R&W	R&W*
Paspalidium flavidum	Poaceae	R&W	R&W	R&W
Passiflora foetida	Passifloraceae	R&W	R&W	

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Pedalium muricatum	Pedaliaceae	R&W	R&W	R&W
Pennisetum pedicillatum	Poaceae	R&W	R&W	R&W
Pennisetum purpureum	Poaceae	R&W	R&W	R&W
Pennisetum typhoides	Poaceae			R&W
Peristrophe bicalyculata	Acanthaceae	R&W	R&W	R&W
Peristrophe paniculata	Acanthaceae	R&W	R&W	R&W
Perotis indica	Poaceae			R&W
Perotis latifolia	Poaceae	R&W	R&W	
Phaseolus aconitifolius	Fabaceae			R&W
Phaseolus mungo	Fabaceae			R&W
Phaseolus radiatus	Fabaceae			R&W
Phaseolus trilobus	Fabaceae	R&W		R&W
Phragmites karka	Poaceae	R&W	R&W	R&W
Phyla nodiflora	Verbenaceae	R&W		R&W
Phyllanthus amarus	Euphorbiaceae			R&W
Phyllanthus debilis	Euphorbiaceae	R&W	R&W	
Phyllanthus maderaspatensis	Euphorbiaceae			R&W
Phyllanthus virgatus	Euphorbiaceae	R&W	R&W	R&W
Physalis peruviana	Solanaceae			R&W
Pistia stratiotes	Araceae	R&W		R&W
Plectranthus barbatus	Lamiaceae	Perennial	Perennial	
Plectranthus japonicus	Lamiaceae	Perennial	Perennial	
Polycarpaea aurea	Caryophyllacae			R&W
Polycarpaea corymbosa	Caryophyllacae	R&W	R&W	R&W
Polycarpon prostratum	Caryophyllacae			R&W
Polygala arvensis	Polygalaceae	R&W	R&W	R&W
Polygala chinensis	Polygalaceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Polygala elongata	Polygalaceae	R&W		R&W
Polygala erioptera	Polygalaceae		R&W	
Polygala furcata	Polygalaceae	R&W		
Polygala persicariifolia	Polygalaceae	R&W	R&W	
Portulaca oleracea	Portulacaceae			R&W
Portulaca pilosa	Portulacaceae	R&W		R&W
Portulaca quadrifida	Portulacaceae		R&W	
Pouzolzia bennettiana	Urticaceae	R&W	R&W	
Psoralea corylifolia	Fabaceae			R&W
Rhynchosia hirta	Fabaceae			R&W
Rhynchosia minima	Fabaceae			R&W
Rhynchosia rothii	Fabaceae	R&W	R&W	
Rhynchosia suaveolens	Fabaceae	R&W	R&W	R&W
Rhynchosia viscosa	Fabaceae	R&W	R&W	
Rostellularia diffusa	Acanthaceae	R&W	R&W	R&W
Rostellularia procumbens	Acanthaceae	R&W	R&W	R&W
Rostellularia prostrata	Acanthaceae	R&W	R&W	R&W
Rostellularia simplex	Acanthaceae	R&W	R&W	R&W
Rostellularia vahlii	Acanthaceae	R&W	R&W	
Rothia indica	Fabaceae			R&W
Ruellia tuberosa	Acanthaceae	R&W	R&W	R&W
Rungia parviflora	Acanthaceae	R&W	R&W	R&W
Rungia pectinata	Acanthaceae	R&W	R&W	R&W
Rungia repens	Acanthaceae	R&W	R&W	R&W
Saccharum officinarum	Poaceae	Perennial	Perennial	Perennial
Saccharum spontaneum	Poaceae	Perennial	Perennial	Perennial
Sagittaria guayanensis	Alismataceae	R&W		R&W
Sagittaria sagittifolia	Alismataceae	R&W		R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Salvia coccinea	Lamiaceae	R&W		R&W
Sansevieria roxburghiana	Agavaceae	Perennial	Perennial	
Schoenoplectus articulatus	Cyperaceae	R&W		R&W
Scilla hyacinthine	Liliaceae			R&W
Scoparia dulcis	Scrophulariaceae	R&W		R&W
Scutellaria rivularis	Lamiaceae			R&W
Sesamum indicum	Pedaliaceae			R&W
Sesamum prostratum	Pedaliaceae			R&W
Sesbania aculeata	Fabaceae	R&W		R&W
Sesbania bispinosa	Fabaceae	R&W		R&W
Sesbania procumbens	Fabaceae	R&W		R&W
Setaria glauca	Poaceae			R&W
Setaria intermedia	Poaceae	R&W	R&W	
Setaria italica	Poaceae			R&W
Sida acuta	Malvaceae	R&W	R&W	R&W
Sida cordata	Malvaceae	R&W	R&W	R&W
Sida rhombifolia	Malvaceae	R&W	R&W	
Sida spinosa	Malvaceae	R&W	R&W	
Smilax zelanica	Smilacaceae	Perennial	Perennial	
Solanum melongena	Solanaceae			R&W
Solanum nigrum	Solanaceae			R&W
Solanum tuberosum	Solanaceae			R&W
Solanum xanthocarpum	Solanaceae	R&W		R&W
Sopubia delphinifolia	Scrophulariaceae	R&W		R&W
Sopubia trifida	Scrophulariaceae	R&W		R&W
Sorghum halepense	Poaceae			R&W
Sphaeranthus indicus	Asteraceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Sporobolus coromandelianus	Poaceae	R&W	R&W	R&W
Sporobolus indicus	Poaceae			R&W
Sporobolus maderaspatanus	Poaceae			R&W
Sporobolus tremulus	Poaceae	R&W	R&W	R&W
Stemodia viscose	Scrophulariaceae			R&W
Striga angustifolia	Scrophulariaceae			R&W
Striga asiatica	Scrophulariaceae			R&W
Striga densiflora	Scrophulariaceae	R&W		
Stylosanthes fruticosa	Fabaceae	R&W	R&W	
Tephrosia procumbens	Fabaceae	R&W	R&W	R&W
Tephrosia pulcherrima	Fabaceae	R&W	R&W	
Tephrosia pumila	Fabaceae		R&W	
Tephrosia purpurea	Fabaceae	R&W	R&W	R&W
Tephrosia tinctoria	Fabaceae	R&W		
Tephrosia villosa	Fabaceae	R&W	R&W	R&W
Themeda arundinacea	Poaceae	R&W	R&W	
Thespesia lampas	Malvaceae	Perennial	Perennial	
Tiliacora acuminata	Menispermaceae	Perennial	Perennial	
Tinospora cordifolia	Menispermaceae	Perennial	Perennial	
Tinospora sinensis	Menispermaceae	Perennial	Perennial	
Tragia involucrata	Euphorbiaceae	R&W	R&W	R&W
Tragus roxburghii	Poaceae	R&W	R&W	R&W
Trianthema decandra	Aizoaceae			R&W
Trianthema portulacastrum	Aizoaceae			R&W
Trianthema triquetra	Aizoaceae			R&W
Tribulus terrestris	Zygophyllaceae	R&W	R&W	R&W
Trichosanthes cordata	Cucurbitaceae			R&W

Name of the Species	Family	Reservoir	Catch-ment area	Command area
Trichosanthes cucumerina	Cucurbitaceae			R&W
Trichosanthes tricuspidata	Cucurbitaceae			R&W
Tridax procumbens	Asteraceae	S,R&W	S,R&W	S,R&W
Triumfetta pentandra	Tiliaceae	R&W	R&W	R&W
Triumfetta pilosa	Tiliaceae	R&W	R&W	R&W
Triumfetta rhomboidea	Tiliaceae			W&S
Tylophora indica	Aristolochiaceae	Perennial	Perennial	
Tylophora marantha	Aristolochiaceae	Perennial	Perennial	
Typha angustata	Typhaceae	S,R&W	S,R&W	S,R&W
Urginea congesta	Liliaceae			R&W
Urginea indica	Liliaceae	R&W		R&W
Vallisneria spiralis	Hydrocharitaceae	R&W		R&W
Vernonia cinerea	Asteraceae	R&W	R&W	R&W
Vernonia albicans	Asteraceae	R&W		R&W
Vigna aconitifolia	Fabaceae			R&W
Vigna mungo	Fabaceae			R&W
Vigna radiata	Fabaceae			R&W
Vigna trilobata	Fabaceae			R&W
Viscum articulatum	Viscaceae	Perennial	Perennial	
Viscum orientale	Viscaceae	Perennial	Perennial	
Vitis heyneana	Vitaceae	Perennial	Perennial	
Waltheria indica	Sterculiaceae	R&W	R&W	R&W
Withania somnifera	Solanaceae	R&W	R&W	R&W
Wolffia globosa	Lemnaceae	R&W		R&W
Wolffia microscopica	Lemnaceae	R&W		R&W
Woodfordia fruticosa	Lythraceae	Perennial	Perennial	
Xanthium strumarium	Asteraceae	R&W	R&W	R&W
Zingiber officinalis	Zingiberaceae			R&W

5.09 Importance values of the dominant species in catchment, reservoir and command areas are given in Table – 5.4.

Table – 5.4 : KELO PROJECT
IMPORTANCE VALUES OF DOMINANT SPECIES IN CATCHMENT RESERVOIR AND COMMAND AREA

Name of species	Catchment	Reservoir	Command area
Shorea robusta	37.2	82.5	1.0
Buchanania lanzan	16.5	44.2	1.0
Ficus religiosa	13.6	12.7	2.1
Butea monosperma	22.9	17.7	3.6
Diospyros melanoxylon	25.5	14.6	12.5
Eucalyptus sp.	12.1	2.8	6.6
Acacia nilotica	5.4	1.2	46.5
Acacia leucocephala	7.9	2.6	9.2
Oryza sativa	9.8	0.0	124 .5
Leucaena leucocephala	5.4	1.0	6.3
Tectona grandis	8.6	6.2	5.2
Terminalia arjuna	7.4	6.6	4.8
Ziziphus rugosa	7.5	2.7	8.6
Hyptis suaveolens	22.8	23.5	16.3
Parthenium hysterophorus	18.6	6.6	17.2
Cymbopogon spp.	12.1	18.4	1.0
Vitex negundo	4.2	2.3	5.6
Prosopis spicigera	5.0	2.2	6.6
Dendrocalamus strictus	6.5	24.6	1.0
Jatropha curcas	2.2	1.1	3.4
Prosopis juliflora	2.6	1.2	6.2
Helianthus annus	0.0	0.0	3.5
Pithecellobium dulce	2.5	1.0	2.6
Others	43.7	24	4.7

5.10 Among the Orchids, *Vanda tesselata* was most common on Mango and *Ficus* trees. *Cuscuta chinensis* and *Cassytha filiformis* were the most common parasitic flowering plants in all the three areas. *Dendrophthoe falcata (=Loranthus falcata)* and *Viscum articulatum* were widespread on a variety of trees in the catchment and reservoir areas.

5.11 The Bryophytes and Pteridophytes listed in Table – 5.5 were found both in the catchment and Reservoir areas.

Table – 5.5 : KELO PROJECT
LIST OF BRYOPHYTES AND PTERIDOPHYTES FOUND IN THE CATCHMENT (CA) AND RESERVOIR AREAS (RA) OF THE KELO IRRIGATION PROJECT

Latin name	Local /Common name	Area of occurrence
Riccia fluitans	Riccia (Liver wort)	CA&RA
Marchantia polymorpha	Marchantia (Liver wort)	CA&RA
Anthoceros punctatus	Anthoceros (Liver wort)	CA
Anthoceros laevis	Anthoceros (Liver wort)	CA
Pellia epiphylla	Pellia (Liver wort)	CA
Porella elegantula	Porella (Liver wort)	CA
Pogonatum patulum	Moss	CA
Bryum apiculatum	Moss	CA
Bryum argentium	Moss	CA
Bryum wrightii	Moss	CA
Dryopteris marginata	Fern	CA
Equisetum arvense	Horse tails	CA
Ptieris eniformis	Fern	CA
Pteris cretica	Fern	CA
Pteris excelsa	Fern	CA
Pteris vittata	Fern	CA
Note : Most of them were found mainly during the rainy season		

5.12 List of algai species found in the Kelo River, in paddy fields, wells and other water bodies of the Reservoir and Command areas during the rainy and winter seasons of the study period are given in Table – 5.6. There were no different infloristic composition and a common list is given below :

Table – 5.6 : KELO PROJECT
LIST OF ALGAL SPECIES RECORDED FROM THE RESERVOIR AND COMMAND AREAS OF THE KELO IRRIGATION PROJECT DURING THE RAINY & WINTER SEASONS.

Names of Algae	Division
Chlamydomonas sp.	Chlorophyta or green algae
Chlamydomonas reinhardi	Chlorophyta or green algae
Chlorella vulgaris	Chlorophyta or green algae
Chlorella pyrenoidosa	Chlorophyta or green algae
Chlorococcus sp.	Chlorophyta or green algae
Gonium pectorale	Chlorophyta or green algae
Pandorina sp.	Chlorophyta or green algae
Pandorina morum	Chlorophyta or green algae
Eudorina elegans	Chlorophyta or green algae
Volvox sp.	Chlorophyta or green algae
Hydrodictyon sp.	Chlorophyta or green algae
Pediastrum duplex	Chlorophyta or green algae
Pediastrum boryanum	Chlorophyta or green algae
Tetraspora sp.	Chlorophyta or green algae
Synedra acus	Chlorophyta or green algae
Scenedesmus acuminatus	Chlorophyta or green algae
Scenedesmus dimorpha	Chlorophyta or green algae
Scenedesmus obliques	Chlorophyta or green algae
Scenedesmus quadricauda	Chlorophyta or green algae
Spirogyra sp	Chlorophyta or green algae
Ulothrix sp.	Chlorophyta or green algae

Names of Algae	Division
Oedogonium sp.	Chlorophyta or green algae
Cladophora sp.	Chlorophyta or green algae
Chaetophora sp.	Chlorophyta or green algae
Chara sp.	Charophyta
Euglena proxima	Euglenophyceae
Euglena intermedia	Euglenophyceae
Euglena pisciformis	Euglenophyceae
Euglena polymorpha	Euglenophyceae
Euglena oxyuris	Euglenophyceae
Euglena viridis	Euglenophyceae
Vaucheria sp	Bacillariophyceae
Ankistrodesmus falcatus	0Bacillariophyceae
Asterionella sp.	Bacillariophyceae
Navicula cuspidata	Bacillariophyceae
Navicula viridis	Bacillariophyceae
Navicula cryptocephala	Bacillariophyceae
Melosira granulata	Bacillariophyceae
Melosira various	Bacillariophyceae
Diatoma vulgare	Bacillariophyceae
Pinnularia sp	Bacillariophyceae
Cyclotella sp.	Bacillariophyceae
Triceratium sp	Bacillariophyceae
Chroococcus sp.	Cyanophyceae
Microcystis aeruginosa	Cyanophyceae
Gleocapsa sp.	Cyanophyceae
Gleotrichia sp.	Cyanophyceae
Anabaena constricta	Cyanophyceae
Rivularia sp.	Cyanophyceae
Lingbya sp.	Cyanophyceae
Oscillatoria limosa	Cyanophyceae
Oscillatoria tenuis	Cyanophyceae
Oscillatoria chlorina	Cyanophyceae
Oscillatoria princepes	Cyanophyceae
Oscillatoria chlorina	Cyanophyceae
Oscillatoria putrida	Cyanophyceae
Oscillatoria splendida	Cyanophyceae
Nostoc sp.	Cyanophyceae

5.13 List of fungi collected from the study area given in Table – 5.7.

Table -5.7 : KELO PROJECT
LIST OF FUNGAL SPECIES RECORDED FROM THE CATCHMENT AREA, RESERVOIR AND COMMAND AREAS OF THE KELO PROJECT DURING THE RAINY SEASON.

Name of Fungus	Habitat / Habitat
Agaricus bisporus	Edible mushroom
Agaricus compestris	Edible mushroom
Alternaria tenuis	Facultative parasite
Amanita muscaria	Poisonous mushroom
Amanita phalloides	Poisonous mushroom
Aspergillus candidus	Spoiled grains
Aspergillus flavus	Produces Aflotoxin
Aspergillus fumigatus	Soils
Aspergillus indicus	Soils

Table -5.7 : KELO PROJECT
LIST OF FUNGAL SPECIES RECORDED FROM THE CATCHMENT AREA, RESERVOIR AND COMMAND AREAS OF THE KELO PROJECT DURING THE RAINY SEASON.

Name of Fungus	Habitat / Habitat
Aspergillus nidulans	Soils
Aspergillus niger	Soils and air
Aspergillus oryzae	In paddy grains
Candida albicans	Facultative parasite
Candida tropicalis	Facultative parasite
Claviceps purpurea	Ergot of grain in the Command area
Cercospora arachidicola	Tikka disease of groundnut in the Command area
Cercospora personata	Tikka disease of groundnut in the Command area
Colletotrichum falcatum	Red rot of Sugar cane
Coprinus cinereus	Dung and organic materials
Fusarium oxysporum	Wilt disease in the Command area
Ganoderma sp.	On live tree trunks
Gibberella fujikuroi	Pathogen of Paddy of the Command area
Helminthosporium maydis	Maise leaf spot in the Command area
Helminthosporium oryzae	Paddy leaf spot in the Command area
Lycoperdon sp.	Puff balls
Mucor mucedo	Soils and air
Mucor racemosus	Soils and air
Neurospora crassa	Saprophyte
Neurospora tetrasperma	Saprophyte
Oidium sp	Powdery mildew
Penicillium brevi-compactum	Soil, air & organic matter
Penicillium chrysogenum	Soil, air & organic matter
Penicillium claviforme	Soil, air & organic matter
Penicillium glaucum	Soil, air & organic matter
Penicillium notatum	Soil, air & organic matter
Penicillium patulum	Soil, air & organic matter
Perenospora tabacina	Plant pathogen
Peziza ostracoderma	On dung
Phoma sp.	Plant pathogen
Phyllachora graminis	Tar spots of grasses
Polyporus circinatus	Wood rotting fungi
Polyporus hispidus	Wood rotting fungi
Polyporus obtusus	Wood rotting fungi
Polyporus sulphureus	Wood rotting fungi
Pleurotus mutilis	Edible mushroom
Puccinia graminis	Rust fungus
Pyricularia oryzae	Blast of Rice
Pythium debaryanum	Damping off of seedlings
Rhizoctonia lugumicola	Damping off of seedlings
Rhizoctonia solani	Damping off of seedlings
Rhizopus nigricans	Soils & organic matter
Rhizopus oryzae	Spoiled rice grains

Table -5.7 : KELO PROJECT
LIST OF FUNGAL SPECIES RECORDED FROM THE CATCHMENT AREA, RESERVOIR AND COMMAND AREAS OF THE KELO PROJECT DURING THE RAINY SEASON.

Name of Fungus	Habitat / Habitat
Rhizopus stolonifer	Bread mould
Saprolegnia ferax	Water and decaying insects
Scerotium rolfsii	Moist grains
Trichoderma viride	Soils
Ustilago hordei	Grain smut
Ustilago maydis	Smut of Maize

FAUNA

5.14 List of vertebrates either noticed or reported from the Kelo Project area are presented in Table -5.8. Most mammals and birds listed were of very rare occurrence. There were no resident birds in the command area as evidenced by the absence of nests of birds or resting or other breeding activity. Only Crows, Parrots, Doves and Mynas were more common among birds. India spotted eagle was the only endangered bird spotted hovering around. House sparrows (*Passer domesticus*), once a common bird but now an endangered bird was found in the hamlets in the catchment area. Similarly, there were no hiding places or breeding grounds of wild mammals.

5.15 Among the mammals, only Mongooses and Sqirrels were seen frequently in the catchment and reservoir areas. However, the reptiles and amphibians were relatively more frequent but not abundant. Probably because of the proximity to Rayagarh town and the heavy traffic on the highway running across the catchment and reservoir areas, no jungle cats or other major carnivores are reported.

Table – 5.8 : KELO PROJECT
LIST OF VERTEBRATE SPECIES FOUND IN AND AROUND THE SITE DURING THE STUDY PERIOD.

	MAMMALS:	
Sl.No.	Common name	Latin name
1	Indian Mongoose	*Herpestes fuscus*
2	Bengal Mongoose	*Herpestes palustris*
3	Crab eating Mongoose	*Herpestes ula*
4	Wild boar	*Sus scroba*
5	Hare	*Lepus nigricollis*
6	Bonnet Monkey	*Macaca radiate*
7	Common Mongoose	*Herpestes edwardsi*
8	Squirrel	*Funambulus ponnanti*
9	Brown flying squirrel	*Petaurista sp.*
10	Porcupine	*Hystrix indica*
11	Indian flying fox	*Pteropus giganteus*
12	Fox	*Vulpes bengalensis*
13	Jackal	*Canis aureus*
	REPTILES	
1	Indian python	*Python molurus*
2	Sand boa	*Eryx johni*

Table – 5.8 : KELO PROJECT
LIST OF VERTEBRATE SPECIES FOUND IN AND AROUND THE SITE DURING THE STUDY PERIOD.

	MAMMALS:	
Sl.No.	Common name	Latin name
3	Krait	*Bungarus caeruleus*
4	Cobra	*Naja naja*
5	Russell's viper	*Vipera russseli*
6	Saw scaled viper	*Echis carinatus*
7	Rat snake	*Ptyas mucosus.*
8	Tree Snake	*Dryphis sp.*
9	Blind Snake	*Typholops sp.*
10	Whip Snake	*Dryphis nasutus*
11	Monitor lizard	*Varanus indicus.*
12	Chameleon	*Chameleon sp*
13	Wall lizard	*Hemidactylus sp.*
14	Garden lizard	*Calotes versicolor*
15	Small wall lizard	*Gecko sp.*
16	Fresh water turtle	*Trionxy sp.*
17	Indian star tortoise	*Testudo elegans*
18	Fresh water tortoise	*Geomyda sp.*
	AVES	
1	Cormorant	*Phalacrocorax higher,*
2	Crow	*Corvus sp1lendens*
3	Jungle Crow	*Corvus macrohyuchos*
4	Crow pheasant	*Centrpus sinesis*
5	Cuckoo, Common hawk	*Cuculus varus*
6	Ring Dove	*Streptopelia d ecactao*
7	Cattle Egret	*Bubulcus ibis*
8	Egret, Little	*Egretta garetta*
9	Ibis, Black	*Pseudibis papilosa*
10	Ibis, white	*Threskiornis melenocephalu*
11	Koel	*Eudynamis scolopaceus*
12	Munia, Spotted	*Lonchura striata*
13	Munia, White-Throated	*Lonchu ra malabarica*
14	Myna, Black-headed	*Sturnus pagodarun*
15	Myna, common	*Acridothers trists*
16	Owlet Barred Jungle	*Galuciddum radiatuum,*
17	Owl, Spotted	*Athene brama*
18	Parakeet Large Indian	*Psittacula eupatria*
19	Parakeet, Rose-ringed	*Psittacula krameri*
20	Partridge, Grey	*Francolinus pondicerianus*
21	Common Peafowl	*Pave oristatus*
22	Pigeon, Blue Rock	*Columbia livaia,*
23	Pigeon, common Green	*Treron pheoenicoptera,*
24	Indian Robin	*Saxicoloides fulicata*
25	Swift, house	*Apus affinis*
25	Swallow, common	*Hirando rustica,*
27	Wood pecker, Golden backed	*Dinopium bengalensis*

Table – 5.8 : KELO PROJECT
LIST OF VERTEBRATE SPECIES FOUND IN AND AROUND THE SITE DURING THE STUDY PERIOD.

	MAMMALS:	
Sl.No.	Common name	Latin name
28	Duck, comb	*Sarkediornis melanothus*
29	Eagle (Spotted Indian)	*Aquila hastata*
30	Indian Peafowl	*Pavo cristatus*
31	House sparrow	*Passer domesticus*
	AMPHIBIANS	
1.	Ordinary frog	*Rana hexadactyla.*
2	South Indian Toad	*Bufo melonosticatus*
3	Tree Frog	*Hyla arboria*
4	Burrowing frog	*Cacopus bystema*
5	Tiger Frog	*Rana tigrina*
	FISHES	
1	Catla	*Catla catla*
2	Rohu	*Labeo rohita*
3	Murrel	*Channa striatus*
4	Wallago	*Wallago attu*
5	Cat fish	*Mystus vittatus*
6	Cat fish	*Hetyeropneustes fossilis*
7	Spiny eel	*Mastecembalus armatus*
8	Prawn	*Macrobrachium rosenberghii*
9	Prawn	*Macrobrachium malcolmsonii*
10	Giant prech	*Lates calcarifer*
11	Silonia	*Silonia silonia*
12	Pearl spot	*Etroplus suratensis*
13	Eel	*Anguilla sp.*
14	Gobies	*Glossogobius giuris*
15	Mrigal	*Cirrhinus mrigala*
Most of the fishes listed above are caught from the Kelo river and the tanks in the command area by the local fisherman.		

5.16 Other than a few field sparrows and parakeets, none of the birds or mammals listed in Table VIII is residents of the area under consideration. Nests of Parakeets were noticed on the *Acacia nilotica* trees in the catchment area. Since *Passer domesticus* (House sparrow) was found in the hamlets in side the catchment area, the Kelo irrigation project is unlikey to pose any additional thread to this tiny bird. Similarly, the Peacocks were also found in the catchment area only. The reptiles and amphibians are transitory. The Monitor lizard is protected by law.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume – I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART- II
BASELINE DATA

VI

AIR AND NOISE ENVIRONMENT

Air Environment

6.01 Assessment of impacts on air environment and feedback for environmental management Program (EMP) requires information of ambient air quality status. The data has been collected, analyzed and evaluated. The basic considerations for designing a surveillance program include information on micro-meteorological conditions, quantity, quality, location, time availability, and resources, monitoring technology and operation criteria. All these aspects were considered for devising operational scheme for air quality monitoring along the proposed activity.

Ambient Air Quality

6.02 The air sampling stations were established in and around the core and buffer zone to study the present ambient air quality. The ambient air quality monitoring was conducted at five stations during summer season using respirable dust sampler. The sampling station locations are given in Table - 6.1 and same marked in Fig. VI.1.

Table - 6.1 : KELO PROJECT
LOCATION OF AIR SAMPLING STATIONS

Sl.No	Location	Location Code
1	Plant site	CA 1
2	Gorhi	BA 1
3	Jhinkabahal	BA 2
4	Dolesara	BA 3
5	Jharna	BA 4

Sampling Schedule and Parameters

6.03 The study was conducted in summer season with frequency of twice a week at each site 24 hourly samples were collected from each station. These samples were analyzed in laboratory by the methods specified in National Ambient Air quality standards by Ministry of Meteorology, R&D laboratory New Delhi. The following air pollution parameters are being sampled continuously during the sampling periods.

1. Respirable Particulate Matter (RPM)
2. Suspended Particulate Mater (SPM)
3. Sulpher Dioxide (SO_2)
4. Oxides of Nitrogen (NOx)
5. Carbon Monoxide (Grab Sampling)

METHODOLOGY

6.04 Respirable Particulate Matter: The sampling of ambient air was performed with respirable dust sampler (Make: Envirotech Instruments, New Delhi), which is primarily a high volume sampler fitted with a cyclone separator for pre separation of particles larger than 10 microns diameter. Air exiting from the separator is drawn at a measured rate through the separator followed by a pre-weighed glass fiber sheet of 20 cm x 25 cm sizes (Watchman, EPM 2000). The RPM concentrations are determined gravimetrically from the average airflow rate, sampling period and the mass of particulate matter collected over the GF filter surface.

6.05 Suspended Particulate Matter : Sampling for SPM was also performed with the sampler used for RPM sampling. The coarser particles (NRPM) collected in the cyclone separator are transferred quantitavely on a Petri dish and evaluated gravimetrically. The sum of masses of coarser (NRPM) and respirable particles (RPM) gives the mass of SPM collected during sampling. The SPM concentrations are computed from the total mass of SPM and total volume of air sampled.

6.06 Sulphur Dioxide : The sampling of ambient air for evaluating SO_2 concentrations was performed with a multigas sampler, using the vacuum created by the respirable dust sampler for drawing the air samples through the impinges. Air is drawn at a measured and controlled rate of 400 to 500 ml/min through a solution of sodium tetrachloro mercurate.

6.07 After completion of sampling, the used absorbing reagent is treated with dilute solutions of sulfuric acid. Formaldehyde and Para rosaniline hydrochloride. The absorbance of the intensely coloured Para rosaniline methyl sulphonic acid is measured and the amount of SO_2 in the sample was computed from graphs prepared with standard solutions. The ambient SO_2 Concentrations were computed form the amount of SO_2 collected and the volume of air sampled.

6.08 Oxides of Nitrogen : The sampling of ambient air for evaluating NO_x concentrations was performed with multigas sampler using the vacuum created by the respirable dust sampler for drawing the air sample through the impinges at a measured and controlled rate of about 200 ml/minute through an orifice – tripped impinge containing solutions of sodium hydroxide and sodium arsenate. After

completion of the sampling, an aliquot of the used absorbing solution was treated with solutions of H_2O_2, Sulphanilamide and NEDA. The nitrite ion present in the impinger was calculated from the absorbance of the resulting solution and from the graphs prepared with standard solutions. The ambient NO_x concentrations were computed from the total nitrite ion present in the impugners, overall efficiency of the impinger and the procedure, and the volume of air sampled.

6.09 Carbon Monoxide : Sampling and evaluation of ambient CO levels was performed by the detector tube technique. Summary of the testing procedures is presented in Table - 6.2

Table - 6.2 : KELO PROJECT
PROCEDURE FOR DETERMINING
VARIOUS AIR QUALITY PARAMETERS

Parameter	Testing Procedure
SPM	Gravimetric method using high volume air sample IS: 5182 (part IV) 1973
NOx	Absorption in dil. NaOH and then estimated colorimetric ally with sulphanilamide and N(I-Nepthyle) Ethylene diamine Dihydrochloride and Hydrogen Peroxide (IS: 5182 – 1975, Part – VI)
SO_2	Absorption in sodium Tetra Chloro-mercurate followed by Colorimetric estimation using P-rosaniline hydrochloride and formaldehyde (IS: 5182 Part – II 1969)
RPM	Respirable particulate matter sampler
CO	By MSA tube

Air Quality Standards & Observation

6.10 The national ambient air quality standards as per environment (Protection) rules, 1996 are presented in Annexure VI.1.

6.11 The summarized results of air quality studies are given in Table 6.3.

Table - 6.3 : KELO PROJECT
SUMMARY OF AMBIENT AIR QUALITY TEST RESULTS (MG/M^3)

Air Quality Parameters	Location	Max	Min	Avg	98% tile
RPM	At plant site (CAI)	57	21	40	55
	Gorhi (BAI)	60	25	42	59
	Jhinkabahal(BA2)*	115	51	72	112
	Dolesara (BA3)	52	24	37	52
	Jharna (BA4)	52	35	45	55
SPM	At plant site (CAI)	175	58	120	171
	Gorhi (BAI)	168	75	123	166
	Jhinkabahal(BA2)*	351	159	221	342
	Dolesara (BA3)	155	70	104	152
	Jharna (BA4)	163	110	135	163
SO_2	At plant site (CAI)	7.7	3.8	5.9	7.6
	Gorhi (BAI)	9.0	3.8	6.2	8.8

Air Quality Parameters	Location	Max	Min	Avg	98% tile
SO_2	Jhinkabahal(BA2)*	12.5	5.2	9.1	12.3
	Dolesara (BA3)	10.5	6.0	8.1	10.5
	Jharna (BA4)	12.4	6.3	8.8	12.1
NOx	At plant site (CAI)	12.1	8.3	10.3	12.0
	Gorhi (BAI)	13.2	9.2	11.5	13.2
	Jhinkabahal(BA2)*	20.7	10.6	15.8	20.3
	Dolesara (BA3)	19.0	11.0	14.5	18.6
	Jharna (BA4)	12.0	6.3	9.1	12.0
Near coal stacking/handling site of Gare IV/1 coal mine of JSPL					

Micro-Metrological Survey

6.12 Micro meteorological survey was undertaken for monitoring wind speed, wind direction, ambient air temperature and relative humidity during March to May 2006. The Micro-Meteorological monitored data is summarized in Table 6.4.

Table - 6.4 : KELO PROJECT
PREDOMINANT WIND DIRECTION

Particulars	Maximum	Minimum	Average
Temperature (^{0}C)	43.9	16.0	28.7
Relative humidity	75.0	14.0	33.9
Cloudiness	Nil	Nil	Nil
Wind Speed (km/hr)	22.7	Calm	5.488
Predominant wind direction	NE (16.01% readings)		

Wind Speed

6.13 Wind speed plays a dominant role in the dispersion of air pollutants. The wind speeds were found in the range between nil and 22.7 kmph, with the average value of 5.88 kmph. Winds were found usually below 15 kmph.

Wind Direction and wind rose Diagram

6.14 This is also one of the important parameters in the dispersion of air pollutants since it determines the direction of transport. Frequency of occurrence of winds from different wind directions under different wind speed ranges, also called wind rose pattern, have been computed from the hourly average values recorded continuously during the three months of summer season.

6.15 The 16 directional wind rose data for day and night hours as well as the 24 hour period have been presented in Table 6.5. Based on the data, wind rose diagrams for the three averaging period have been prepared and presented as Fig. VI.2.

Table - 6.5 : KELO PROJECT
WIND FREQUENCY TABLE OF DATA MONITORED
DURING 01.03.2004 TO 31.05.2004

Direction from	Percent frequency (wind speed in km/hr)							
	Calm	1.8 - 5	5 - 10	10 - 15	15 - 20	>20	Total	Ex.Calm
Day time 06 Hrs to 17 Hrs								
E	0.55	3.09	1.82	0.00	0.00	0	5.46	4.91
ENE	0.64	5.91	2.55	0.09	0.00	0	9.19	8.55
NE	0.73	14.55	8.73	0.09	0.00	0	24.1	23.27
NNE	0.27	4.91	3.55	0.09	0.00	0	8.82	8.55
N	0.64	0.55	0.18	0.00	0.00	0	1.37	0.73
NNW	0.73	0.09	0.27	0.00	0.09	0.	1.18	0.45
NW	1.09	0.55	0.45	0.00	0.00	0	2.09	1
WNW	0.37	0.09	0.18	0.09	0.00	0.18	0.9	0.54
W	0.82	0.18	0.36	0.00	0.00	0.	1.36	0.54
WSW	0.27	2.09	2	0.18	0.00	0.	4.54	4.27
SW	0.09	6.64	4.27	0.00	0.00	0	11	10.91
SSW	0.18	2.36	1.27	0.00	0.09	0	3.9	3.72
S	0.73	1.73	1	0.00	0.00	0	3.46	2.73
SSE	0.55	2.36	1.27	0.00	0.00	0	4.18	3.63
SE	0.09	7.82	3.27	0.00	0.00	0	11.18	11.09
ESE	0.82	4	2.45	0.00	0.00	0	7.17	6.45
TOTAL	**8.56**	**56.92**	**33.62**	**0.54**	**0.18**	**0.18**	**100**	**91.44**
Night Time (18 Hrs to 05 Hrs)								
E	0.64	0.55	0.92	0.09	0.00	0.00	2.20	1.56
ENE	0.73	0.37	0.64	0.18	0.00	0.00	1.92	1.19
NE	0.73	3.11	3.39	0.64	0.00	0.00	7.87	7.14
NNE	0.55	1.37	1.83	0.46	0.00	0.00	4.21	3.66
N	0.73	2.29	3.02	0.27	0.00	0.00	6.31	5.58
NNW	0.73	2.75	3.66	0.55	0.00	0.00	7.69	6.96
NW	0.73	4.58	6.32	1.01	0.00	0.00	12.64	11.91
WNW	0.73	2.47	3.75	0.55	0.00	0.00	7.50	6.77
W	0.55	0.92	3.21	2.01	0.00	0.09	6.78	6.23
WSW	0.55	0.92	3.02	1.65	0.00	0.00	6.14	5.59
SW	0.46	3.75	6.23	2.56	0.00	0.00	13.00	12.54
SSW	1.19	1.74	2.66	0.64	0.00	0.00	6.23	5.04
S	0.92	1.65	2.66	1.01	0.09	0.00	6.33	5.41
SSE	0.64	0.55	1.19	0.37	0.09	0.00	2.84	2.20
SE	0.64	2.01	2.47	0.27	0.00	0.00	5.39	4.75
ESE	0.82	0.55	1.47	0.09	0.00	0.00	2.93	2.11
TOTAL	**11.34**	**29.58**	**46.44**	**12.35**	**0.18**	**0.09**	**99.98**	**88.64**
Composite (Day + Night)								
E	0.59	1.82	1.37	0.05	0.00	0.00	3.83	3.24
ENE	0.68	3.15	1.6	0.14	0.00	0.00	5.57	4.89
NE	0.73	8.85	6.07	0.36	0.00	0.00	16.01	15.28
NNE	0.41	3.15	2.69	0.27	0.00	0.00	6.52	6.11
N	0.68	1.41	1.6	0.14	0.00	0.00	3.83	3.15

Direction from	Percent frequency (wind speed in km/hr)							
	Calm	1.8 - 5	5 - 10	10 - 15	15 - 20	>20	Total	Ex.Calm
NNW	0.73	1.41	1.96	0.27	0.05	0.00	4.42	3.69
NW	0.91	2.55	3.38	0.50	0.00	0.00	7.34	6.43
WNW	0.55	1.28	1.96	0.32	0.00	0.00	4.11	3.65
W	0.68	0.55	1.78	1.00	0.00	0.09	4.1	3.38
WSW	0.41	1.51	2.51	0.91	0.00	0.05	5.39	4.93
SW	0.27	5.2	5.25	1.28	0.00	0.00	12	11.73
SSW	0.68	2.05	1.96	0.32	0.05	0.00	5.06	4.38
S	0.82	1.69	1.82	0.50	0.05	0.00	4.88	4.06
SSE	0.59	1.46	1.23	0.18	0.05	0.00	3.51	2.92
SE	0.36	4.93	2.87	0.14	0.00	0.00	8.3	7.94
ESE	0.82	2.28	1.96	0.05	0.00	0.00	5.11	4.29
TOTAL	**9.91**	**43.29**	**40.01**	**6.43**	**0.20**	**0.14**	**99.98**	**90.07**
Note: Calm is cut off at wind speed <1.8 km/hr as per CPCB								

Noise and Air Pollution Sources

6.16 The main cause of air and noise pollution is due to construction activity and the socio-economic development. Due to this pollution eventually there will be short-term impact on the surroundings. The activities that will increase the air pollution are the vehicular movement, excavation and other related construction activities. The air pollution will also be generated due the activities of the temporary human settlements. The same activities will also have impact on the noise environment. For the study, conducted, data was collected from the project area and it is overviewed in an angle to estimate how the area will be pollute with the activity. The locations of noise monitoring stations in the project area are shown in Figure – VI.3.

Noise Environment

6.17 The noise environment is one of the prime concerns in any projects as the noise pollution may cause the problems in the project area. Exposure to excessive noise may lead to the following:

- Prevention of sleep, insomnia and fatigue;
- Decrease in speech reception, communication, distraction and diminished concentration thus adversely affect the job performance or efficiency of the worker attached to the works where there is high noise;
- Chronic psychological disturbance including impaired hearing; and
- In certain extreme cases, there are irreparable cardiovascular damages.

Noise Levels

6.18 Measurement of noise levels was carried out at five locations on a round the clock basis. The locations are sown in Fig VI.4. The values obtained are presented in Annexure VI .2 and summarized in Table - 6.6

Table - 6.6 : KELO PROJECT
AMBIENT NOISE LEVELS IN db(A)

Sl.No	Locations	Noise Level in (Leq.in db (A))		Permissible limits	
		Day time	Night time	Day time	Night time
1	Core zone	46.6	41.9	55	45
2	Gorhi	53.6	40.7	55	45
3	Gare	50.0	40.2	55	45
4	Samkera	41.5	37.3	55	45
5	Dolesara	49.3	38.3	55	45

6.19 During the observation it was found that the noise levels in the project area ranged between 37.30 to 53.60 db(A).

Annexure –VI.2

KELO PROJECT **Noise Level – Leq in dB(A)**					
Hours	Core Zone (CNI)	Gorhi (BNI)	Gare (BN2)	Samkera (BN3)	Dolesara (CN4)
Date of Monitoring	16-17/07/06	19-20/4/06	21-22/4/06	27-28/4/06	29-30/4/06
0.00 - 1.00	40.6	38.10	41.80	37.80	37.40
1.00 – 2.00	41.40	43.00	41.80	38.20	38.80
2.00 – 3.00	40.20	36.00	34.90	33.80	39.70
3.00 – 4.00	42.80	39.30	39.00	35.80	36.90
4.00 - 5.00	42.20	46.40	39.10	36.60	38.80
5.00 – 6.00	42.50	40.90	36.60	37.80	39.80
6.00 – 7.00	43.10	55.80	42.30	38.40	49.90
7.00 – 8.00	46.90	53.20	50.20	38.60	41.00
8.00 – 9.00	45.00	55.40	53.80	41.30	48.50
9.00 – 10.00	45.50	52.30	46.20	44.20	53.90
10.00 – 11.00	44.30	55.90	51.10	40.10	54.20
11.00 – 12.00	51.60	52.70	49.10	44.90	48.80
12.00 – 13.00	43.70	55.80	49.70	43.80	43.90
13.00-14.00	51.40	55.30	44.70	43.10	46.50
14.00 – 15.00	44.90	56.10	52.70	41.00	44.90
15.00 – 16.00	47.20	51.10	48.30	37.50	52.20
16.00 – 17.00	42.70	50.30	52.00	42.80	50.80
17.00 – 18.00	52.30	50.80	53.40	43.80	49.70
18.00 – 19.00	42.10	52.00	45.20	43.60	54.00
19.00 – 20.00	47.90	55.60	53.90	35.70	47.10
20.00 – 21.00	51.00	51.60	46.00	44.00	54.20
21.00 – 22.00	43.00	47.90	53.60	35.90	42.30
22.00 – 23.00	42.00	36.40	41.90	38.20	37.00
23.00 – 24.00	42.00	36.40	41.90	38.20	37.00
Day time Leq.	46.60	53.60	50.00	41.50	49.30
Night time Leq.	41.90	40.70	40.20	37.30	38.30
Average Leq.	44.80	48.70	46.30	40.00	45.20
Permissible (Day)	55.00	55.00	55.00	55.00	55.00
Permissible (Night)	45.00	45.00	45.00	45.00	45.00

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume – I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - II
BASELINE DATA

VII

SOCIO ECONOMIC ASPECTS IN CATCHMENT AND COMMAND AREA DEVELOPMENT

Introduction

7.01. The Kelo Irrigation project is located in Raigarh Block of Raigarh district. The catchment area of the project is spread over the blocks of Raigarh and Gharghoda. The Project is likely to irrigate 26956 ha (22810 ha in Kharif and 4024 ha in rabi season). The command area of the project covers three blocks, viz. Raigarh, Pussore and Kharsia in Raigarh district and Dabra block of district Jangir champa.

7.02. In order to assess the benefits likely to accrue from the project in the areas which would be getting irrigation, it is necessary to study the socio - economic aspects both in the catchment and the command area. Both the command and the catchment area is spread in Raigarh district, the socio – economic conditions have been studied for this district and the same is discussed in the subsequent paragraphs.

Geographical area

7.03 The total geographical area of Raigarh district comprising 9 blocks distributed in 6 Tehsils. The block- wise geographical area is given in Table - 7.1

Table - 7.1 : KELO PROJECT BLOCK-WISE CHATTISGARH BLOCK- WISE GEOGRAPHICAL AREA OF RAIGARH DISTRICT				
S.No	Name of the block	Total geographical area (ha)	Gram Panchayat	Janpad Panchayat
1	Dharamjayagarh	1537.69	105	1
2	Laillangu	910.35	70	1
3	Ghargoda	469.00	41	1
4	Tammar	433.04	57	1
5	Raigarh	510.33	85	1
6	Pussore	400.77	80	1
7	Kharsia	942.72	77	1
8	Sargarh	851.12	111	1
9	Baramkela	781.34	84	1

Demography

7.04 The total population of Raigarh district is 12,65,529 (2001 census) out of which the male population accounts for 634597 (50.14 %) and female population is 630932 (49.85 %).The sex ratio is 994 females for every 1000 males. The population density is 185 per sq. km.The scheduled caste population in the district is 1,79,744 accounting for 14.20 % of the total population. The total population of schedule tribes is 447703 accounting for 35.57 %. In Raigarh and Pussore blocks, the scheduled tribes population is 20.90 % and 23.11 % of the total population. The working force and non- working force details for Raigarh district and Raigarh blocks is given in Table 7.2

Land use Pattern

7.05 The total geographical area of Raigarh district during 2006-2007 is 5,03075 ha, out of which forests account for 11.59 % land not available for agriculture 12.76%, and net area cropped accounts for 55.08%. The details of the land use pattern is given in table 7.3

Table 7.3 : KELO PROJECT CHATTISGARH DISTRICT, LAND USE PATTERN, RAIGARH DISTRICT 2007			
S.No	Land use	Area	%
1	Total geographical area	503075	
2	Forest area	58310	11.59
3	Land not available for agriculture	64226	12.76
4	Other land put to non - agriculture use	64140	12.74
5	Culturable waste	7852	1.56
6	Culturable land	31531	6.26
7	Net cropped area	277125	55.08
8	Gross cropped area	309818	-
9	Are town twice	32693	-

Irrigation

7.06. The total irrigated area in the district is 49227 ha. The total well irrigated area is 975 ha, area under tanks is 4967, by pump sets it 25467 ha and by canals it is 17818 ha during 2006 – 07. The area irrigated through different sources is given in table 7.4.

Table 7.4 : Kelo Project
SOURCES OF IRRIGATION AND AREA IRRIGATED IN RAIGARH DISTRICT 2006-07

S.No	Source of irrigation	Ayacut (ha)	Net Area Irrigated (ha)
1	Canals	19015	17818
2	Wells with pumpsets	28318	25467
3	Wells without pumpsets	1028	975
4	Tanks	5038	4967
	Total	**53399**	**49257**

Agriculture

7.07 Agriculture is the main occupation of the population. The total cropped area during 2006-07 in the district is 2, 76,496 ha. Rice is the most important crop grown in the district with an area of 240616 ha during 2006-07 while the other important crops grown are pulses (36,183 ha) and oilseeds (19400 ha). The area under other food crops like maize, jowar, etc. is negligible.

Medical and Health facilities:

7.08 The Medical and Health facilities in the district are average. The district caters to the Medical and Health facilities through allopathic hospitals and seva kendras at the district, hospitals are also levelat the Tehsil level. In addition primary health centers and sub-seva centers are located at block headquarters. Allopathic doctors and doctors of other systems are also available. The details of the medical and health facilities are given in Table 7.5.

Table 7.5 : Kelo Project
MEDICAL AND HEALTH FACILITIES IN RAIGARH DISTRICT

District/Block	Allopathic Hospitals/Seva kendras	Primary Health Centres	Sub seva Kendras	Ayurvedic & Homeo	Available facilities	
					Allopathic	others
Raigarh district	12	50	311	28	690	30
Raigarh Tehsil	3	16	65	10	346	30
Raigarh block	2	9	37	7	316	30
Pussore block	1	7	40	5	130	-

7.09 The protected drinking water supply is available in the district. The water supply through pump sets is 1381,Tap water supply accounts for 57 and the protective drinking water supply under the protected water supply scheme covers 205 villages.

Socio Economic aspects in Catchment
and
Command Area Development

Table 7.2 KELO PROJECT

WORKING AND NON WORKING POPULATION RAIGARH DISTRICT 2001

S.No	District/Block	Agriculture			Agriculture Labor			Family Members			Others		
		M	F	T	M	F	T	M	F	T	M	F	T
1	Raigarh District	151721	95162	246883	108078	125351	233429	7930	6177	14107	45599	125221	170820
2	Raigarh Block	27173	15783	42956	27576	29519	57095	2066	1791	3857	44764	8484	53248

S.No	District/Block	Seasonal works			Total works			Non- workers		
		M	F	T	M	F	T	M	F	T
1	Raigarh District	400094	372305	772399	400094	372305	772399	279620	384152	663772
2	Raigarh Block	11432	27118	38550	113011	82695	195706	84035	123087	207122

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume - 1

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - II
BASELINE DATA

CHAPTER - VIII

REMOTE SENSING AND GIS STUDIES

Introduction

8.01 GIS and Remote Sensing, play an important role in generating automated spatial data sets and in establishing spatial relationship. The Environmental Impact Assessment, for the dam construction on the Kelo river, Chattisgarh State, India was performed using GIS and Remote Sensing software Arc Info, Arc View and ERDAS Image. The impact of the dam in terms of catchment area and command area was computed to assess the net benefit to the Society.

Location of the Project

8.02 The dam is proposed to be located across Kelo River, a tributary of Mahanadi River, in Raigarh District in Chattisgarh State. The site is located between 83^0 23' 20" E longitude and 21^0 57' 8" N latitude covering SOI Toposheet numbers 64N series 7, 8, 11 and 12 and 64O5 for catchment and 64 series 2, 5 and 6 for command area. The catchment area is demarcated into 20 sub-watersheds covering an area of 920 sq.km. The command area covers an area of 29,000 ha spreadover of 175 villages.

7.03 This dam shall impound gross storage of 60.785 M Cum of water and is expected to irrigate 26,800 hectares of land. The construction of the dam is aimed at

improving the land productivity in the command area. Proper utilization of the irrigation water from the dam is suggested to prevent increase in the land salinity in the command area. The study

shall assess the status of erosion and land degradation in the catchment area to prevent siltation and to suggest the future plan of treatment.

Methodology

8.04 The study is carried out by combining the features of satellite imagery, topo sheets and secondary maps data to produce the necessary information layers of natural resources. Digital interpretation procedure was adopted using LISS-III data of the IRS-P6 in the form of multi-temporal geocoded FCC imageries. Identification of different classes were made based on the image characteristics, location, etc. SOI Topographical maps were used for generation of base map, slope map, etc. The multi layer thematic maps were generated and compilation and area calculations for different categories have also been carriedout using Arc info, Arc View GIS packages to provide detail insight to suggest the necessary improvement of the command and catchment areas.

8.05 The methodology adopted in generation of multi-layer thematic maps like slope, land use and land cover, hydrogeomorphology, soils, etc. are given below:

Slope

8.06 The slope map is derived by using the GRID and TIN features of Arc/Info. The input data are the contours from the Survey of India topographic sheets. SOI topographical maps on 1:50,000 scale of 20 m contour interval have been used to derive the information on slope, aspect and altitude in the project area. The close spaced contours indicate the highest percentage of slope as compared to sparse contours in the same area. Thus, the density of contours were utilized for preparing the slope map of the project area. The slope categories and their corresponding contour spacing followed in generation of slope mapping is given below:

Slope Category	Lower and upper limit of slope %
1. Nearly Level	0-1
2. Very Gently sloping	>1 to 3
3. Gently sloping	>3 to 5
4. Moderately sloping	>5 to 10
5. Strongly sloping	>10 to 15
6. Moderately steep to steep	>15 to 35
7. Very steep sloping	>35

Hydrogeomorphology and groundwater

8.07 The hydrogeomorphological map is prepared by overlaying geomorphology, lithostratigraphy, structure and land use. The hydrogeomorphologic conditions for each landform type are identified based on the above layers. Groundwater prospects are assigned to each unit. A total of five classes of groundwater prospect areas have been identified in the catchment area.

Soils

8.08 The soil map was prepared based on ASLU image, physiography, and physio-chemical data. Each mapping unit was assigned a number depending on the type of soil and composition.

Land-Irrigability

8.09 In the command area, based on the soil texture, structure and permeability, soil-irrigability classes are assigned and each type of soil irrigability class is given a unique code. This soil-irrigability la yer is unionized with the slope layer to derive the land-irrigability classes. Based on the percent slope and soil irrigability classes, four land-irrigability classes have been identified .

Land Capability

8.10 Overlaying the slope, soil, land use and environmental factors land capability classes are generated. Each land capability class is identified by a unique characteristic, having similar hazards of the soil to various factors, which causes soil damage, decreases soil fertility, and its potential for agriculture.

Land Use Land Cover

8.11 In the present study Land Use Land Cover mapping was carried out on 1:50,000 scale using the classification system adopted by NRSA. Digital interpretation technique have been adopted for delineating the various land use categories. IRS Satellite P6 LISS-III geocoded standard FCC data of rabi 2007 were used in conjunction with SOI toposheets. The interpreted details were verified on the ground. The land use / land cover classes have been identified in the command area as well as in the catchment area are given below:

1	Builtup Land	a) Town/City b) Village
2	Agricultural Land	a) Crop Land
		b) Plantations
3.	Forest	a) Deciduous dense
		b) Deciduous Open
		c) Scrub Forest
4.	Waste Land	a) Scrub Land
		b) Gullied/Ravines
		c) Stone y waste

		d) Mining
		e) Sandy lands
5.	Water Bodies	a) Tanks
		b) Reservoir
		c) River
		d) Canal
6.	Roads	a) Major
		b) Other
7.	Railway	Railway network

Sediment Yield Index:

8.12 Based on the characteristics of the sub-watershed units of Kelo Catchment area are assigned weightage and delivery ratio. The Sediment Yield Index is assigned to each unit. The sub-watersheds have been identified based on the area eroding more in time and space and have been prioritized based on the Sediment Yield for future treatment. .

Treatment plan for the catchment area

8.13 After a detail assessment of the above overlays, it is recommended to treat each sub-watershed from different aspects. Based on the Sediment Yield Index, the sub-watersheds were prioritized for treatment. According to the land capability, the catchment area can be treated with soil and water conservation methods to increase the moisture retention capacity, thus improving the fertility of the soil.

8.14 The drainage line treatment is also necessary in the catchment area to prevent soil erosion. The catchment area having diversified slope, soil and land use, the treatment suggestions carried out in three parts separately:

- For forest and watershed
- For agricultural land
- Drainage line treatment

8.15 The major drainage lines are assigned stream order and divided into upper, middle and lower reaches based on the slope of the terrain. The length of each drainage line in each type of land use is calculated. Different treatments based on the length of the drainage lines in the upper middle and lower reaches, in each type of land use, different soil conservation measures have been recommended.

Treatment Plan for Command Area

8.16 Based on the soil, land use, slope, land irrigability etc. of the command area, suggestions have been made to change the land use pattern and undertake reforestation in some of the areas.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - 1

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - III
IMPACT PREDICTION

IX

AIR ENVIRONMENT

Introduction

9.01 Government of Chattisgarh had proposed Kelo Irrigation Project across Kelo river in Raigarh district to mitigate the hard ships of farmer community besides providing drinking water supply to the Raigarh urban area and to two industries near by. During the construction phase and later the climate is likely to be effected unless mitigative measures are taken up to minimize the adverse effects. The present chapter focuses the impacts on the Air Environment due to the project during construction phase.

Sources

9.02 The main sources of air or for the matter of air, noise pollution is due to the construction activities and the socio economic development. Due to this pollution eventually there will be short term impacts on the surroundings. The activities that will increase the air pollution are, the vehicular movement, excavations and other related activities. The air pollution will also be generated due to the activities of the temporary human settlements such as labour colonies. For the study conducted, data was collected from the project area and it is over viewed in an angle to estimate how the area will be polluted with the activity. The air pollution impact of the activity on surroundings is mainly during construction phase. Most of the operati ons are mechanised and are operated on diesel. The Heavy Machinery like power generators, excavators, tippers, dumpers rollers etc., are operated on Diesel. The activity contributes to increase the Suspended Particulate Matter (SPM), SO_2 and Nox. The attached activity like the te mporary human settlements near the project will also have impact but is insignificant when compared to other sources of air pollution. The listing of major pollutants, their sources and effects is presented in Table - 9.1.

9.03 The list of potential pollution generating equipments and the level of pollution

generated by them is quantified in the following paragraphs. Table - 9.2 shows the emissions of pollutants by some major mechanical equipment.

Table - 9.2 : KELO PROJECT
EMISSIONS OF POLLUT ANTS

Sl.no	Equipment	Activity	Mode of Operation	Emissions of Pollutants
1	Shovel	Excavation	Diesel	$SPM_{1,}SO_2$ & NO_x
2	Tippers/ Trucks	Transportation	Diesel	$SPM_{1,}SO_2$ & NO_x
3	Compressors	Drilling	Diesel	$SPM_{1,}SO_2$ & NO_x
4	DG sets	Power Supply	Diesel	$SPM_{1,}SO_2$ & NO_x
5	Dozers with rosters	Excavation Leveling	Diesel	$SPM_{1,}SO_2$ & NO_x
6	Concrete Mixer	Mixing Aggregates	Diesel	$SPM_{1,}SO_2$ & NO_x
7	High Discharge Pumps	Baling out Water	Diesel/Power	$SPM_{1,}SO_2$ & NO_x
8	Road Rollers (7 to 10 tonnes)	Consolidation of Banks	Diesel	$SPM_{1,}SO_2$ & NO_x

9.04 Approximate consumption of fuel of the equipment will be as in Table - 9.3.

Table - 9.3 : KELO PROJECT
AVERAGE CONSUMPTION DETAILS

Sl.no	Type of Equipment	Average level consumption lits/hr	No.of vehicles or equipment proposed
1	Tippers /Trucks	10	13
2	Compressor	26	6
3	DG Sets	55	2
4	Dozers with rosters	49	2
5	Concrete Mixer	10	7
6	High discharge pumps	10	8
7	Road Rollers	10	3

Release of pollutants from road transportation is as below:

Sl.no	Description	Emission in gm/m^2			
		Dust	NOx	SO_2	CO
1	Transport empty	0.000011	0.0001	0.000011	0.000078
2	Transport loaded	0.000031	0.00015	0.000017	0.000117

About 30 transport vehicles are proposed to work for the project besides private vehicles.

Calculation of Emission factor for SO_2

Sulphur dioxide emission factor = 138 Ib X (% of Sulphur)/ 1000 gallons of Diesel
= 138 Ib X (0.25)/1000 gallons
= 34.5 Ib/ 1000 gallons = 3.44 gms/ltr of Diesel/hr.

Based on No. of vehicles of Equipment used, quantity of Fuel used SO_2 emission can be calculated as follows:

No.of vehicles or equipment used = 41

Total diesel consumed by them in litres: 130+156+110+98+70+80+30 = 674
Total SO_2 emitted by the equipments and vehicles is 0.64 gms/sec

Calculation of Emission factor for Nox

Nox emission factor = 68 Ib/1000 gallons of Diesel = 6.79 gms/ltr of Diesel/hr

Based on No.of vehicles or equipment used, quantity of Fuel used Nox emission can be calculated as follows:

No.of vehicles or equipments used = 41

Total diesel consumed by them in litres: 674

Total Nox emitted by the vehicles and equipment is 1.27 gms / sec

9.05 There is a proposal for installing a mix of 750,1250 and 1500 KVA , DG sets for power requirements during the main supply failure. The DG sets proposed will consume about 590 kgs of HSD) per hour. The diesel consumed will have 0.5% of Sulphur content and will quantify to 2.95 kg/hr. The emission generated by Sulphur is Sulphur dioxide, which quantifies to 0.256 gm/sec. The volume of gases emitted by the DG set is about 1600m^3/hr. The stack height for DG sets is calculated based on the KVA, and as per this formula H+0.2 Sqrt.250, H is the height of the building, which houses the DG set. The formula yields a result of 3.5 mts above the height of the building. Which houses the DG set. The power outage per day is about 2 hour in the region so there would not be any considerable impact on surroundings due to the DG set emissions. The DG set emissions will be maintained below the limits prescribed by the state pollution control board. A noise attenuation equipment will also be installed to avoid noise nuisance.

9.06 The emission of the vehicles and equipments are moderate in quantity and the pollution due to the activity is short term as the vehicles and equipment are operated for few hours only in the region. The nearest habitation is about 4 km from the proposed main construction area of the project. Hence the effect of the emission on the habitation is minimal. The generated air pollution due to the activity will be dispersed easily since the region has the average wind speed around 5 kmph and above and the dispersion of the air emissions is easier. The wind direction and speeds

were measured near the project site from March 2006 to May 2006 are as below:

Wind Pattern 8.30 hrs

9.07 The predominant winds are from NE during winter and SW summer and monsoon season during morning hours.

Wind pattern 17.30 hrs

9.08 During this period there is slight change in the pattern of wind direction . NE was more dominant during October and January than the NE compared to the 8.30 hrs. Most of the winds were from NW between February and May and SW between June and September.

Total wind pattern

9.09 The analysis of final average of wind pattern shows predominant winds from NE and SW with wind frequencies of 24.1% and 13.00 respectively. The SE percentage frequency was 11.18 during morning hrs and NW percentage was 12. 64. Predominant wind speeds of 0-10 km/hr were recorded.

9.10 The above data indicates that the predominant winds are from North - East and South-West. Hence the dispersion of the pollutants during construction of the weir and canal is mostly in North East, South West directions only. No habitations adjacent to the project site are existing. Most of the habitats are in N & S directions and 3 to 4 km away also there is advantage of elevation differences for project components which are located at higher elevations than villages which are comparatively less populated in the study area.

9.11 Another potential impact on air quality will be due to de-fuming of blasting operations undertaken during spill way excavation. It is to be noted that the project require a spillway excavation, which poses adverse impacts on air quality in terms of high Nox and SPM levels. The potential fugitive sources of dust emissions are expected from project traffic movement, open excavations, road construction, quarrying, blasting and transportation. Emissions from hot mix plants and concrete mixers during construction activities pose potential impacts on air quality. Topography of the project area being hilly in nature with high gradient differences, vehicular movements during construction phases will be restricted subject to development of proposed network of roads connecting various project components. This shows, that there will be high vehicular movements down at village, requiring regulated movement of fleet.

9.12 The average ambient air quality monitored in villages show SPM to be within 99.6 to 166.9 $\Phi g/m_3$ as against a CPCB standard of 200 $\Phi g/m_3$ for residential, rural and other areas. Similarly, SO_2 NO_x concentrations in AAQ ranged from 3.4 to 6.3 $\Phi g/m_3$ (and 4.7 to 13.6 $\Phi g/m_3$ respectively as against corresponding CPDB limit of 80 Φg/cum) both for SO_2 and NO_x for residential, rural and other areas. With the addition of incremental levels in the baseline, the AAQ will remain within the prescribed limits .

Occupational Health Hazards Due to Dust Pollution

9.13 Progressive disintegration of suspended solid particles or dust results in major health problems. Smaller the particle size (less than 10Φ) higher is the chemical and biological reactivity, resulting in increased toxicity than the parent lump. These micron sized particles, once air borne, are extremely difficult to be colleted or trapped. Due to the minute size of the particles, the ambient environment remains clear, giving a deceptive sense of security to the workers and the management. The restorable dust has serious impact on the health of the workers. Lung functions are impaired due to both respirable and non respirable dust particles. Chronic exposure leads to respiratory illnesses like asthma. Emphysema severe dyspnea (shortness of breath) and bronchitis and in extreme cases pneumoconiosis or the black-lung disease of minors. There may be several components of limestone dust. The effect of dust may be harmful to the human health. The probable effects of air pollutants on plants and animals are listed in the following Table - 9.4.

Table - 9.4 : KELO PROJECT
EFFECTS OF AIR POLLUTANTS ON PL ANTS AND ANIMALS

Pollutants	Principal source and effect
Carbon Dioxide	Fuel combustion for heating, transport, energy production. No direct effect on people, however may lead to increase in global warming.
Carbon Monoxide	Incomplete fuel combustion-vehicles etc. deprives tissues of oxygen. People with respiratory diseases.
Sulphur Dioxide	Burning of sulphur containing fuels like diesel in DG sets

- Combined with smoke, increase risk and effects of respiratory diseases.
- Causes suffocation, irritation of throat and eyes.
- Combines with atmospheric water vapor to produce acid rain, leads to acidification of soils.
- Reduces crop yield.
- Corrodes buildings. TSP smoke from domestic, industrial and vehicular sources.
- Possible toxic effects depend on specific composition, aggravates effects of SO2
- Reduces sunlight.

Operation Phase

9.14 Impacts of air quality post construction phase will be mainly due to vehicular traffic movement connecting network of roads with various project components. The summary of likely impacts on the ambient air quality of the study area is given in Table - 9.5.

Table - 9.5
SUMMARY OF IMPACT ASSESSMENT :AIR QUALITY

Impact	**Nature of Impact[1]**	**Target/Interest2**	**Magnitude3**	**Overall significance4**
Degradation of air quality for the duration of project	Reversible increase in traffic	Workers on site, vegetation	Local/Regional dust emission should be quickly suppressed	Major, deposition of SPM on human being, plant or animal ,potential effect on health
	significance deposition of pollutant SPM in human being and local area	Potentially impact due to accumulation of SPM deposition	Potential effect on human health due to SPM deposition in the lungs; flora and fauna	Moderate/Minor

1. Description; short or long term; reversible or permanent; associated with construction,. Operation, decommissioning. Cumulative, accidental, etc.
2. Targets and interests potentially affected.
3. Adverse or beneficial, small, Large, etc; very localized (within the project component locations only), local regional nations.
4. Overall significance against criteria (Minor moderate some significance; major.)

Summary of Impact Evaluation

9.15 The environmental impact evaluation of possible effects as a result of proposed activity and various environmental parameters is primarily based on careful study of plants, geological field survey, its operation, surrounding environment, etc. The aspects, such as air components of environment have been assessed on the basis of experience for similar activities.

9.16 The environmental impacts identify the possible relationship of proposed activity with respect to environmental parameters. These relationships can be beneficial or adverse and can be classified as short term or long term, reves5ribnle or irreversible, local or regional.

9.17 The proposed activity has little or marginal adverse effect on various environmental parameters related to air quality, while they have positive impact on socio-economic status of community.

9.18 The proposed activity creating air pollution such as fugitive emissions from drilling, excavation, construction material handling, etc have marginal adverse effect with respect to air quality and aesthetics during construction phase. Utmost care has to be taken because even in the case of minor lapses, appreciable adverse effects may be noticed.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - III
IMPACT PREDICTION

X

NOISE ENVIRONMENT

Introduction

10.01 The climate of the project area constitutes three distinct seasons. They are a) Winter from December to February followed by (b) Pre monsoon or Summer season from March to May and (c) Monsoon season influenced by south west monsoon which sets in June and last up to September and North East monsoon to some extent in October and November. The Kelo Project is situated at about 8 km towards North of Raigarh which is the district head quarters. This town ship is sufficiently away from the project site and hence does not have any significant noise pollution effects at present. The Raigarh Ambikapur state highway passes near by (1 km). In view of the lean traffic, noise pollution is below normal limits at present.

Noise Pollution Sources

10.02 The main cause of air and noise pollution is due to construction activity and the socio-economic development. Due to this pollution eventually there will be short-term impact on the surroundings. The activities that will increase the Noise pollution are the vehicular movement, excavation and other related construction activities. The above activities will have impact on the n oise environment. For the study conducted, data was collected from project area and it is over viewed in an angle to estimate how the area will be polluted with the activity.

Construction Phase

10.03 The following activities during the construction phase have potential to cause impact on noise environment:

- Drilling & Blasting during spill way & head works construction;
- Rock excavations;
- Road Construction;
- Operation of concrete mix plants, DG sets. Cranes, & all heavy machinery;
- Vehicular movement.
- Spill channel excavation and rock blasting would also result in generating ground vibrations. Noise due to vehicular movement will be intermittent and will be restricted to project component locations as new roads proposed are for the project only and will last for short term only.

Ground Vibrations

10.04 The following activities during the construction phase will have potential to cause ground vibrations, which in turn might result in sudden intermittent noise and also destabilize near structures, if any.

- Blasting operations during quarrying.
- Blasting operations during spill way foundation excavation.

10.05 It has been observed that construction activities generally lead to higher noise levels if not properly controlled. It is expected that construction activities will involve noise generation above 90-db (A). The sound pressure level generated by a noise source decreases with increasing distance from the source due to wave divergence. Noise attenuation with respect to distance in all directions over horizontal distance can be given by the following equation:

Sound level dB(A) = Lw - 20 log 10 R-8
Where Lw = Sound level of source, dB(A)&R = Source distance, m

Occupational Health Hazards of Noise Pollution

10.06 The noise levels in many situations would be above TLV. Exposure to noise levels, above TLV, has been found to have detrimental effect on the workers' health. During construction phase workers engaged for more than 4 to 4.5 hours per shift in high noise generating areas would be greatly affected, unless suitable mitigatory measures are taken.

10.07 The noise environment is one of the Prime concerns in any project as the noise pollution may cause certain problems in the project area. Exposure to excessive noise may lead to the following:

- Prevention of sleep, insomnia and fatigue;
- Decrease in speech reception, communication, distraction and diminished concentration thus adversely affect the job performance or efficiently of the

worker attached to the works where there is high noise;
- Chronic psychological disturbance including impaired hearing; and
- In certain extreme cases, there are irreparable cardiovascular damages.

10.08 Due to blasting, the vibrations can cause damage to the nearby structures if appropriate control erasures are not adopted. Therefore, the control measures suggested in environmental action plan should be adhered to. When an explosive charge is fired in a hole, stress waves propagate radially in all directions and cause the rock particles to oscillate. The oscillation is felt as ground vibration. The blasting operations using short-hole drilling and blasting using delay detonators propagate some ground - vibrations. The vibrations are measured as per the assessment criterial given under Bureau of Indian Standard Criteria for Safety and Design Structures subject to Underground Blasts - IS:6922 - 1973 (Reaffirmed 1995).

10.09 As per the assessment criteria, the value of ground particle velocity may be computed from the following expression:

V=K1[Q2/3/R] 1.25
Where
V=Ground particle velocity in mm/sec
K1=Constant which may be normally taken as 880 for soft rocks and soil and 1400 for hard rocks
Q = Charge per delay (kg), and
R= Distance (m) from blast point.

10.10 The noise produced by blasting should take place during night time for better management 65 dB(A) and 55 dB(A) are the limits during day time and night time respectively for mixed areas prescribed by CPCB. Therefore, no negative impacts are anticipated at the nearest villages. The project proponent is proposing to further minimize ground vibrations by using specialized techniques and special explosives. For an approximate estimation of dispersion of noise in the ambient air from the source point a standard mathematical model for sound wave propagation is used by considering 95dB(A) as the resultant noise level generated from the construction activities including DG set operation in the vicinity of major project component locations. It is clear that noise generated during construction activities will be merged with the noise level of 65 dB(A) (during day time) at a distance of 150m from the source and with the noise level of 55 dB(A) (during night time) at a distance of 300 m from the source. There will not be any noise impact from the project components of Kelo project during night time as the construction activities will be restricted to two shifts only at the maximum. The impacts over the surrounding habitats can be minimized by adopting adequate precautions during blasting and also by properly scheduling it as indicated in the environmental action plan.

10.11 Based on the above equation, the ground particle velocities at different distances (50m 80m, 100m, 190m, 400m, and 500m are calculated considering K1 to be 880 for soft rocks and 1400 for hard rocks. The charge proposed for the spill channel estimated to be 120 Kg of explosive charge for removal of about 132 m3 of rock during single incidence of blasting. The maximum charge per day is estimated as

20kg for 6 days. As per the Standard, for safety of structures from threshold damage, the ground particle velocity should not exceed the following: Soil, Weathered or Soft rock 50 mm/sec Hard Rock 70 mm/Sec.

10.12 The results are presented in the Table - 10.1 for the maximum charge.

Table - 10.1 : KELO PROJECT
GROUND PARTICLE VELOCITIES (V)

Constant K1	Charge per delay	Ground Particle Velocity (v) mm/sec Dist. From blasting in							
		50	80	100	150	190	250	400	500
880 Q	20 Kg	80.3	44.6	33.8	20.3	15.1	10.7	6.0	4.5
1400 Q	20 Kg	127.8	71.0	53.7	32.4	24.1	17.1	9.5	7.2

10.13 It is clear that with Q = 20 Kg charge per delay the ground particle velocity up to 81 m is above the permissible level for hard rock, however, at subsequent distances ground particles velocities are expected to be within the safe limits for any structures.

10.14 Thus, it can be seen that the ground vibrations generated by blasting during the spill excavations will not likely to effect the structures proposed in the vicinity of >81 m from the point of blast. The project proponent is proposing to further minimize ground vibrations by specialized techniques and special explosives.

10.15 When noise in the form of waves impinges the eardrum, it begins to vibrate, stimulating other delicate tissues and manifested in the form of discomfort leading to annoyance and in extreme cases to loss of hearing. Detrimental effects of noise pollution are not only related to sound pressure level and frequency, but also on the total duration of exposure and the age of the person. Table - 10.2 gives frequency levels and associated mental and physical response of humans.

Table - 10.2 : KELO PROJECT
NOISE EXPOSURE LEVELS & ITS EFFECTS

Noise Level db(A)	Exposure Time	Effect
85	Continuous	Safe
85-90	Continuous Annoyance	Irritation
90 - 100	Short term	Temporary shift in hearing threshold, generally with complete recovery
Above 100	Continuous	Permanent loss of hearing short term Permanent hearing loss can be avoided
110 - 120	Several Years	Permanent Deafness

120	Short Term	Extreme Discomfort
140	Short Term	Discomfort with pain
150 above	Single Exposure	Mechanical damage to ear

10.16 Though the possible impacts due to the project on noise environment are little, the main impacts would be during the construction of foundation excavation activity. In the modern times most of the work is mechanized and the following equipments to be used would generate the corresponding noise levels (Table - 10.3 and 10.4)..

Table - 10.3 : KELO PROJECT
NOISE LEVELS OF MACHINERY

S. No	Equipment or machinery	Noise levels generated in db (A)
1.	Excavator	70-90
2.	Tippers	70-85
3.	Drill	85-95
4.	Compressor	75-90
5.	Turbine	80-90
6.	Motor scraper	85-92
7.	D.G. set	80-90
8.	Vibrator	70-80
9.	Compactor	81-85

Table - 10.4 : KELO PROJECT
SHOWS THE FREE NOISE ATTENUATION WITH DISTANCE

Noise level at Source db (A)	Distance in mts	Noise level at receptor db (A)
90	100	42
90	200	36
90	300	33
90	400	30
90	500	28

10.17 Noise levels that are generated by various equipments at different times are given below in Table - 10.5

Table - 10.5 : KELO PROJECT NOSIE LEVELS AT DIFFERENT OPERATIONS		
Machines	Conditions	Noise Levels db (A)
Tippers	While being loaded	78-85
	Traveling with load	76-83
	Traveling without load	75-80
Drill Machine	Close to the Machine with Compressor	88-95
	50 mts away from the Machine	75-85
	100 mts away from the Machine	60-65

Maximum permissible exposure to sound intensities

Sound level dB(A)	Maximum exposure hours
90	8.000
93	4.000
96	2.000
99	1.000
102	0.500
105	0.250
108	0.125

10.18 It is inferred from the above table that maximum exposure levels is 8 hrs for noise level of 90 db (A) and while for 108 db (A) it is 0.125 hrs.

Operation Phase

10.19 During post construction phase no significant impacts are predicted in respect of either ground vibrating or noise environment.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO MAJOR IRRIGATION PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - III
IMPACT PREDICTION

XI

WATER AND PUBLIC HEALTH ENVIRONMENT

Introduction

11.01 Kelo river is one of the tributaries in Mahanadi river basin. It emerges from Dongbira reserve forest hill ranges at an elevation of + 710.36m and travels for a length of 112 km till it confluences with Mahanadi river in Orissa state. It traverses in hilly in hilly terrain for about 34.60 km where it enters plains. The river merges Mahanadi river in Hirakud reservoir at about 40 km below the proposed Kelo project. Thus the Kelo project is proposed about 72 km from its origin. The topography till the proposed dam site is with good vegetation cover on both the flanks and the water in the Kelo river is found to be of good quality. The dam site is proposed at about 8 km upstream of Raigarh township and the river flows through the middle of township.

Water Quality

11.02 The proposed project is located in an area with low population density of 283 per sq km and with no major sources of pollution. Few habitats in the catchment area are residing 1 to 3 km away from the river. There are no chances of outfall of the sewage generated in the habitations into river. Also, the effluents generated from domestic sources are found absorbed into the earth and disappear in view of long hot and dry weather periods. Further, there are no industries adjacent to the river in the project area. The area under assured irrigation is negligible and no pollution due to agro chemicals observed.

Water Environment - Surface water

11.03 The major sources of surface water pollution during the project construction phase are as below :

- Sewage from labour camps
- Effluents from machinery
- Effluents from other sources

Sewage from labour camps

11.04 The project construction is likely to last for a period of about 2 ½ years. The peak labour strength likely to be employed during construction phase is about 1000 including technical staff. During this phase some of the locals may get employment. This phase also leads to mushrooming of various allied activities to meet the demands of the immigrant labour population in the project area. Thus in the proposed project, the increase in labour population may be of the order of 1500 including families of workers and aspirants of job opportunities and indirect workers.

11.05 It is assumed that about 80% of the water supplied will be generated as sewage. Thus, total quantum of sewage generated is expected to be of the order of 0.20 mld. The BOD load contributed by domestic sources will be about 70 kg/day. Generally, labour population resides in 2 to 3 colonies. Considering the worst-case scenario for the purpose of assessment of impacts on water quality, it is assumed that all the sewage generated from various labour camps/ colonies outfall at two common points on both the banks. It is also assumed that the sewage is discharged after treating the same.

Impact of Effluents

a) Construction phase

11.06 During the construction phase, the agency will commission at least one or two crushers each at dam site and quarry site. The total capacity of the crushes is likely to be in the order of 120-150 tph. Water is needed to wash the boulders or cut stones and to lower the temperature of the crushing edges. About 0.1 m^3 of water is required per tonne of the material crushed. The effluents from the crushers contain high suspended solids in the water. About 12-15 m^3/hr of waste water is likely to be generated from each crusher. The effluent if disposed without treatment can lead to marginal increase in turbity levels in the river water or other water bodies. Therefore, the effluents may be let out into the river only after treatment. The flow diagram of effluent treatment plant and design are given in EMP. The effluents are proposed to be treated in settling tanks and even after the treatment of effluents, a minimum discharge of about 1.00 cumec will be necessary to dilute the effluents to the required standards. From the river gaugings at Kelo bridge near Raigarh town the minimum discharge during hottest month of May are as below :

2001-2002 - 8.69 cumecs

2002-2003	-	11.10 cumecs
2003-2004	-	12.10 cumecs
2004-2005	-	10.10 cumecs
2005-2006	-	12.10 cumecs
2006-2007	-	0.49 cumecs

11.07 During 2008 (February) the flows at the Kelo bridge site are very low and about 0.1 to 0.20 cumecs only and the water is observed to be fully contaminated due to the effluents released into the river from the township, industries etc. Hence even after the improvement of water in the Kelo reservoir minimum releases are to be made into the river below during the hottest months also to minimise pollution and for the survival of fresh water fishes.

11.08 The drinking water to labour colony and project colony may need to be treated. Flow diagram of drinking water treatment plant and its design aspects are presented in EMP.

Operation phase : The major sources of water pollution during post construction phase include;

a. Effluent from project colony
b. Impacts on reservoir water quality
c. Entrophication risks

Effluents from Project Colony

11.09 During project operation phase, cause and source of water pollution will be much different. Since only a small number of operation and maintenance staff will reside in the area in a well designed colony with all infrastructure facilities, the sewage from colony will be treated and treated water will be used for greenbelt and balance if any will be discharged to river after meeting the standards. Hence impact would be negligible. The problems of water pollution due to disposal of sewage are very remote.

Impacts on Reservoir Water Quality - Stratification

11.10 Stratification can limit the mixing of the water body, leading to depletion of DO levels. This can lead to reducing conditions in waters. Since the depth of the proposed reservoir is not very high, the annual variation up to MDDL would prevent formation of any significant temperature stratification. Thus no problems related to reservoir stratification are anticipated. Enrichment of impounded water with organic and inorganic nutrients will be the main water quality problem immediately on commencement of the operation. However this phenomenon is likely to last for a short duration of few years from the filling up of the reservoir. Therefore, any significant impact on reservoir water quality is not anticipated.

Entrophication Risks

11.11 Another significant impact, which can accrue in the reservoir, is the problem of entrophication in the reservoir. This occurs mainly due to the disposal of nutrient rich effluents from the agricultural fields. However, within the catchment, the proportion of agriculture land irrigated is low i.e., about 35% of the total catchment area. The agro-chemical dosing is low in the area. Even in the post project phase, use of fertilizers in the project catchment area is not expected to rise significantly in view of the maximum rainfed crops being grown in the area. Considering the low fertilizer usage in the area, significant loading of nutrients is not anticipated. Thus, problems due to entrophication are not anticipated in the proposed project.

Water Environment : Groundwater
Rainfall Contribution

11.12 The long term rainfall data for the period of the project area indicates that the mean annual rainfall is 1373 mm and minimum annual rain fall (1979) is 703 mm. Analysis of data during this period shows that there is no dearth of rainfall. The south- west monsoon contributes 70 per cent with September being the rainiest month of the year.

Hydro geology

11.13 The occurrence and behavior of ground water is an interplay of climatological, geological, structural and hydro geological factors. The depth, degree and the lateral extent of weathering in these rocks vary widely from place to place. The occurrence of ground water is controlled by degree of interconnection of secondary pores / voids Dion.

11.14 Ground water occurs under water table conditions in the weathered rocks and in water table to semi-confined conditions in the fissured and jointed rocks. Due to the deepening of water levels, the community dug wells present in the surrounding villages have been replaced by bore wells fitted with hand pumps. The depth to water level ranges between 3.9 and 7.75 m below ground le vel during pre-monsoon and between 2.9 and 4.65 m during post-monsoon season in the area. Ground Water exploitation in and around the project area is found to be on moderate scale, mostly utilized for drinking and irrigation.

Impact of the Proposed Proje ct

11.15 The soil layer is very deep in the project area. Hence no impact due to erosion is anticipated.

11.16 The building of water storage of 60.785 m cum in the project will be very beneficial for ground water recharge. This will build up the water levels and will improve the yields in the wells in the area. In the post construction stage of project ,

the existing recharge is predicted to increase by 30% even after the increase in private use and proposed Govt tube wells. There will not be any change in the balance potential. Apart from ground water recharge, the quality of ground water will also improve in the entire area.

11.17 In the entire process of impoundment of water, because of availability of plenty of surface water in the storage , canals and in the river course, surface water usage can be planned for irrigation in conjunction with ground water. This will reduce the stress on ground water for irrigation in the adjacent areas. The areas away from the command, will have the advantage of ground water due to higher recharge and better quality both for drinking and irrigation.Thus the project will have positive impacts on the water environment front.

11.18 Surface water pollution is already in existence in the river due to the Raigarh township habitation which is about 8 km downstream of the dam site. However measures to minimize the present pollution and curb further deterioration of the water environment of the river near Raigarh town are discussed under EMP.

PUBLIC HEALTH

Introduction

11.19 Public Health constitutes one of the most important aspects of Environmental Impact Assessment in construction of a reservoir or a dam. The health and hygiene of the population residing in the Project area is of great importance in Environmental Impact assessment (EIA) and needs special attention. The habitation near the project area has been studied in details from the point of view of impact of the proposed project on health and hygiene of the people, present status of the incidence of water borne diseases, their control and present health delivery system and its adequacy. Even though the storage capacity of reservoir is small, it is likely to affect the status of occurrence of water borne diseases to some extent. This impact is attributed to likely change in the pattern of prevailing diseases due to disturbance in the existing environmental status and also through influx of new diseases into the area by migration of labour. Hence, an attempt had been made to study the impact of the project on water borne and other diseases in the area.

11.20 Health risk includes potential disease hazards due to lack of hygienic/sanitation (water supply and human waste disposal) vector and water borne diseases and spread of sexually transmittable diseases like AIDS. Incidences of malaria, Dengue, Jaundice and Dysentery etc are reported in and around the project area. With the development of project, potential health risks would also grow if left unchecked. Mitigation measures include proper sanitary health care and human waste disposal facilities. Sanitation facilities are included in the project estimate to take care of cost to be borne towards human waste disposal facilities.

11.21 Due to impounding water in the proposed reservoir, and due to construction ofcanal network system of 350 km length covering about 175 villages in Raigarh and Sakti Tehasils, the villages are likely to come under inversed malaria conditions. Also the labour employed during construction period are likely to be affected by Malaria

and other diseases. Necessary health management plan for the workers and staff working during construction period has been discussed in chapter 20 under EMP (Part iv). The control of Malaria in the command area villages can be effected by maintaining a close laison with the National Malaria Eradication Programme Organisation. The other diseases can be controlled by strengthening the existing the public health care system in the respective Tahsils and villages.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - III
IMPACT PREDICTION

XII

LAND ENVIRONMENT

Introduction

12.01 Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of the proposed Kelo Project have been identified. This Chapter addresses the basic concepts and methodological approach for conducting a scientifically based analysis of the potential impacts likely to accrue as a result of the proposed project. The Environmental Impact Assessment (EIA) for quite a few disciplines are subjective in nature and cannot be quantified. Wherever possible, the impacts have been quantified and otherwise, qualitative assessment has been undertaken. This Chapter deals with the anticipated positive as well as negative impacts on land environment due to construction and operation of the proposed Kelo Project.

12.02 The impacts which have been covered in the present Chapter are categorized as below:

- Quarrying Operations
- Operation of Construction Equipment
- Pollution form Construction sites
- Muck disposal
- Construction of roads
- Acquisition of land
- Seismicity
- Land Slides
- Soil erosion
- Water logging
- Salinity
- Mines
- Archaeological Monuments Place of Worship

Quarrying Operations

12.03 A project of this magnitude would require significant amount of excavation and use of construction material. The total quantity of muck likely to be generated from various construction activities is assessed to be 4.30 lakh cum. A part of the muck generated is proposed to be used as construction material. Apart from this, about 14.10 lakh cum of earth is to be transported from borrow area.

12.04 Normally, in a hilly terrain, quarrying is normally done by cutting a face of the hill. A permanent scar is likely to be left, once quarrying activities are over. W ith the passage of time, the rock from the exposed face of the quarry under the action of wind and other erosional forces, get slowly weathered and after some time, they become a potential source of landslide. Thus, it is necessary to implement appropriate slope stabilization measures to prevent the possibility of soil erosion and landslides at the quarry sites. Also, the slopes of the earth in the borrow area are likely to collapse, besides development of ponds in the quarry site. Various measures have been suggested as a part of Environmental Management Plan (EMP), which has been outlined in Chapter- 19 of this Report.

Operation of Construction Equipment

12.05 During construction phase, various types of equipment will be brought to the site. These include Crushers, Batching plant, Drillers, Earth movers, etc. The installation of these construction equipment would require significant amount of space. Similarly, space will be required for storing of various other construction equipment. In addition, land will also be temporarily acquired, i.e. for the duration of project construction for storage of quarried material before crushing, crushed material, cement, rubble, etc. Efforts must be made for proper siting of these facilities. Various criteria for selection of these sites would be:

1. Proximity to the site of use
2. Sensitivity of forests in the nearby areas.
3. Proximity from habitations

12.06 The level or severity of impacts would vary with the distance of the settlement from the construction sites and intensity of construction activities. Most of the villages or settlements at various sites are located at least 1 km from the construction site. Considering the type of pollutant sources in the construction phase, significant impact is anticipated.

Pollution form Construction sites

12.07 The run off from the construction sites will have a natural tendency to flow towards river Kelo or its tributaries. For some distance downstream of major construction sites, such as dam, there is a possibility of increased sediment levels which will lead to reduction in light penetration, which in turn could reduce the photo synthetic activity to some extent of the aquatic plants as it depends directly on sunlight. This change is likely to have an adverse impact on the primary biological productivity of the affected stretch of Kelo river. Since , the Kelo river has flows, impacts on this account are not expected to be significant. However, runoff from construction sites, entering small streams would have significant adverse impacts on their water quality. The runoff would increase the turbidity levels with

corresponding adverse impacts on photo synthetic action and biological productivity. The impacts on these streams and rivulets thus, could be significant. Adequate measures need to be implemented as a part of EMP to ameliorate this adverse impact to the extent possible.

Muck disposal

12.08 Exploration of foundations and other activities would generate significant amount of waste, as a result of foundation excavations, spillways, head works, construction of roads, etc. About 1.0 Mm^3 of muck is likely to be generated of which about 20 Mm^3 would be used in construction of the various civil structures for the project. The balance (0.80 Mm^3) shall have to be disposed at designated sites. An area of 15ha has been earmarked for muck disposal. Normally, muck is disposed in low lying areas or depressions. Trees, if any, are cut before muck disposal, however, shrubs, grass or other types of undergrowth in the muck disposal at sites perish. The muck disposal sites in the proposed project are located close to river Kelo. If adequate protection measures are not undertaken, then the muck can roll into the river. This can affect the river flow and

aquatic ecology. Appropriate management measures need to be implemented for ameliorat ion of adverse impacts, which have been outlined in Chapter - 19 of this report.

Construction of roads

12.09 The project construction would entail significant vehicular movement for transportation of large construction material, heavy construction equipment. New access roads would have to be constructed. A total about 15.0 km of new road are proposed to be constructed Some of the existing roads in the project area, would require widening and repairs.

12.10 The construction of roads can lead to the following impacts:

- The topography of the project area has moderate slope which descends into valleys. The conditions can give rise to slight erosion hazards due to movement of soil aggregates.
- With the removal of vegetal cover, erosive action of water gets pronounced and accelerates the process of soil erosion and formation of deep gullies. consequently, the slopes are bared of soil vegetative cover and enormous quantities of soil and rock can move down the rivers, and in some cases, the road itself may get damaged.
- Construction of new roads increases the accessibility of an hitherto undisturbed areas resulting in greater human interferences and subsequent adverse impacts on the ecosystem.
- Increased air pollution during construction phase.

12.11 Various management measures have been recommended for control of adverse impacts due to construction of roads and the same have been outlined in Chapter - 19 of this Report.

Acquisition of Land

12.13 The total land to be acquired for the project is 1324 ha. A part of this land is required for labour camps, quarry sites, muck disposal, storage of construction material, siting of construction equipment, which will be required temporarily and returned once the construction phase is over. Permanent acquisition of land is required for dam axis, submergence area , project colony, etc. The break up details of land required for various project appurtenances is given in Table - 12.1.

Table - 12.1 : KELO PROJECT
D ETAILS OF LAND REQUIREMENT

Project Component	Area (ha)
Reservoir Area	1206
Dam site	48
Dumping yard	12
Quarries	15.0
Colony	5.0
HT line diversion	9.385

Canals	22.65
Approach road to quarries, dam site, etc	6.20
Total	**1324.235**

12.14 Out of the above, forest land is 361.90 ha and balance comprises of other Government and private lands. The project affected families will get adequate compensation as per the National Policy on the Resettlement and Rehabilitation of the Project Affected Families 2007 (NPRR-2007). The details are presented in Volume - 2 of the report.

Seismicity

12.15 The Geological investigation of the Kelo dam across Kelo reveal the presence of Granite gneiss, Quartzitic sand stones around the proposed alignment./ Archean sand stones around the proposed alignment. Archean Granite gneiss, bore blends gneiss and amphibolites associated with quartz veins form the foundation rock along the major portion of the dam axis of the Danote site. Chandrapur and sandstone, shale hillocks along the axis and isolated hill features are existing on the left flank of Kelo River. The project area falls in zone II of the seismological map of India. The GSI felt that the present status of the boundary fault and other cross faults may not be active in the present day period and would only present crushed zones for local foundation treatments. The seismic intensity is broadly associated with intensity of VII on the MMI scale. The Earth quakes occurred in the recent times have already been furnished in chapter 4 of volume I of this report. Thus the area is prone to Earthquakes and hence the dam and appurtenant works shall be suitably designed to account for the seismicity.

Risk Due to Forest Fires

12.16 Forest fire is not unusual in forested mountain areas generally. However there is no evidence form the study area to indicate that extensive fires have occurred in the recent historical period. Adequate knowledge of precautionary measures for prevention of forest fires will be provided to the people in the villages who will be deputed for construction in the project area.

Risk Due to Slope Failures - Landslides

1.17 Landslides are not common events in the area even during high intensity monsoon rains. It is important that before start of construction activities areas prone to landslide are identified periodically and suitable measures for slope stabilization are undertaken as per the need. Particular emphasis of such inspections is required before every monsoon season. Even during operational phase. Present topography of the ground in the vicinity of dam is not vulnerable to landslides in view of flat slopes of 1:10.

Soil
Erosion - Command Area

12.18 Soil erosion is a removal of fine soil particles from the land surface by wind or air. Since the command area is located in the humid to semihumid region, there is least chance for the wind erosion. But since the rainfall over the command area is in between 1200 to 1600 mm annually and 87 percent

of the rains are received in the monsoon period only, there are greater chances for erosion. The slope gradient favour it specially during the onset of monsoon when the command area is left barren after paddy harvest and the chances of soil erosion are maximum. But the existing paddy cultivation is limited to 38% only. The erosion phase of the command area was normed by the actual extent of the hazards. The observations taken in respect of soil erosion is presented in Table -12. 2.

Table - 12.2 : KELO PROJECT
TABLE SHOWING THE DIFFEREN T EROSION CLASSES

Sl.no	Erosion Class	Description	Area in ha.	Percentage of the Surveyed area
1	e1	Non to slight erosion	3021	10.78
2	e2	Moderate erosion	21850	77.98
3	e3	Severe erosion	3150	11.24
	Total		**28021**	**100**

12.19 The above table reveals that only 3021 ha . i.e. 10.78 percent of the surveyed area, is free from erosion. The maximum area of the command faces moderate soil erosion hazard which is 21850 ha. i.e. 77.98% of the total surveyed area. Such area needs on farm development measures to minimize the risk of soil erosion. The area under severe erosion class is 3150 ha. 11.24 of total surveyed area such area required soil conservation measure to minimize the soil erosion. Special precautions are required to manage such area under cultivation of the crop. Such areas should also be kept under perennial crop cover to protect the surface soil from erosion.

12.20 The catchment area of Kelo Project comprises more than 30% of forest area with good canopy cover. The nature of soils are able to sustain heavy rainfall. However few patches where they are liable for moderate erosions are to be treated under Catchment Area Treatment plan discussed in Chapter 15 of Volume .I of the report.

Water logging and Salinity

12.21 The Ground Water in the Command area during monsoon period under pre project condition is about 5 to 6 m mbgl. It goes down to 15 m and above during hot weather period. In the post project conditions the water table is likely to go up by 30%. Even then water logging conditions are not going to prevail since the Ground Water level during the monsoon may rise upto a maximum of about 3 mbgl. However, few low level pockets nearer to Mahanadi may be subjected to water logging. Hence necessary management plan is required to deplete the Ground water during premonsoon seasons duly adopting conjunctive use of ground water with surface water. Even as per the reports of Deputy Director of Agriculture, water logging problem is not predicted. There is no problem of salinity or alkalinity of soils under the command area of Kelo Project. The possibility of development of salinity arises only when water is allowed to stagnate. Areas of saline or problematic soils have not been identified in the project area. Since the existing cropping pattern is designed with a view of crop diversification, development of salinity is not predicted.

Mines

12.22 There is no minerals of economic importance in the submergence area, catchment and command areas. Also there are no injurious minerals which may be harmful for use of the water for Irrigation, Drinking and Industrial purposes. Exploration of coal seams has been carried out by the

Director of Geology and mining, Raipur and as per the preliminary report, coal reservoir in Kelo submergence area are not of economic importance. The quality of the coal schemes found in the submergence area are of inferior

quality and are not of economically workable order. Hence the Kelo Project would not have any impact on the mines and minerals in the area.

Archaeological Monuments

12.23 There are no Archaeological monuments of hist orical or religious importance coming under the reservoir submergence or in the catchment areas. There are certain local places of worships at some villages and also not of much importance. There are no places of tourism available in the study area. Thus there will be no impact on the above due to Kelo Project.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume – I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XIII

ECOLOGY

Introduction

13.01 A study was conducted during year 2007 survey of living natural resources, both flora and fauna in and around the project components and within the catch ment area of proposed irrigation project.

13.02 The study was carried out at both terrestrial Ecosystem and Aquatic Ecosystems. No endangered species are likely to be affected due to the proposed project does involve submission of diversion and forestland and will involve cutting of trees. The insignificant impacts on ecology are described in details in the following paragraphs.

Forest

13.03 The project will result in loss of forest for formation of reservoir, roads, canals, relocation of H.T. Line and the other ancillary facilities. However, the submersion area does not fall within reserve forest category.

Wildlife

13.04 The project surrounding area comprises sufficiently suitable feeding areas for the wild species and there is no indication that the area has corridor functions to other wildlife refugees. Moreover the construction and operation activities of dam, spill channel will be on ground. It is expected that there will be no impact on the wildlife due to the loss of forest cover due to deforestation.

Natural Hazards

Risk Due To Earth Quake

13.05 The project area falls within the seismic zone III as per Seismic Zoning Map of India (Is: 1893-1975) where shocks of the intensity of greater than 4 on richter scale have been reported. Necessary safety factors have been incorporated in designing the structures under the worst combination of forces.

Risk Due To Forest Fires

13.06 Forest fire is not unusual in forested mountain areas generally. However there is no evidence from the study area to indicate that extensive fires have occurred in the recent historical period. Adequate precaution and education or prevention of forest fires will be provided to the people in the villages and who will be deputed for construction in the project area.

Risks Due To Slope Failures

Landslides

13.07 13.01 A study was conducted during year 2007 survey of living natural resources, both flora and fauna in and around the project components and within the catch ment area of proposed irrigation project.

13.02 The study was carried out at both terrestrial Ecosystem and Aquatic Ecosystems. No endangered species are likely to be affected due to the proposed project does involve submission of diversion and forestland and will involve cutting of trees. The insignificant impacts on ecology are described in details in the following paragraphs.

Forest

13.03 The project will result in loss of forest for formation of reservoir, roads, canals, relocation of H.T. Line and the other ancillary facilities. However, the submersion area does not fall within reserve forest category.

Wildlife

13.04 The project surrounding area comprises sufficiently suitable feeding areas for the wild species and there is no indication that the area has corridor functions to other wildlife refugees. Moreover the construction and operation activities of dam, spill channel will be on ground. It is expected that there will be no impact on the wildlife due to the loss of forest cover due to deforestation.

13.08 Present topography of the ground in the vicinity of dam is not vulnerable to landslides in view of slopes of 1:10.Measures to restore the possible damages to the ecology has been discussed in chapter 16 and 19.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XIV

SOCIO ECONOMIC CONDITIONS IN THE CATCHMENT AREA AND COMMAND AREA

Introduction

14.01 A project of this magnitude cause vulnerable impacts on the living conditions of the people in the area. The impacts on the socio economic conditions can be grouped into

A) Adverse Impacts
B) Positive Impacts

14.02 When compared with the positive impact likely to occurs in the post project conditions, the adverse impacts are small and can be negotiated

Adverse Impacts

14.03 Due to formation of reservoir across Kelo River by means of a dam near Danote, about 1206 ha. of land of different categories is likely to be submerged. This causes adverse impacts on the people living in the habitations which are going to be submerged partially after completion of the project. The affected people loose their houses, cattle, land and other assets besides earning opportunities by way of agriculture and other activities. To mitigate the hand ships of the PAPs necessary acceptable Resettlement and Rehabilitation plans are proposed in Volume II, R&R plan. These people shall be imparted with suitable training measures to Resettle in the new area and earn their livelihood.

Positive Impacts

14.04 The construction of Kelo Project is proposed to be completed ion a span of 30 months. The total project activities likely to generate employment potential for about 70,000 to 80,000 laborers. Besides, skilled semiskilled categories also will have job opportunities helping the soico-economic condition of their families and thereby the habitations to up lift from the present status. This is likely to happen in the people of the habitations in the catchment area as well as Raigarh town ship which is situated just 8 km below the dam site. In view of the use of heavy machinery etc potential for skilled categories such as mechanics. helpers will also be developed besides improvement of business activities as well as

floating population in the township.

Command Area

14.05 Mostly benefitted people due to the project are farmer community. About 175 villages gets the benefit of assured water supplies for irrigating an area of 22,800 hectares. This will surely boost up the productivity which envisages well being of the socio-economic conditions of farmer community. The villages will be developed a lot more. The flows in the canal system causes the water table in the area to rise and there will be about 30 per cent rise in the ground water potential. This solves the water demand for agriculture as well as drinking and other domestic purposes too.

Drinking Water to Raigarh Municipality

14.06 The project envisages to provide certain quantity of water to meet the accute shortages in the drinking needs for the people of Raigarh township. Thus the project brings cheer among the dwellers in the township.

Industries

14.07 The project also envisages to provide moderate quantum of water to two steel industries situated in the project area as per demand. This will also help to improve the socio-economic condition of the people in the area.

Summary

14.08 Thus, even in spite of certain agony to some of the people in the submerged area the project fulfills the needs of the socio-economic conditions in the area for their upliftment.

SINDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XV

CATCHMENT AREA TREATMENT PLAN

Introduction

15.01 The irrigation development projects constructed across rivers or any water course get silted up at a faster rate over a period of time resulting in shrinkage in its command. Land degradation and deterioration of natural ecosystem in catchment area of the reservoirs beyond a particular point, cause large scale soil erosion. The soil displaced will be carried away by run off and deposited in the reservoirs. Thereby huge investments made on construction of the reservoirs will go waste defeating the main purpose of providing irrigation to the large localised ayacut. Therefore, catchment area treatment is the most crucial and essential component to arrest/minimize the soil erosion and consequent sedimentation into the reservoirs.

Objectives

15.02 The main objectives of catchment area development and treatment in the Kelo Project are as follows:

a) prevention of further land degradation in the catchment area;
b) reduce the rate of soil erosion in the catchment area;
c) arrest silt accumulation in the various tributaries, streams and gullies and in Kelo river across which the reservoir is proposed to be built so that the rate of siltation in the reservoir is reduced ; and

d) maintain ecological balance in the catchment area and increase the productivity of the cultivable lands by improving the vegetative cover by revegetating and increasing the density of existing vegetation on the wastelands.

Characteristics of Project Catchment

15.03 The Catchment area of the proposed Kelo Irrigation Project is 92,200 hectares and the entire catchment is in Chattisgarh limits only. The catchment area consists mostly with upto gently slopes(47.46%), moderate to steep areas of about 30.93% and very steep areas of about 19.34%. The topography of the catchment is undulating with steep areas valleys and plains. The slopes vary from nearly level (0-1%) to very steep (>35%) category.

15.04 Major part of the catchment is covered with forest area (50.27%) of which about 33-35% is degraded forest. The river Kelo with its tributaries and numerous small drains are flowing in the catchment area. The forest area besides Dense and open forest constitute , 35.36% of scrubs of categories including open scrubs. The agriculture lands in the catchment area constitute 45.29 per cent. River and water body constitute 4.44%.

Land use / Land cover and treatments proposed

15.05 In the moderate steep slopes where degradation of forest is observed by soil erosion, it is suggested to dig continuous contour trenches (CCTs) at suitable intervals with contour plantation. In the areas within the reserve forest boundaries, the State Forest Department should be made responsible to implement of this component. The spatial distribution of land use and land cover with its extent in the catchment area is presented in Table - 15.1. Sub Watershed wise land use / land cover areas are presented in Annexure - XV.1 (See Figure XV.1).

Table - 15.1 : KELO PROJECT
SPATIAL DISTRIBUTION OF AREA UNDER
LAND USE / LAND COVER CLASSES

Sl.No.	Land use / Land cover		Area (ha)	Area %
1	Builtup land	Settlements	2000.49	2.17
2	Agricultural land	Crop Land	41753.40	45.29
3	Forest	Dense forest dense	17833.90	19.34
		Open forest	7762.26	8.42
		Scrub forest	6967.11	7.56
		Dense Scrub	4363.86	4.73
4	Wasteland	Land with open scrub	9422.65	10.22

		Rivers / Streams	1171.43	1.27
		Tanks	917.951	1.00
Total			**92193.05**	**100**

Forest

15.06 It is a notified forest having trees and other type of vegetation. The total forest area constitute 36927 ha (40.05%) of the total catchment area including Dense scrubs lands. The forest area can be sub-divided into the following classes.

a) Dense Forest : These are forests with teak, sal, bamboo and other economically important species. It accounts for about 17833.90 ha (19.34%) of the catchment area.

Treatment proposed : Due to thick vegetative cover there will be no problem of soil erosion and siltation even though these areas are situated at higher elevations. Hence no treatment is proposed.

b) Degraded forest : These are situated within the boundaries of reserve forest, but degraded due to various factors. There are still stunted trees and bushes / scrubs covering the soil. Degradation occurring on moderately steep and slopes. The area under this category is 6967.11 ha (7.56%).

Treatment proposed : Since there is vegetative cover of bushes and scrub, no problem of soil erosion is anticipated . However, the forest department should take up plantations in these forest areas with more economical tree species under their regular departmental programmes so as to bring positive changes in the environment of the locality and economic conditions of the people.

c) Open Forest : These areas under the forest category is having moderately steep to steep slopes. About 7762.26 ha falls under this category (8.42%). This type of forest is outside the reserved forest area but within the notified forest area having not much of vegetative cover.

Treatment proposed : (i) Vegetative treatment measures : Afforestation is proposed in an area of 2300 ha (about 30%) to arrest the soil erosion. About 200 to 300 species per hectare are proposed to be planted in the gap areas. Size preparation should be based on V-ditches, trenches or terraces strictly on the contour where the existing tree/ scrub vegetation has to be preserved. Structural work have been excluded to introduce vegetation reinforcements as they are appropriate in these areas. Two meter wide strip along the top boundary of the area has to be worked 15-20 cm deep and sown with local grasses / shrubs. Such field strips would be placed in the entire area at 10-15 m interval along the slopes. Fire line would be maintained in and around the plantation area as per standard ecological specifications.

d) Dense Scrubs : This type of lands are having adequate land cover because of the dense scrubs out side the forest area. Such area is about 4363.86 ha (4.73%) in the catchment area of the Kelo project.

Treatment proposed : In as much as adequate soil cover is available, no treatment is to be proposed.

Waste Lands / Open Scrubs

15.07 These are degraded lands which can be brought under vegetative cover with reasonable effort and are currently under utilised. They cover an area of about 9422.65 hectares (10.22%). These lands are further divided into the following sub-classes.

a) Waste lands with scrubs : Those lands are covered with uneconomic shrubs and other vegetation. This vegetative cover protects the soil, checks soil erosion, and does not pose any problem to the proposed reservoir by way of silting. The area covered under this category is 9422.65 ha (----of the catchment area).
Treatment proposed : No immediate treatment is proposed in this area. In due course afforestation with more economic species is suggested at project cost in common or Government lands and also in private lands under the ongoing watershed and waste land development programmes.

b) Waste lands devoid of vegetation : However, for the gaps in the waste lands which are generally prone to soil erosion due to lack of vegetative cover and undulating slope, plantations of economic importance of forest species is suggested in this type of lands. By taking up plantations along with contour, the soil erosion and siltation of reservoir can be checked. The plantations should be taken up across the slopes along the contour so as to serve as barriers to run off and prevent soil erosion during rains. The plant species selected for such afforestation should suit the soil type with fast growing habit. Wherever possible, dry land horticulture can be taken up. About 1000 ha of waste land out of the open scrubs is proposed under this type of treatment.

c) Pasture lands : These are the lands having vegetative cover in the form of grazing lands.No such area is under this classification as per the analysis with R.S. applications.

d) Area covered under Rivers, Streams and Tanks : Considerable area of About 2089.38 ha of land (2.27% of catchment area) in the catchment area is occupied by rivers, streams and tanks. About 2 major tributaries are joining with Kelo river upto the reservoir site. Besides, several streams are joining the river in its course. Gullies are likely to be formed at the junction points of the major streams as well as on both the flanks of the main river due to floods and heavy rains. To arrest erosion and formation of gullies along the flanks of the main river, plantations are proposed on both the flanks. Plantations along the periphery of the tanks in the catchment area is suggested. Green belt

development along the foreshore of the reservoir has been proposed under Land Environment Management Chapter 19.

d) Builtup lands : An area of about 2000 ha (2.17% of catchment area) is occupied by residential buildings, roads, institutions, industries, recreational and other uses associated with water drainage and vegetation.

Treatment Proposed : No treatment is proposed . However, tree plantation is suggested in vacant lands all around village sites, and common lands maintained by the gram panchayat.

Agricultural Land

15.08 The agriculture in the catchment area is mostly rainfed. Dry crops like Kodukutki, pulses & wheat are mostly grown under tanks paddy is also grown. The area under agriculture cropped land is 41753 ha. In plains, rainfed paddy is cultivated under tanks and in uplands other crops like maize, pulses, millets, etc. are grown. Wheat is grown as Rabi crops under tanks occassionally.

Slope

15.09 The slope in agriculture lands in the catchment area is ranging from nearly level sloping (0 to 1%) to gentle sloping terrain(upto 5% slope). Rainfed crops are in about 40 percent of the catchment area and to a greater extent it is bunded or terraced. The paddy crop is grown under the tanks in the catchment area to a limited extent. In the balance area kharif rainfed ID crops are grown. Due to sloping nature, about 10 percent of the lands are prone to mild sloping erosion and may cause siltation of the proposed reservoir if not treated properly. About 10% i.e., 4000 ha requires treatment.

Treatment of Agricultural Land

a) Formation of graded bunds: - Graded bunds across the slope are constructed over high rainfall area in the agricultural lands to remove excess water safely out of the field; and erosion of fertile top soil is prevented to conserve rain water. In fact the bund serves only to guide the water to nearby waterway or drain. Graded bunds are designed essentially for diverting excess water safely from the cropped land. Suitable outlets are required to remove the water drained into them.

15.10 In the catchment upto 31% slope, bunding is not proposed and soil erosion can be checked by cultural practices like contour cultivation etc. Out of the lands above 3% slope approximately an extent of 4000 ha of agricultural land in the catchment needs treatment. The spacing adopted for graded bunding is as in Table -15.2.

Table - 15.2 : KELO PROJECT : SPACING FOR GRADED BUNDING

Slope (*%)	Vertical distance (m)	Horizontal distance (m)	Length of bund / ha(m)

Upto 1	1.05	185	95
Upto2	1.35	67.5	148
Upto 3	1.8	60	166
Above 3	-	45	221

15.11 While laying out the bunds the vertical interval is fixed on the basis of slope of the land by adopting the following formula.

Vertical interval = S/2+3 ft. Horizontal distance = 300/S+50 ft (S=% of slope).

Grade : The grade depends upon soil type and length of the bund. The grades suitable in different soils are as follows :

Soil Type	**Grade (%)**
Clay soil	0.1 to 0.2
Medium (loamy soils)	0.3 to 0.4
Sandy soils	0.5

15.12 On an average 0.3% grade can be adopted in this catchment area treatment. If the length of the bund is small i.e., 15 to 200 m, a uniform grade is to be given. However, if the length of the bund is large variable grades are to be given, starting from mild grade initially to higher grade in the last reaches.

Cross Section of the bund : It is suggested to form 0.5 sq.mts section bunds uniformly. But however in black soils the section can be increased to 0.65 sq.mts.

Waterways : The existing natural water courses can be utilised for water ways to the extent possible. In case natural waterways do not exist, nearby artificial waterways need to be provided. This treatment is needed on agricultural lands situated near the forest boundaries of Kelo Project Catchment Area.

15.13 These bunds can be stabilised with vegetation of local grasses. In the areas with higher percentage of slope, species like khus grass, bodh grass, kooper grass, lemon grass, citronella or any other vegetation or fodder crop like stilo hamato may be used.

Sediment Yield Estimation

15.14 The free catchment at the reservoir site is the source for the sediment entering into it. It is observed that soil erosion is due to un controlled deforestation, increased agricultural practices and various land uses. This in turn contributes to increased sediment flow into the streams. It is therefore essential that the catchment area of the prorject should be treated with suitable measures to increase the life of the project. In order to prepare the catchment Area Treatment Plan under Environment Management Plan, sediment yield estimation is required. In addition data relating the the characteristics of the catchment is also necessary.

Prioritisation of Sub-Watersheds

15.15 Realising the seriousness of soil erosion and land degradation problems, the Ministry of Agriculture, Govt. of India launched two centrally sponsored schemes of soil conservation and watershed management in the Catchment area of River valley projects and Flood Prone Rivers (FPR's). The task of identifying subsets of hydrologic basin within the Catchment areas, producing relatively high silt yields and generating high run off, was assigned to All India Soil and Land Use Surveys (AISLUS), Ministry of Agriculture and Cooperation (Govt. of India). The methodology for Prioritisation of sub-watersheds has been progressively refined overtime through discussions and consultations with the hydrologists, soil conservationists, soil scientists and other application personnel and subsequently tested for validity. The Sediment Yield Index Model (SYI) considering sedimentation as product of land erodibility and aerial extent was conceptualized in the AISLUS as early as 1969 and has been in operational use since then to the requirements of prioritization of smaller hydrologic units within RVP catchment areas. It has been refined and modified over the years and tested for validity in a number of areas with varying agro-climatic conditions. The model conceptualizes sediment delivery from hydrologic unit into a reservoir as a multiplicative function of the potential soil detachment material and the area of the hydrologic entity.

15.16 The erosivity is simulated with the sediment yield weightage value which is based on assessment of the composite effect of assemblage of erosivity determinants where as delivery ratio is adjudged by the likely delivery of the eroded material into the reservoir.

Sediment Yield Index (SYI)

15.17 The Sediment Yield Index (SYI) is defined as the yield per unit area and SYI value for hydrologic unit is arrived by taking the weightage arithmetic mean of the products of the weightage value and delivery ratio over the entire area of the hydrologic unit by using suitable empirical equation.

15.18 The prioritization of smaller hydrologic units within the catchment is based on the sediment yield Indices of the smaller units. Studying the frequency distribution of SYI values and locating the suitable breaking points facilitates to arrive at the boundary values or range of SYI values for different priority categories, the sub-watersheds are subsequently classified into various categories corresponding to their respective SYI values. The following formula which has been taken into consideration of optimal number of parameters involved in the calculation of sediment yield, index has been adopted by AIS & LUS.

Sediment Yield Index

$$= SYI = \frac{3(Ai \times Wi \times Di)}{AW} \quad i = 1 \text{ to } m$$

Where :

Ai = Area of the unit (EIMU)
Wi = Weightage value of the mapping unit
Di = adjusted delivery ration assigning to the mapping unit
n = No. of mapping units
Aw = Total area of sub-watershed.

Methodology

15.19 The following steps are involved for arriving at Sediment Yield Index (SYI) and for prioritizing the delineated watersheds of the reservoirs ofr the proposed treatment.

1. Preparation of framework of watersheds of the balancing reservoirs through systematic delineation and codification
2. Assignment of weight age values to various mapping units based on relative sediment yield.
3. Assignment of maximum delivery ratios to various erosion intensity mapping units and assessment of adjusted delivery ratios for different watersheds.
4. Computing Sediment Yield Index for Individual sub watersheds of the Catchment area.
5. Grading of watershed into very high, high, medium, low and very low priority categories.

Erosivity Weight age Values

15.20 The individual composite erosion-intensity mapping units are assigned relative Erosivity values. The erosivity values are assessed by the individual watersheds as a resultant of influence of a set of the factors namely, climate, physiography, slope, land use/land cover conditions, soil characteristics and the existing erosion.

15.21 The values of delivery ratios employed as a measure of transportability of the detached soil material to the site of catchment of the reservoir are adjudged for individual mapping units based on the factors influencing the suspension and mobility of the suspended material. Land use/land cover condition, terrain, slope configuration and soil are the main parameters considered for assessing the maximum delivery ratios to the units.

Priority Ratings of Sub-watersheds

15.22 The gradation and assignment of priority ratings to the sub watersheds (balancing reservoir catchments) are based on the descending values of Sediment Yield Index values. For deciding upon the boundaries of various priority categories, namely very high, high, medium, low and very low categories the SYI data are tabulated. The frequency distribution of the data is worked out by grouping the data in narrow bands of SYI values, against the number of sub watersheds within each of the ranges. The SYI values obtained thus are further adjusted by multiplication with a suitable factor to account for the deposition of the material enroute the reservoir site such as small dam silt trap, ponds or tanks.

15.23 For prioritisation of the sub-watershed the SYI ranges furnished in Table - 15.3 are considered for identification of the sub-watersheds in Kelo project for catchment area treatment.

Table - 15.3 :KELO PROJECT
SYI VALUES FOR PRIORITIZATION OF SUB-WATERSHEDS

SL No	Priority category	SYI Ranges
1	Very high	1300 and above
2	High	1200-1299
3	Medium	1100-1199
4	Low	1000-1099
5	Very low	Below 1000

15.24 As per the above classification the sub-watersheds are prioritised into the above categories and the details of prioritised sub-watersheds are given in Table - 15.4.

Table - 15.4 : KELO PROJECT
PRIORITIZATION OF SUB WATER SHADES
BALANCING / STORAGE RESERVOIRS

Sl.No.	Sub-watershed Number	Area in sq.km.	SYI	Priority
Kelo Catchment Area				
	1	3122	1050	Low
	2	4036	1040	Low
	3	4974	975	Very Low
	4	5482	910	Very Low
	5	6010	1275	High
	6	7517	1200	High
	7	1036	1050	Low
	8	3343	1190	Medium
	9	4414	1275	High
	10	4913	1190	Medium
	11	5785	1050	Low
	12	3406	910	Very Low
	13	3308	1050	Low
	14	5615	1040	Low
	15	5429	1040	Low
	16	3639	1040	Low

	17	6770	1170	Medium
	18	2701	1280	High
	19 20	2857 7833	112 1050	Medium Low
	Total	**92190**	**20897**	

Catchment Area Treatment

15.25 The main purpose of catchment area treatment is to reduce the rate of siltation into the reservoir to sustain its life time and ensure the dependent irrigation facilities. Care should also be taken to ensure that the treatment measures do not lead to instability in the catchment. The causes for siltation of the reservoirs are flooding, erosion by rainfall and runoff, steep slopes, inadequate vegetative cover and occurrence of impermeable formation at or near the surface and shallow water table which increases the runoff. A combination of these factors increase the rate of siltation. The present land use in the study area predominantly consists of deciduous dense forest, open forest dense scrubs. Agricultural crop lands. The Forest area of the study area is mainly classified as deciduous dense forest and open forest. The treatment is proposed only in the degraded / scrub forest areas due to less canopy coverage. While doing so, the sub-watersheds which are prioritised as high Sediment yield index range are proposed for catchment area treatment. (Fig. XV.3).

Vegetative Treatment Measures

15.26 Vegetative treatment measures are proposed for the treatment of the catchment area covering land with open scrub category. Further, all the waste lands that do not

qualify placement under any of the wasteland categories outside the forest area are included under this class.

15.27 The treatment is mainly to conserve soil and minimise soil losses from erosion by re-vegetation with small trees, shrubs and legumes / grasses and afforestation in the gap areas with social forestry or horticultural crops.

15.28 About 200 to 300 species per hectare are proposed to be planted in the gap areas. Site preparation should be based on V-ditches, trenches or terraces, strictly on the contour where existing tree/shrub vegetation is to be preserved and discontinuous vegetation barrier of vetiver grass and legumes is to be developed. For the contour planting preparation, a flat terrace or a small inward sloping terrace in the high elevations could be used. Structural work have been excluded to introduce vegetation reinforcements where appropriate. Two meter wide strip along the top boundary of the area would be worked 15-20 cm deep and sown with local grasses/shrubs. Such filter strips would be placed in the entire area at 10-15 m interval along the slope. Fire-line would be maintained in and around the plantation area as per standard ecological specifications. Green belt plantation is recommended for reservoir periphery. Which was laready dealt with under land environment chapter.

Plant Species proposed in the High Priority Zone Sub Watersheds

15.29 It is proposed to take up plantation in the high priority zones with Non Timber Forest Plantations (NTFP) species which will remain useful to local public for obtaining only userfacts . Some important tree species proposed for plantation are:

1. Acacia nilotica
2. Azadirachta indica (Vepa, Neem)
1. Cochlospermum religiosum
2. Dendrocalamus strictus (Veduru)
3. Derris indica (Kanuga)
4. Dolichandrone crispa (neeruddi)
5. Emblica officinalis (Usiri)
6. Feronia limonea (Velaga)
7. Ficus benghalensis (Marri)
8. Ficus microcarpa
9. Ficus religiosa
10. Hardwickia binata (Narepi)
11. Pterocarpus santalinus (Erra chandanam)
12. Sapindus emarginatus (Kumkudu)
13. Sterculia urens
14. Terminalia arjuna (tella maddi)
15. Terminalia catappa
16. Vitex negundo
17. Wrightia tinctorea
18. Eucalyptus

Important soil binding shrubs and grasses proposed for plantation are :

Agave sps.
Jatropha curcas
Vetiveria zizanoides

15.30 The list is only indicative and other species may be added by the implementing agency based on experience gained. Depending on the site conditions and local preferences, the practice could be changed. Live fencing has been preferred for its durability, renewability and easy maintenance. It may be expedient to start live fencing around the area with locally available material.

Open Scrubs & Dense Scrubs

15.31 These are the degraded lands which can be brought under vegetative cover with reasonable effort and are currently underutilised. They cover an area of about 1000 ha. The subclasses are :

a) Wastelands with open scrubs : Treatment already suggested under vegetative treatment measures holds good for this; and
b) Waste land devoid of any vegetative cover : Under this category about 1000 ha of waste lands devoid of vegetative cover is proposed to be treated as already indicated under para 15.

Proposed Physical Structures

15.32 The Gully control works/Engineering treatment measurements are recommended in the treatment areas mainly to control the sediment from the catchment as well as to increase the ground water recharge. Engineering measures include the construction of small hydraulic structures like rockfill dams, sunken gully pits, check dams, water harvesting mini-percolation tanks, trenches, graded bunds, etc. Five types of such works viz. gully plugs by rock fill dams and sunken gully pits, percolation tanks and check dams are proposed in the catchment area (Annexure - XV.2). The sub-watershed wise treatment measures proposed are presented in Figure XV.5 to XV .8.

Gully Control works

15.33 The catchment area consists of net work of gullies flowing into Kelo river throughout the course both in hill ranges and also in plains. The valleys in the catchment get flooded during torrential rains. This flooding is likely to result in siltation of reservoir down the stream. About 2 majortributaries besides several streams are joining the river.

15.34 The area is eroded due to stream bank erosion. in the high pririty sub water sheds. These lands are mostly seen adjacent to river and its tributaries in sub watersheds 5,6,9 and 18.

15.35 The gully control works are smalls structures which include rockfill dams and sunken gully pits which are constructed across the streams of first and second order

with the available local material to arrest the velocities of surface water flow and thereby reduce the soil erosion and improve the soil moisture profile. This practice also help the eventual growth of vegetation on the stream banks thereby stabilising them.

Rockfill dams

15.36 Deep gullies of ½ to 1 mt depth are treated by plugging with loose boulders of big size into trapezoidal shape, formed across the gully with an apron, retention wall and side revetment to arrest the silt coming from upper area and to allow silt free water flow over the bund. These structures will help in preventing the silt from higher elevations and cultivable lands being transported into the reservoir

15.37 There are about 2 main tributaries of various sizes beside many other small gullies joining Kelo river. These gullies are the main source in bringing silt / soil into the reservoir, along with water during rainy season. It is proposed to construct rock fill dams on these gullies at suitable places just above joining points into other streams or main stream so that only filtered water enters into the river avoiding danger of silting of the reservoir.

15.38 The location of the structure should be strategic in the sense that sites with narrow width and strong banks should be considered.

15.39 The height of the rockfill dam (rubble stone check dam) may be limited to one metre The upstream side of the structure should be backed upto with soil of the foundation.

15.40 Free board should be based on the peak runoff, and it should be subject to minimum of 0.6 m. Top width of the structure should be half of its height, subject to minimum of 0.5m . The following side slopes should be followed.

Height of structure m	Upstream side	Down stream side
0.3	Vertical	0.0423611111
Upto 1.0	0.0423611111	0.0423611111
Above 1.8	1.5:1	0.0840277778
Apron of 0.9 m and retaining wall of 0.6m, are to be provided		

15.41 Rubble stone pitching of gully banks on upstream side and down stream side of stone structure is to be provided with slope of 1:1 upto 1 metre length parallel to the surface of the structure. The borewall to be extended upto 0.6m inside the gully banks on either side. The follow ing are the depths of foundation to be adopted.

1. Main structure and wall
a) Red soil - 0.30 m
b) Black soil - 0.45 m

Apron in red soils	-	0.30 m
Retaining wall both red & black soils.	-	0.60 m

15.42 Agave or any quick establishing shrubs may be grown on upstream and down stream side to check the velocity of water and formation of silt.

15.43 Rockfill dams are proposed in high, priority zones classified as per sedimentation yield index calculations. As per this criteria 60 rockfill dams are proposed in the sub-watersheds of the catchment area. Typical figure of the rockfill dam is shown in Fig. 15.1. The typical technical details are presented in Annexure - XV.1.

Sunken Gully Pits

15.44 Sunken gully pits are constructed in small streams with moderate velocities. This involves construction of three pits and one silt trap as one set of sunken gully pits. The shape of each pit is of trapezoidal type of size 2.4m x 0.6mx0.3m with side slopes 1:1.The work involves earthwork and rubble stone work on side slopes and bottom of pits. The works are useful in dissipating the velocity of water and arresting silt carried by the water. In total 9 sunken gully pits are proposed in the catchment area. Typical figure of sunken gully pits is presented in Diagram - XV.2. The technical details are presented in Annexure - XV.3.

Water Harvesting Structures
Check dams

15.45 Kelo river across which the reservoir is proposed has a lengthy course of about 712 km and flows from high elevations to plains. In the catchment area of this stream there are some habitations and also areas under cultivation in patches all along the course of the main streams and tributaries. At present the water is flowing without any checks except few anicuts resulting in moderately eroding velocity. If the flow is unchecked, the contribution to ground water percolation / recharge is meagre in the lands on both sides of the main stream.

15.46 With a view to check the velocity of flowing water in the main stream and its sub-sidaries, to improve ground water resources in the lands situated along the banks, to provide open canal irrigation directly from the river and also to solve problem of siltation in the reservoir, it is suggested to construct low height check dams with masonry work at suitable places across main streams and across Kelo river.

15.47 Suitable sites with narrow widths and strong banks will be selected. As far as possible the site of dam should be on upstream side of the villages to take full advantage of them. The typical technical parameters are presented in Annexure - XV.3. Taking into cognisance of the size of the streams, slopes, villages etc, it is suggested to construct 12 checkdams in the catchment area preferably in cropped lands in the priority zones of 5,6,9 and 18.

Percolation Tanks (PTs)

15.48 At places where there is sudden depression and hump on either side or in wide and deep gullies at the location of entering gentle slope areas where maximum water can be stored an earthen bund with stone revetment on the upstream side and a surplus weir on one side are to be constructed. The catchment constitutes about 40% of the area with slopes 0-5% only which enables suitable places for construction of mini percolation tanks which helps in good water recharge as well as drinking water facilities to human and cattle, etc. So as to reduce the siltation into the proposed reservoir 4 nos. of percolation tanks are also proposed to be formed in the catchment area. The technical details of the mini-percolation tanks are presented in Annexure - XV.4.

Cost Estimates

15.49 The rate for engineering and gully control works may be arrived in detail from SSR of the Water Resources Department for 2006-2007. The total cost estimated is approximate and may vary depending upon the field surveys and designs made by the line departments.

Afforestation

15.50 As already discussed elsewhere there is considerable area under the category of open scrub out of which about 1000 ha is proposed for afforestation with some soil cover.

Catchment Area Treatment Cost

15.51 The cost of CAT treatment comprises the components such as biotic treatment with soil and moisture conservation measures, engineering and gully control works, compensatory afforestation besides staff component. The treatment measures are proposed in Government as well as in private lands. The catchment area treatment will be taken up by Forest Department and the Agricultural Department with the funds provided by Water Resources Department of GOG. The cost towards compensatory afforestation will be dealt with Land Management Plan - Chapter - 19.

Total Financial Requirements

15.52 The total cost for the implementation of CAT Plan is arrived at by multiplying the number of units with unit cost. In the previous paras it had been estimated that the afforestation would be taken up in 1000 ha, graded bunds with vegetative barriers are proposed in an extent of 2064 ha, (10% of prioritizing area). In addition, it was also proposed 13 checkdams and 60 rockfill dams besides 9 SGPs and 4 mini percolation tanks are proposed. The item wise cost of CAT plan is presented in Table - 15.5.

15.53 The total cost of CAT plan works out to Rs. 427.96 lakh in which the cost of bunding (Rs. 154.80 lakh) will be borne by the beneficiaries only. The total cost is exclusive of compensatory afforestation.

Phasing

15.54 The implementation of CAT plan is phased over a period of three years and the physical and financial phasing is presented in Table - 15.6.

CONJUNCTIVE USE OS WATER

Hydrology: The area is covered by Granite gneiss, Schists and Quartzites of Archean age, Sandstone, Shale, Limestone of Gondwana age and Alluvium of recent age. The occurrence of groundwater is confined to weathered and fractured zones and at places in the contact zone and occur under confine to semi confined to weathered and fractured zones and at places in the contact zone nad occur under confine to semi confined conditions. Sandstone, Limestone and Alluvium constitute the main aquifers. The groundwater levels vary from 3.9m to 7.75m during pre monsoon and 2.9m to 4.65 m during post monsoon. Groundwater exploitation in and around the project area is found to be on a moderate scale and is mostly utilized for drinking, irrigaiton and industry. Cultivation is mainly through tank irrigaiton, dug wells and to a very negligible extent through Tube wells.

Groundwater Potential: The groundwater potential has been calculated based on water table fluctuation method and rainfall infiltration index. The total annual recharge is estimated at 43.49 MCM by water table fluctuation approach and 48.58 MCM by the rainfall ad hoc norms. The net annual utilizable recharge available for irrigaiton development is 36.97 MCM and gross draft is 7.98 MCM. Thus, the ground water balance comes to 2899 MCM after deducting potential draft of 7.98 MCM. Thus, any further transport of surface water through the network of canals in the command area will augment the groundwater resource by the rise in the water table.

Impact of Canal Irrigation: In the post construction stage of project the existing recharge is expected to increase by 30% raising it to 56.53 MCM after neglecting the increase in private use and proposed Government tube wells estimated at 19.98 MCM. This will leave a balance potential of 36.55 MCM. Thus, there will not be much change in balance potential even after neglecting the increase in private use. The quality of ground water will not be affected as the terrain has a good drainage and watertable is below 4m.

Conjunctive use: At present there are about 176 irrigaiton tube wells in the command area. Expecting this number to be doubled in the next 8-10 years groundwater can be aquifers that are available in the area. This model will help to quantify the peak requirements of water for each crop sets and safe withdrawal of groundwater from the basin for irrigaiton and thereafter balance requirement by means of surface water in each segment of the command area.

15.55 As above the balance ground water potential is 36.55 MCM. Conjunctive utilization of ground water along with surface water is proposed in the command area.

Advantages of Conjunctive Less of Water

a) Reduces or eliminates areas of continuos overdraft of ground water basin
b) Increases storage of ground water for water needs during peak periods and during drought years
c) Control and prevents deter mating ground water quality in localized areas of groundwater basin.
d) More intensity and effective case of ground water available to meet water demands (in conjunction with available surface supplies) at an overall cost likely to be lower than importing surface water.
e) Based on the available balance potential, about 6000 additional wells are feasible for the ID cropping pattern proposed in the CCA at a rate of 172 ha per Mcum (12 acres per Mcft). However at present 200 wells one proposed in the command area at a cost of Rs. 400 lakhs. Financial assistance necessary may be arrange to the farmers through institutions with subsidies is needed. Agricultural and state ground water boarders shall provide suitable assistance to the farmers.

Table - 15.5 : KELO PROJECT
COST ESTIMATES FOR CATCHMENT AREA TREATMENT

Sl.No	Recommended Treatment	Area to be treated (in ha or Nos.)	Cost per ha/ each in Rs.	Cost in Rs. lakhs (approx.)
I.	**Vegetative recommended treatment**			
a)	Afforestation and revegetation	1000	20000	200.00
b)	Graded bunds with vegetative barriers (10% of area of high prioritizing zone)	2064	7500	154.80
	Sub-Total			**354.80**
II.	Gully Control and Engineering treatment			
a)	Gully plugs - Rockfill dams	60	2000 / each	1.80
b)	Gully plugs - Sunken gully pits	9	4000/set	0.36
c)	Soil and water conservation - Checkdams	13	500000 / each	65.00
d)	Mini percolation tanks	4	150000	6.00
	Sub-Total			73.16
	Grand Total			**427.96**

Table - 15.6 : KELO PROJECT
PHASING OF PHYSICAL AND FINANCIAL TARGETS

Sl.No	Recommended Treatment	Physical in ha / Nos.			Unit Cost Rs./ ha / No.	Financial in Rs. lakhs			Total
		1st year	2nd year	3rd year		1st year	2nd year	3rd year	
I.	Vegetative recommended treatment								
a)	Afforestation and revegetation	500	500	500	20000	100.00	100.00	-	200.00
b)	Graded bunds with vegetative barriers	500	1000	564	7500	37.50	75.00	42.30	154.80
Sub-Total			-	-	-	137.50	175.00	42.30	354.80
II.	Gully control and Engineering treatment (in Number)								
a)	Gully plugs - Rockfill dams (Nos)	20	20	20	3000	0.60	0.60	0.60	1.80
b)	Gully plugs - Sunken gully pits (sets)	3	3	3	4000	0.12	0.12	0.12	70.36
c)	Soil and water conservation wave,Check dams	3	5	5	500000	15.00	25.00	25.00	65.00
d)	Water conservation - Mini percolation tanks (Nos)	1	1	2	150000	1.50	1.50	3.00	6.00
Sub-Total					-	17.22	27.22	28.72	73.16
Total Cost		-	-	-	-	154.72	202.22	71.02	427.96

Annexure - XV.1

NILWAI MEDIUM IRRIGATION PROJECT TECHNICAL DETAILS ROCK FILL DAM PROPOSED		
Sl.No.	**Description**	**Dimension adopted**
1	**Bottom width of gully (stream)**	**3.0 mt.**
2	**Side slopes**	**1 : 1**
3	**Top width of Rock Fill Dam**	**0.3 mt**
4	**Height Rock Fill Dam**	**0.6 mt**
5	**Dam side slopes**	**1 : 1**
6	**Dam width at bottom**	**0.30 + 2 x 0.6 = 1.50 mt**
7	**Keying into stream banks on both sides**	**0.30 mt**
8	**Length of downstream rough stone apron**	**1.0 mt**
9	**Specifications**	**Body wall and apron 225 mm thick with 225 mm stones**
10	**Earth work**	**In all soils with initial ledge 10 mts and initial length 2 mts.**
11	**Toe walls below R.F.D.**	**225 mm thick and 225 width.**

Annexure - XV-2

NILWAI MEDIUM IRRIGATION PROJECT TECHNICAL DETAILS OF SUNKEN GULLY PITS PROPOSED		
Sl.No.	**Description**	**Dimension adopted**
1	**Work involved**	**Earth work excavation. Rough stone revetments and bed pitching with 225 mm stones.**
2	**Quantity per one set of SGPs**	**Three pits and one silt trap**
3	**Length**	**4.0 mt**
4	**Width at bottom**	**0.60 mt**
5	**Depth**	**0.90 mt**
6	**Side slopes on all sides**	**1 : 1**
7	**To length**	**5.80 mt**
8	**To top width**	**2.40 mt**
9	**Length of silt trap**	**2.40 mt**
10	**Width of silt trap**	**0.60 mt**
11	**Depth of silt trap**	**0.30 mt**
12	**Side slops**	**1 : 1**
13	**Top width**	**1.20 mt**
14	**Length of SGP at bottom**	**4.0 mt to 8.0 mt can be adopted**
15	**Depth of SGP at bottom**	**0.90 mt to 1.50 mt can be adopted**

Annexure -X.3

NILWAI MEDIUM IRRIGATION PROJECT TECHNICAL DETAILS OF CHECK DAMS		
Sl.No.	**Description**	**Dimension adopted**
1	**Depth of the Gully**	**1.20 mt**
2	**Proposed length of the Check Dam**	**8.00 mt.**
3	**Height of the Check Dam**	**0.60 mt**
4	**Apron dimensions Length Width Depth**	**8.0 mt 0.90 mt 0.30 mt**
5	**Retaining wall Length Width Height**	**10.00 mt 0.60 mt 0.60 mt**
6	**Side revetment for both sides**	**Roughstone revetments 0.30 thick**
7	**Upstream side Length**	**0.67 mt**
8	**Downstream side Length**	**1.08 mt**
9	**Length of apron**	**1.50 mt**
10	**Core Wall Length Width Height**	**1.50 mt 0.50 mt 0.60 mt**

Annexure : XV.4

NILWAI MEDIUM IRRIGATION PROJECT TECHNICAL DETAILS OF MINI-PERCOLATION TANKS

Sl.No.	Description of Parameter	Dimension adopted
	Work involved	**Earth work excavation and formation of bank**
1	**Average length of mini-percolation tank**	**120 mts.**
2	**Top width of bank**	**2.0mt**
3	**Width at bottom**	**9.0 mt**
4	**Front side slopes**	**1 ½ :1**
5	**Rear side slopes**	**0.0840277778**

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume – I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART- IV
ENVIRONMENT MANAGEMENT PLAN

XVI

ENVIRONMENT MANAGEMENT PLAN

Introduction

16.01 The project involves construction of a medium size reservoir. There is going to be disturbance due to human activity during different stages. But the disturbances are limited mainly to the dam site which is not a home for any of the endangered or endemic species of plants or animals. There shall be no change in the land use pattern of the command area. As such the biological and ecological impacts of the project on the flora and fauna are temporary and are easily reversible with proper management plan. Only about 1320 Ha of open forest land is going to be submerged. A careful examination of the flora and fauna of the area of submergence is not different from other areas as there are no differences in climate, altitude, rainfall and soils. Compensatory afforestation is planned in 2650 Ha of land to compensate for the the loss due to submergence

.

16.02 Along the canal banks, locally adapted plant species are proposed to be planted. In addition to the trees listed below (Table 16.1), shade - tolerant perennial shrubs and soil binders will be planted. *Agave americana, Jatropha curcas, Dodonaea viscosa, Withania somnifera* and perennial grasses are propsed as soil binders.

Table - 16.1 : KELO PROJECT
LIST OF PLANTS IDENTIFIED FOR ROADSIDE PLANTATIONS AND SHELTER BELT.

Botanical name	Family	Importance
Acacia nilotica	Mimosaceae	The most preferred tree of the area
Acacia auriculiformis	Mimosaceae	Avenue tree
Ailanthus excelsa	Simaroubaceae	Tree borne oil
Albizia lebbeck	Mimosaceae	Shade, timber and scented flowers
Anacardium occidentale	Anacardiaceae	Cashew nut
Azadirachta indica	Meliaceae	Neem oil & neem products
Callistemon citrinus	Myrtaceae	Ornamental tree
Cassia fistula	Caesalpiniaceae	Ornamental and bark is a source of tannin
Casuarina equisetifolia *Delonix regia*	Casuarinaceae Caesalpiniaceae	Pulp and construction material Ornamental avenue tree
Eucalyptus spp.	Myrtaceae	Pulp and construction material
Ficus benghalensis	Moraceae	Shade and a source of food for birds
Ficus racemosa	Moraceae	Edible fruits
Ficus religiosa	Moraceae	Shade and a source of food for birds
Gmelina arborea	Verbanaceae	Timber
Grewilia robusta	Proteaceae	Avenue tree
Holoptelia integrifolia	Ulmaceae	Fibre and timber
Leucaena leucocephala	Mimosaceae	Fodder and pulp wood
Mangifera indica	Anacardiaceae	Edible fruit
Michelia champaca	Magnoliaceae	Scented flowers
Mimosops elengi	Sapotaceae	Shade and edible fruit
Peltophorum pterocarpum	Caesalpinaceae	Evergreen shade tree
Pongamia pinnata	Papilionaceae	Source of biodiesel
Polyalthia pendula	Annonaceae	Majestic tree with drooping branches
Polyalthia longifolia	Annonaceae	Avenue tree
Samania saman	Mimosaceae	Shade, timber and fruits are a good live stock feed.
Sapindus emarginatus	Sapindaceae	Soap nut tree
Shorea robusta	Dipterocarpaceae	Timber
Spathodea companulata	Bignoniaceae	Ornamental avenue tree
Syzygium cumini	Myrtaceae	Edible fruits
Tabernaemontana divaricata	Apocynaceae	Ornamental bush
Tamarindus indica	Caesalpiniaceae	Tamarind fruit and leaf
Tectona grandis	Verbanaceae	Timber
Terminalia arjuna	Combretaceae	Timber and shade tree
Terminalia catappa	Combretaceae	Edible nuts
Ziziphus rugosa	Rhamnaceae	Edible fruits

16.03 Planting stocks are readily available from the Social Forest Department as well as from the local private nurseries. All plants are locally adapted and the canal banks can support their growth with suitable horticultural practices. Sufficient resources and man power for development and maintenance of the canal bank plantations are provided in the plan.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO MAJOR IRRIGATION PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XVII

COMMAND AREA DEVELOPMENT PLAN

Introduction

17.01 The proposed Command Area of Kelo Project constitutes raifed lands of Raigarh District and small area in Janjgir. Champa District. The proposed Irrigation scheme is spread over 175 villages, in 3 blocks covering an area of 22,800 hectares. This includes crop diversification towards commercial and I.D crops in place of existing uncertain paddy and other crops entirely depending upon the rainfall. The blocks and villages under the proposed command of the project are given in Annexure - XVII.1. The population of this area is mostly tribal agricultural labour, small and marginal farmers and few agriculturists. There is an enormous irrigation potential in the Mahanadi main basin which is running towards south of the command area. The command area is bounded by dam and hilly region on North, Kelo river on the East, and Mand river on the west and Mahanadi on the south. Command area of the project is proposed only on the right flank of Kelo river.

Details of the Scheme

17.02 The sequence of transportation of water in the system from the river Kelo to the main canal is discussed below in brief:

17.03 The full reservoir level will be kept at +233.00m, while the lowest sill level proposed is +227.00m. the gross storage of the reservoir proposed is 60.785 M.cum allowing a dead storage of 14.178 M.cum. Thus the live storage proposed for utilization towards Irrigation, Drinking water to Raigarh township and Industries will be 160.60 M.cum of which quantity of 133.32 M.cum is set apart for irrigation.

17.04 The water will be delivered into the main canal starting from the right flank of the dam and run for a length of 28.80 km. The main canal is divided into two arms. The main canal traverses south west and the other arm called as Jharmuda branch canal towards south for a length of 16.09 km. The canals

are supported by vast canal network system to feed the entire CCA of 22,800 ha. The main canal traverses as a contour canal till it branches off into main canal and Jharmada branch canal. The length of canal system excluding main canal is about 305 km serving the entire command area.

Command Area Development

17.05 The different stages of transportation of water have been discussed in the earlier paragraph. Based on these aspects the command area development in the project is planned and the same is highlighted in the subsequent paragraphs.

17.06 The usage of water and its retention in soil depends on the properties of soil and plant that affect its movement and very much attribute to soil-plant - water relationship. Soil provides the room for water to be used by plants through the roots present in the same medium and water which is the carrier of large amount of nutrients is required in a large measure for the successful growth of crops. Application of additional water to soil, for plant use, becomes essential due to inadequate and uneven distribution of rainfall, especially during the growth period of the crop.

17.07 Needless to state that the irrigation is one of the most important factors for assured crop production. It helps and permits better utilisation of all other production The command area development therefore, plays an important role in a comprehensive irrigation development programme. The important aspects, therefore are as follows:

- Integrated development of water resources.
- Judicious method of water application.
- Proper soil and crop management practice and
- Scientific scheduling of irrigation according to developmental system of the plan.

17.08 As such, efficient water management requires a thorough study of plant - water relationships, climate, agronomic practices and economic assessment besides the physicochemical properties of "soils" occurring in the area.

Objectives of the Command Area Development

17.09 Command area treatment is aimed at development of an effective irrigation system which will ensure controlled and uniform application of water to crop lands in required time with minimum cost to produce optimum yields without waste of water and without any adverse affect on soil in the form of soil salinity and water logging problems.

Slope Classification

17.10 The slope in the Command area is mostly nearly level, covering about 97.60 percent with slope ranging from 0 - 1 percent. In the slope range of 1-3 percent, category, i.e., very gentle to gentle slope covers about 1.30 percent of the total command area. About 1.10 percent falls under the category of moderate slope in the range upto 5 percent. No steep slope category is existing in the command area. The details of slope categorization is presented in Table - 17.1. Map showing the slope categorization is at Fig XVII.1.

Table - 17.1 : KELO PROJECT
SLOPE CLASSIFICATION IN THE GROSS COMMAND AREA

Sl.no	Slope (%)	Slope Category	Area (ha)	Percent of total area
1	0 - 1	Nearly level	42837	97.60
2	1 - 3	Very Gentle slope	574	1.30
3	3 - 5	Sloping gently	13	0.03
4	5 - 10	Slope Moderately Steep	462	-
5	10 - 15	steep	-	1.07
		Total	43886	100.00

Land use / Land Cover in the Command Area

17.11 Detailed analysis relating to the land use / land cover has been generated based on Remote sensing satellite data processing and GIS applications. The details are shown in Table - 17.2 Map showing the land use / land cover in the command area is at Fig XVIII.2.

Table - 17.2 : KELO PROJECT
LAND USE/LAND COVER IN THE COMMAND AREA

Sl.no	Classification	Area	Percent
1	Built up land	2425	4.96
2	Cropped land	42837	87.61
3	Degraded Forests	476	0.97
4	Land with scrubs	112	0.23
7	Rivers / streams / Tanks	3047	6.23
	Total	**48897**	**100.00**

Soils

17.12 The soils in the command area are generally alluvium and clay. On the basis of texture of top soil, the soils in the command area are classified as below :

i) Sandy loam ; (ii) Silty loam; (iii) Loam ; (iv) Clay loam; and (v) Gravelly soils.

Soil Erosion

17.13 The general topography of the command area is broadly plain. Since the soils are having fairly sufficient soil cover, the erosion could be controlled by adopting suitable conservation measures like leveling and bunding. This is necessary in case of irrigated dry crops. The land development or land shaping involves smoothening, grading, forming earth bunds and land leveling.

17.14 The total proposed command area is 22800 ha out of which in about H atank / rainfed / wet

crop area exists. Area of ha is already under rainfed dry crops. Out of this area atleast of the area needs hardly any measures while the remaining of the area only needs development to some extent.

Land shaping, land smoothening, Land Grading, Earth bunds and Land Levelling

17.15 The land shaping / levelling largely depends upon the method of irrigation used. The irrigation methods depend on the types of lands and crops. Any method adopted for irrigation must ensure uniform distribution of water in the crop root zone and high water application efficiency. land levelling should be done as far as possible concurrently with field channels and drains so that efficient water management practices are introduced at the outlet from the beginning. Before undertaking grading or levelling of the lands, the depth of soil infiltration rate slope of land and erosion characteristics of soils should be thoroughly examined.

17.16 The land after development should be able to carry run-off due to rainfall, and irrigation water without causing erosion of the soil.

17.17 The earth movement needed for land grading/levelling should be kept minimum and the depth of cut should be such that the soil cover of the developed land will be sufficient to support the root zone for the crops proposed to be grown. Also it should not be excessive (more than 30 cms) since, the land would require a long period to build up to its normal level of productivity. Earthwork can be substantially reduced if the plots are demarcated between contours, by aligning the graded bunds parallel or little inclined to the contours, and width of plots are reduced especially in steep sloping areas.

17.18 In the top portion of the developed land, the removal of top soil would cause reduction in crop yield because the sub-soil contains fewer nutrients than the top soil. If the cut areas are ploughed deep before grading, and the filled areas after grading, top soils can be retained to a great extent.

17.19 In shallow soils where the initial cover of the soil is not greater than 22 cm, land smoothening and promotion of ridges and furrows for irrigation will be the main items of the farm development after water courses and field drains are provided . Development of shallow lands with steep slopes is difficult since deep cut could substantially reduce soil cover after farm development and render it too shallow to support production of any crop. Ridge and furrow method of irrigation with ridges and deep furrows (the width of ridges and depth of furrows depending upon soil properties) provide a workable solution for development of such lands for growing row crops. However in the case of Kelo Project, the top soils are available with adequate depths of cover.

17.20 When the land are sufficiently flat (less than 0.6%) they need not be levelled. What is needed is, only planning of the land surface without changing the general topography. Small irregularities in the land surface should be removed so that the finished surface from the water channel to the drain has one uniform grade. About ---- of the land falls under this category.

17.21 Cross slope (slope of the land at right angles to the direction of irrigation) should be very nearly flat. To reduce earth work and depth of cut, the bunds should be spaced closer for lands with steeper slopes. The elevation difference in the width of one strip of land (Cross-wise between the bunds) for border strip irrigation should be not more than 3 cm. For ridge and furrow irrigation, the cross-slope could be steeper but not greater than 2%. For basin irrigation, the lands should be flat.

17.22 Normally bunds spaced at 15 m. spacing for lands with initial slopes (before land development) between 2 - 3% and 30 m for lands flatter than 0.6% are found suitable both from the point of view of reduction of earth work and movement of farm machinery. For fully mechanized farming width of strips should be minimum 15m.

17.23 The maximum longitudinal slope of land after development should not exceed 0.6% . The maximum length of land strip is governed by the grade, erosion characteristics of the soil and the infiltration rate.

Procedure for on - farm development

17.24 For development of command area under a bore well, irrigation tank or project, a scaled cadastral plan of the command area shall be prepared by land survey with land marks and field boundaries of each farmer. Then topographical survey is done and contours with one foot or 0.30 metre interval are drawn to know the relief of land. Usually a scale 1:10,000 is adopted. Based on the topography of the command area, the irrigation channels aligned with drop structures to maintain the grade of channel bed and distribution boxes are provided at junctions so that every plot is connected by irrigation and drainage channels. The width and the length of plots depend on type of soil, land slope and crops to be raised. The recommended specification for the width and lengths of plots for different land slopes and different land slopes and different soil types are given hereunder for border strip and furrow irrigation (Table - 17.3).

Table - 17.3 : KELO PROJECT
SPECIFICATIONS FOR LENGTH OF PLOTS

Sl. No	Soil Type	Rate of infiltration		Gradient (%)	Length of the Plot	
		in inches	in centimeters		In feet	In meters
1	Clay	0.2/ha	0.508/ha	0.1	500-700	150-210
2	Clay loam	0.5/ha	1.270/ha	0.15	450-600	135-180
3	Silt loam	1.0/ha	2.540/ha	0.20	400-500	120-150
4	Silt	1.5/ha	3.810/ha	0.25	300-450	90-135
5	Sandy loam	3.3/ha	7.620/ha	0.30	200-300	60-90
6	Sandy/gravelly	5/ha	12.70/ha	0.50	200	60

17.25 Width of the plot (strip) depends upon the slope of land. The width of the plot found suitable for different land slopes is as follows: (Table - 17.4)

Table - 17.4 : KELO PROJECT
WIDTH OF PLOTS

Percentage of land slope	Suitable width of plot	Percentage of land slope	Suitable width of plot
0-1	30 mt	2-3	15 mt
1-2	20 mt	Above 3	10 mt

17.26 A bund of 0.18 sq.mt cross sectional area shall be provided across the slope of the land with the suitable gradient to form the plots of recommended width. Specifications for bund, field channel, etc. are given below:

Specifications

1. Bund

Top width	0.20 m
Height/Depth	0.30 m
Bottom width	1.00 m
Section	0.18 sq.m
Average length / hectare	500 m
When formed with 20 m spacing Earth work	90 m^3
Rate per 10 cubic meters	Rs. 400/-
Cost of bund formation	Rs. 3600 per hectare.

II Field Channel

Top width	0.90 m
Height/Depth	0.30 m
Bottom width	0.30 m
Section	0.18 sq.m
Average length / hectare	25 m
Earth work	4.5 m^3
Rate per 10 cubic meters	Rs. 400/-
Cost of field channel excavation	Rs. 180 per hectare

III Irrigation channel (Sub field channel)

Top width	0.45 m
Height/Depth (0.15 m below ground level)	0.30 m
Bottom width	0.15 m
Section	0.09 sq.m
Average length / hectare	50 m
Earth work	4.5 m^3
Rate per 10 cubic meters	Rs. 400/-
Cost of irrigation channel	Rs. 180 per hectare

IV Drainage channel

Top width	0.90 m
Height/Depth	0.40 m
Bottom width	0.30 m
Section	0.24sq.m
Average length / hectare	50 m

Earth work $12\ m^3$

Rate per 10 cubic meters Rs. 400/-

Cost of drainage channel Rs. 480 per hectare

17.27 An approximate estimate for on-farm Development for irrigated crops is presented in Table - 17.5.

Table - 17.5 :KELO PROJECT
ESTIMATE FOR ON-FARM DEVELOPMENT FOR IRRIGATED CROPS

Sl.no	Details of work	Approximate Amour Rs/Ha
1	Topographical and cadastral survey mapping and plotting	1000
2	Soil survey, collection of soil samples from different depths for physical and chemical analysis of soil @ 10 samples per hectare and Rs. 1000/- per sample	10000
3	Layout of farm roads and path	1500
4	Earth work (cut and fill) for plot leveling / grading	1500
5	Formation of 0.18 sq.mt section bund with 20 m spacing. Average bund length/ha 500 m x 0.18 = $90m^3$@ Rs. 40 per cubic meter	3600
6	Formation of field channel 0.18 m^2section from pipe outlet to farmers fields about 50% bund length 25m per ha	180
7	Irrigation channel for 0.09 m^2 section connecting every field of the command area. About 10% of bund length, i.e 50m/ha	180
8	Formation of drainage channel of 0.24 m^2 section average length per hectare about 10% of bund length - 50 m	480
9	Distribution boxes at 1/4 no per hectare	760
10	Drop structure FC/IC,s	500
11	Crossing for irrigation channel @ ½ No/per ha	350
12	Crossing for drainage channel @ ½ No/ha	350
13	Crossing for drainage channels at out lets	600
	Total	**21,000**

Water Logging and Water Logged areas

17.28 Surface and ground waters belong to the same hydrological circle and are interdependent. In any area or region, where both surface and ground waters are present usually irrigation is based on the use of former or both the sources. However, in most cases it is done without proper planing for co-ordinated development and optimum benefits. When due consideration is not given for a balanced and harmonized development of the two sources, the environment gets affected and problems such as water logging and salinity in certain areas prevail.

17.29 Under the Kelo Irrigation Project , water table fluctuations range between 2.25 to 5.73 mbgl in the post-monsoon period during the years 2001 to 2007 in the observation wells monitored by the State Ground Water Department. The water table fluctuations during pre-monsoon period in the years from

2001 to 2007 is observed to be ranging between 3.2 and 14.25 mbgl. This rise in water table is attributed to the rainfall precipitation and the runoff in the river there after. Even though predicting 30 percent rise in the water table levels after the project, the water table levels may rise up to 1.60 to 4.00 mbgl in the post monsoon period. Thus no water logging in the command area is predicted. Thus the blocks of the command area offer a good scope for development of ground water. It is therefore, suggested that conjunctive use of water as also necessary drainage system should be developed to arrive at savings of water utilization.

Drainage

17.30 The removal of excess water (free or gravitational / standing or stagnant water) from surface or below surface of the soil so as to create favourable soil conditions for plant growth, is termed as soil drainage. Th excess water leads to water logging and salt imbalance; thus endearing the land to less productive and problematic.

17.31 Since most of the area under Kelo Irrigation Project is level to gently sloping the flow of water may not be that rapid under sub-soil conditions. With stabilisation of irrigation and assured water supply, the sub-soil drainage conditions will have to be improved. Thus the conditions warrant provision of drainage system to mitigate ill-effects of poor drainage, which are narrated below.

III Effects of Poor Drainage

a) Lack of air space in the soil for proper root growth where in availability of oxygen is limited.

b) Some of the toxic substances are produced including H_2S, boric acid in the presence of which even paddy crop is affected. This injury is similar to sulphide injury.

c) Natural vegetation like plantations and orchards will be affected due to poor drainage.

d) Standing water for a long period will give rise to many soil health problems.

e) Fertilizers applied will percolate to lower zone or lost due to faster identification

Factors responsible for poor drainage

17.32 The factors responsible for poor drainage are enumerated in the following paragraphs.

a) Soil Type : In clayey and heavy soil the infiltration capacity is low and prone to water logged conditions and needs drainage. The blocks coming under the command of Kelo Irrigation Project negligible area under black cotton soil and heavy soils.

b) Slope : In area with in adequate slope and flat areas, the movement of water is slow and results in poor drainage . The command area of the Kelo Irrigation Project is mostly of level to moderate slopes and warrant proper drainage in selected areas.

c) High Rainfall : The excess rainfall received in the absence of proper drains will create water logging. Raigarh district falls under high rainfall zone limit with normal rainfall of about 1370mm. Benefitting blocks are in the upland area Therefore, problems of water logging due to rainfall are not anticipated.

d) High ground water Table : In the absence of drains where ground water table is high due to lack of sub-soil drainage, water logged conditions are created. Under the Kelo Irrigation Project, such conditions are not anticipated since the ground water table will be sufficiently higher than the limits even after the project, as already discussed before.

Advantage of drainage

17.33 Suitable drainage system has to be provided in the vulnerable areas under the Kelo Irrigation Project in both the wet crop areas and areas localized for ID crops. The advantages of proper drainage are as follows.

- Drainage makes the command more productive
- Proper drainage makes the entire field more uniform in no soil moisture (elimination of wet patches) and results in more effective tillage and harvesting.
- Removal of surplus water from the field increases aerobic microbial activity by permitting air to replace water in more soil prone space. As a result, the bio- micro-organisms will increase which will decompose more organic matter and thus more potential plant nutrients are made available.
- Proper drainage decreases potential losses of nitrogen.
- Drainage reduces the building up on toxic substances in soil.
- Wider varieties of crops and more valuable crops can be raised in well drained soils.
- Drainage permits deeper penetration by plant roots thereby increasing the availability of nutrients to growing plants resulting in higher crop yields. Deep roots make the plant more resistant.

Provision of Drainage in the Command
Surface drainage

17.34 Surface drainage is the removal of excess water due to rainfall or seepage for irrigation from the surface of lands. Both areas localized for wet and ID, crops need surface drainage system. For designing surface drainage system the following factors are to be considered:

- Intensity of rainfall 1 day, 2 day, 3 day rainfall with certain frequencies (5 years, 10 years)
- Infiltration rate of soil
- Evaporation rate
- Crops grown during rainy season or at times of heavy rainfall
- Landscape
- Gradient that can be given to the drainage channels
- Outfall conditions

Main Drains

17.35 In the Kelo Irrigation Project command there are several natural drains existing as major gullies. The velocity of flow is moderate and time taken to drain the water to out falls is short. Hence in the command, there seems to ne no need to strengthen these drains. Surface drainage map of command

area is shown as Fig. XVII.3.

Field Drains

17.36 All field drains will drain into subsidiary drains to be constructed at right angles to natural drains. The size of these drains should be sufficient to take the excess water of the field drains dropped into it. The field boundaries can be made use of in digging these subsidiary drains. The position of filed drains was already discussed earlier.

17.37 These drains are to be constructed by the individual farmers with proper size so that the excess water from their fields are drained into intermediate drains. Field drains or ditches should be at least 30 cm deep with slide slopes tanging between 4:1 and 8:1. These should be constructed considering the low spots which collect water from adjoining higher areas. Ditches should be as straight as possible. The cross-section of the field drain should be trapezoidal shape. The approximate cost of field drains of about 4500 ha (20% of the proposed area)which have to be met by the farmers will be about Rs. 1368 lakhs.

Salinity

17.38 The possibility of development of salinity arises only when water is allowed to stagnate in the soils which are generally poorly drained deep clays. The area of saline or problematic soils have not been identified in the project area.

Soil Fertility Status

17.39 The soil fertility status has been discussed earlier. It is observed from the available data that soils are low to medium in Nitrogen % and P_2O_5 (kg/ha) while in case of K_2O(kg/ha) are medium to high. The fertility level of soils in respect of nitrogen and phosphorous has to be improved by adequate application of fertilisers as well as organic manure after soil test. The regular extension staff of the Agriculture Department generally cater the needs of the farmer. Crop loans are distributed which covers the cost of fertilizers. Keeping in view the above measures, no provisions for this purpose have been made.

Cropping Pattern

17.40 One of the main objectives of the study of soils, rainfall pattern and irrigation aspects is, to suggest a suitable cropping pattern for the proposed command area.

17.41 It is generally suggested that crop rotation on irrigated soils must be based on a long term plan which should be based on the following information:

- The characteristics of the soils of the area;
- The quality and supply of the irrigation water (also climatic conditions including rainfall);
- The Characteristics of the crops to be grown;
- The need for flexibility in the crop rotation programmes;
- Provision for fertility maintenance weed control and Integrated Pest Management; and
- The distribution of economic returns so that farm income can be in maintained at about the same level through out the rotation period .

Existing Cropping pattern

17.42 The entire command is presently under cultivation and the existing cropping pattern in the command area is as follows:

Sl.no	Name of the Crop	Area in ha
1	Paddy	5000 ha
2	ID Crops	17800 ha

17.43 Based on the factors highlighted abo ve and taking into consideration the existing cropping pattern, discussions with the beneficiaries in the command area and the Agriculture Department, Government of Chattisgarh, cropping pattern is suggested duly adopting crop diversification.

Sl.no	Name of the Crop	Area in ha
1	ID Crops	22800 ha

Proposed outlay for Command Area Development

17.44 The total cost of Command Area Development programme is estimated at amount Rs. 5310 Lakh (Table - 17.6)

Table - 17.6 : KELO PROJECT
TOTAL COST OF COMMAND AREA DEVELOPMENT PLAN

Sl.no	Particulars	Rs in lakhs
1	Systematic land development (beneficiary effort) (17800 ha)	908
2	Internal Field Channels (beneficiary effort)	242
3	Field Channel (17800 ha)	2392
4	Drainage (4500 ha)	1368
5	Conjunctive use of ground water (2000 wells)	400
Total		**5310**

Phasing of the Command Area Development

17.45 The Kelo Irrigation Project is proposed to be completed in about two and half years . Therefore, the Command Area Development is phased in 2 ½ years as per details given in Table - 17.7.

Table - 17.7 : KELO PROJECT : YEAR WISE PHASING
OF FINANCIAL COST FOR COMMAND AREA DEVELOPMENT

Sl.no	Particulars	Cost			
		1st Year	2nd Year	3rd year (6 months)	Total
1	Systematic land development	300	400	208	908

2	Internal field channels	60	100	82	242
3	Field channels	800	1000	592	2392
4	Drainage	200	800	368	1368
5	Conjunctive use of ground water	150	150	100	400
	Total	**1510**	**2450**	**1350**	**5310**

Soils in the Command Area

Topography

17.46 In general, the command area of Kelo Project is broad plain, upper pediments being sloping. However in depressions, steep slope and undulations are not met with. The area to the right of Kelo river is levelled plain comprising of deep clayey soils.

17.47 As per the soil map of India, soils of Raigarh district have been grouped under red and yellow soil groups. The soils in the command area are found to be very deep clayey to silty occurring on level to very gently sloping, mid land, moderately well drained , moderately slow permeable, calcareous to non calcareous. The top soil exist is generally deep.

Soil Texture

17.48 Classification of the area on the basis of texture of top soil is shown in Table 17.8

Table - 17.8 : KELO PROJECT : CLASSIFICATION

Sl.no	Classification	percentage Area	Area Surveyed (thousand hectares)
1	Sandy Loam	15.38	8.29
2	Silty Loam	53.85	29.01
3	Loam	23.08	12.43
4	Clay Loam	7.69	4.14
	Total	**100.00**	**53.87**

17.49 It is seen that about 54 percent of the area is predominantly silty loams. Only about 15 per cent of soils is of sandy loam. The percentage of clay in soil generally ranges between 5 to 37 but does not exceed 38 per cent.

Total Soluble Salts

17.50 The entire area is having profile with total soluble salts upto 0.2 percent only. Thus the soils in the command area can be taken as free from excessive slats.

PH Value of soils

17.51 All the samples were tested for their PH values. The classification of the area on the basis of PH of the top soil is indicated in the Table below Table 17.9)

Table - 17.9 : KELO PROJECT : PH VALUE OF SOILS				
Sl.no	Classificaiton	No.of sites	Percentage Area	Area in thousand hectares
1	PH below 7.0	4	30.85	16.58
2	PH between 7.0 & 7.5	6	46.10	24.86
3	PH above 7.5 and below 8.0	3	23.05	12.43
		Total	**100.00**	**53.87**

17.52 Only about 30.86 percent area has soils with PH below 7.0 and no part of the area has PH above 8.0. The surface more or less normal range of PH value coupled with its low soluble content generally good rainfall imply that neither alkalinity nor salinity occur in the area due to induced irrigation.

Calcium Carbonate Content

17.53 The classification based on results of the top soil samples at 13 sites for calcium carbonate content are furnished in Table - 17.10.

Table - 17.10 : KELO PROJECT CALCIUM CARBONATE CONTENT				
Sl.no	Classification	no. of sites	Percentage Area	Area in thousand Hectares
1	$CaC0_3$ below 1 % (0-1)	8	61.54	33.15
2	$CaC0_3$ below 2 % (1-2)	5	38.46	20.72
3	$CaC0_3$ below 3 % (2-3)	Nil	Nil	Nil
	Total	**13**	**100**	**53.87**

17.54 The soils are having calcium car bonate content less than 5 per cent. No harmful effect on crop growth on account of calcium carbonate is expected. On the other hand its presence in soil ensures better tilth, efficient drainage and deterrent to alkalisation of soil setting in.

Soil Erosion

17.55 Soil erosion is removal of fine soil particles from the land surface by wind or air. Since the command area is located in the humid to semihumid region, there is least chance for the wind erosion. The erosion phase of the command area was normed by the actual extent of the hazards. The observations taken in respect of soil erosion is presented in Table - 17.11.

Table - 17.11 : KELO PROJECT TABLE SHOWING THE DIFFERENT EROSION CLASSES				
Sl.no	Erosion Class	Description	Area in ha.	Percentage of the surveyed area
1	e1	Non to slight erosion	3021	10.78

2	e2	Moderate erosion	21850	77.98
3	e3	Severe erosion	3150	11.24
	Total		**28.021.00**	**100.00**

17.56 The above table reveals that only 3021 hact, i.e., 10.78 percent of the surveyed area, is free from erosion. The maximum area of the command faces moderate soil erosion hazard which is 21850 ha. i.e. 77.98% of the total surveyed area. Such area needs careful cultivation to minimise the risk of soil erosion. The area under severe erosion class is 3150 ha. 11.24 percent of total surveyed area require soil conservation measure to minimize the soil erosion.

Soil Depth

17.57 The soil depth of the command area was noted by the excavation of the soil profiles which were dug upto the lithic or paralytic contact or water level which even met earlier since the texture of the command area is light to medium. The area under different soil depth classes is presented below in Table - 17.12.

Table - 17.12 : KELO PROJECT
TABLE SHOWING THE AREA UNDER DIFFERENT SOIL DEPTH CLASS

Sl.no	Depth Class	Depth in cms	Description	Area in ha	Percentage of surveyed area
1	d_3	22.5 to 45.00	Moderately deep	3150.00	11.24
2	d_4	45.00 to 90.00	Deep	11340.00	40.47
3	d_5	above 90 cm.	Vert deep	13531.00	48.29
	Total			**28021.00**	**100.00**

17.58 It is obvious from the above Table -17.12 , that 24871.00 Ha of the command area is under deep to very deep soil depth class which are suitable for the cultivation of most of the crops is suitable agroclimatic condition, and only 3150.00 ha i.e. 11.24 percent of the surveyed area is having moderately deep soils which can be considered marginal for irrigation.

Texture

17.59 The different proportion of sand, silt and clay are grouped into different textual classes. In this way there are twelve soil textual classes based on the percentage present in the soil samples, where minor ingradients were collected during the soil sum of the command area.

17.60 In the command area of Kelo Project the following textual classes are found during the survey. Clay, clay loam, sandy clay loam silt loam and gravelly sand loam. The soil texture is responsible for available water holding capacity of the soil. Good soil texture creates congrinal condition for the root development of the plants. Broadly, texture classes are grouped into three categories first being the coarse texture group which includes sand, loamy sand and sandy loam texture the second is loam group which is medium and moderately fine texture group which includes loam, silt loam, silt, including sandy clay loam, loam-clay, loam silt, clay and the third group is clay which include sandy clay silty clay and

clay.

17.61 The soil having high clay texture content are high in available water holding capacity which is suitable for the crop growth but these soils are difficult for tillage operation especially when they are wet. These soils are liable to create impeded drainage condition if the slope is nearly levelled. The course textured soils, though very easy for tillage operation, they are not much suitable for the crop production due to their poor available water holding capacity. Moreover, due to low clay content these soils have lesser binding power hence are liable for both water and wind erosion. The medium and moderately fine textured soils are found to be the best for crop cultivation due to the their moderate high water holding capacity along with the ease for drainage. The different textual classes of the Kelo command area are presented in Table -17.13

Table - 17.13 : KELO PROJECT
TABLE SHOWING THE AREA UNDER DIFFERENT TEXTURAL CLASSES

Sl.no	Textural class	Mineralogical Composition			Area in ha.	Percentage of the surveyed area
		Sand	Silt	Clay		
1	Clay	40	40	40	960.00	3.43
2	Clayloam	20-45	20	27-40	2061.00	7.36
3	Candy clay loam	20	-	27-40	16780.00	59.88
4	Silt loam	52	-	20	5070.00	18.09
5	Gravelly sandy loam	-	-	-	3150.00	11.24
	Total				**28021.00**	**100.00**

17.62 It is obvious from the above table that the maximum area of the project is having sandy clay loam texture which is 59.88 percent (i.e. 16780.00 ha.) Followed by silt loam texture covering 18.09 percent (i.e. 5070.00 ha) of the command area.

17.63 It is further clear from the above table that moderately coarse texture i.e. sandy loam covers on area of 11.24 percent (i.e. 3150.00 ha.), while fine and moderately fine texture d i.e. clay and clay loam covers 3.43 and 7.86 percent i.e. 960.00 and 2061.00 ha of the command area. Unfavourable textural class may be brought under reduced limit risk (Hazards) by application of organic matter in the soil.

Permeability

17.64 The rate of infiltration observed is low to moderate in unpuddled condition in majority of the area. Under puddle condition infiltration rate goes down to very low to low which is very much suitable for paddy cultivation. To maintain the submergence of water in the paddy field the puddling is an essential operation for reducing the rate of infiltration. The low rate of infiltration is probably in silty loam texture which may be due to the semi hard lateritic structure due to the semi hard lateritic strata present below the solum.

17.65 The results of permeability tests are presented below in Table - 17.14.

Table - 17.14 : KELO PROJECT
PERMEABILITY IN THE SOILS OF THE COMMAND AREA

Sl. no	Name of Village	Soil Unit	Texture	Depth in cm	Permeability rate cm/hrs	Class	Remarks
1	Odekera	Sc1-d5	Sc1	0.75	3.0	Moderate	
		B-e2	Sc1	75-150	4.5	Moderate	
			Sc1	150-225	4.5	Moderate	
			1Sc1	225-300	6.0	Moderately rapid	

17.66 The above table reveals that the rate of permeability in upper three layers is moderate and it is moderately rapid in lower most horizon. The rate of permeability may be reduced by puddling for paddy cultivation but for rabi cultivation such rate of permeability will definitely decrease the interval between two irrigations and ultimately

increase in number of total irrigation required for a particular crop because of the reason that puddling is not done in rabi crops.

Classification of the Command Area

(i) Land Capability Classification

17.67 Land capability classification is interpretative grouping of soils mainly based on the following factors.

1. Soil characteristics

1. External land features

1. Environmental factors that limit the use of land for agricultural purpose.

The land capability class have one or more of the following limitations.

I.e - erosion and run off

II.w - Overflow, water logging condition

II.s - Root zone limitation cither due to shallow soil depth or heavy texture.

Iv - Unfavourable climate

17.68 The above limitations are written suffix to land capability classes. When the limitations are more than one, they are written in sequence of degree of limitation.

17.69 Based on the above criteria the command area of Kelo project has been classified into land capability class II and III The area occupied by each class and sub-class is presented as below in Table 17- 15.

Table - 17.15 : KELO PROJECT
TABLE SHOWING THE AREA OCCUPIED BY DIFFERENT LAND CAPABILITY C LASSES AND SUB -C LASSES

Sl.no	Land Capability	Class & Sub-Class	Area in Ha. the	Percentage of Surveyed area
1	II	IIc	2061.0000	7.36
		IIs	960.000	3.43
		IIe	10510.000	37.50
		IIse	11340.000	40.17

	Total Class - II		24871.000	88.76
	III	IIIse	3150.000	11.24
	Grand Total		28021.000	100.00

(1) **Land Capability Class - II** : These are good soil occurring on nearly levelled to very gentle sloping land with fine to moderately fine texture. In this class the risk of erosion is non to slight. This class includes deep to very deep soils. This class covers an area of 24871.000 Ha. i.e. 88.76 percent of the surveyed area.

(1) **Land Capability Class - III :** These are fairly good soils occurring in gently sloping land with moderately coarse texture. This class includes moderately deep soil and liable to severe erosion. This class covers an area of 11.24 percent i.e. 3150.000 Ha of the surveyed area.

17.70 On the basis of kind and degree of limitations the land capability classes were further divided in the sub-classes.

Soil Irrigability Classification

17.71 Soil irrigation classes are class of the soils according to their suitability for sustained use under irrigation. In establishing soil Irrigability classes, soil and land characteristics are required to be studied and their behaviours should be predicted under altered water regime.

17.72 The criteria for classifying the Irrigability classes are (1) Effective soil depth (2)texture up to 30 cm. depth. (3) Available water holding capacity (4) Soil permeability (5) erosion and (6) drainage

17.73 A ccordingly, the soils of Kelo Project have been grouped under A,B, and C soil Irrigability classes. The extent of area occupied by different classes is presented in Table 17.16 .

Table - 17.16 : KELO PROJECT
SOIL IRRIGABILITY CLASSES

Sl.no	Soils Class	Area in Ha	Percentage
1	A	12571.000	44.86
2	B	12300.000	43.90
3	C	3150.000	11.24
	Total	**28021.000**	**100.00**

Class - A : These are very good soils for irrigaiton and they pose non of the limitations under sustained use for crop production. This class covers an area of 12571.000 Ha. i.e. 44.86 percent of the surveyed area.

Class - B : These are fairly good soils and they face slight limitation of heavy texture and soil depth. The class covers an area of 12300.000 Ha. i.e. 43.90 percent of the total surveyed area.

Class - C : These are moderately good soils having coarse texture, moderate depth, gentle slope and severe erosion. These are least suited soils in the command. However these soils can be managed for

irrigated crop cultivation under special precaution. This class covers an area of 3150.000 Ha. i.e. 11.24 percent of the surveyed area.

Land Irrigability Classification

17.74 Land Irrigability classification is an advance grouping of land for irrigaiton. While classifying the land Irrigability the following factors are taken into consideration.

1. Quality & Quantity of irrigation water
2. Slope
3. Surface grading
4. Internal and External drainage
5. Depth of water table

17.75 In addition to the above factors the economic aspects like production cost and yield potentials land development cost and other factors effecting benefit cost ratio are also taken into consideration. The land development is essential for sustained use under irrigaiton for better yield of crops. On the basis of above criteria the land of Kelo Project has been classified into land Irrigability class II and III. The land Irrigability class have been further sub divided into three sub-classes according to the limitations which is a grouping of land - Irrigability units that have the same kinds of dominant limitations for sustained use under irrigation. The land which are placed in any class lower than I, the limitation have been indicated by appending the letter "s" "t" or "d" to class number to show the deficiency in 'soil' topography or drainage. Lands with more than one major deficiency have been indicated with the relevant letter after the class. The area occupied by different classes and sub-classes are presented in Table -17.17.

Table - 17.17 : KELO PROJECT
TABLE SHOWING THE AREA UNDER DIFFERENT LAND IRRIGABILITY CLASSES & SUB-CLASSES

Class	Land Irrigability and Sub-class	Area in ha.	percentage of the surveyed area	Remarks
1	--	20.61.000	7.36	
2	2 s	960.000	3.436	
	2 t	10510.000	37.51	
	2 st	11340.000	40.47	
	Total of Class	**24871.000**	**81.40**	
3	3 st	3150.000	11.24	
	Grand Total	**28021.000**	**100.00**	

Land Irrigability Class :1

17.76 These are the very good soils and create no risk or hazard under sustained use under irrigation for crop production. Since this class has no limitation hence no sub-class is identified. This class covers an area of 2061.000 ha i.e. only 7.36 percent of the surveyed area.

Land Irrigability Classes - 2

17.77 On the basis of type of limitation this class has been divided into following sub - classes.

Sub-Class 2 S : These are very good land having moderate limitation of soil i.e. heavy texture on nearly levelled land. Such soils needs careful cultivation of irrigated crops 'The provision of proper drainage may reduce the risk of heavy texture. This class covers an ar ea of 960.000 Ha. ie., 3.42 percent of the surveyed area.

Sub-Class 2T: These are good land on very gentle slope. Such land faces the problem of topography due to undesirable slope. The land slope can be improved by levelling. This class covers an area of 10510.000 ha. 37.51percent of the surveyed area.

Sub-Class 2T: These are also good lands having gentle slope with moderately coarse texture. The slope can be improved by leveling but the risk of Unfavourable texture can be reduced up to some extent only by manures and fertilizers. This class covers an area of 11340.000 ha. i.e. 40.47 percent of the surveyed area.

Land Irrigability Class - 3

17.78 These are moderately good land and can be grouped under one sub-class only i.e. 3 st.

Sub-Class 3 ST : These are moderately good land for irrigation having hazard of topography and soil upto severe extent. The shallow depth further increases the risk of moderately coarse texture. Such risk can not be reduced beyond a reasonable extent. However the risk of topography can be minimized by way of levelling with careful land cutting because the depth of the soil is usually moderately deep. This class covers an area of 3150.000 ha. i.e. 11.24 percent of the surveyed area.

Available Water Holding Capacity

17.79 The available water holding capacity of the command area based on different soil texture, comes under the following ranges of available water holding capacity is presented in Table-17.18.

Table - 17.18 : KELO PROJECT
WATER HOLDING CAPACITY

Sl.no	Soil Texture	Range of AWHC.	Area of covered	Percentage of the surveyed Area
1	c 12-16	16.20	960.00	3.43
2	c]12-16	15.30	2061.00	7.86
3	sc]12-16	13.50	10510.000	37.51

4	Si] 12-16	13.50	11340.000	40.46
5	gs]	below 6	3150.00	11.24
	Total		**28.21.000**	**100.00**

17.80 From the above Table- 17.18, it inters that majority of the area i.e. 22871.000 Ha. (88.76 percent) comes under high range of available water holding capac ity i.e. from 12 to 16.00 which is good for crop production. Only 3150.000 Ha. area i.e. 11.24 percent is coming under low range of available water holding capacity i.e. below 6.

17.81 The low available water holding capacity area will require more number of irrigations for successful crop production. Addition of organic manure will also increase available water holding capacity upto some extent to resist the crop from drought condition.

Soil Fertility Status

17.82 In general, the soils in the command area of Kelo Project are low to medium in organic carbon percentage. Low to medium in available Potassium. The fertility level of soils in respect of Nitrogen and Phosphoreus has to be improved by adequate application of fertilizers as well as orga nic manures after soil tests. The regular staff of Agriculture department generally eater to the needs of the farmer. Soils analysis report is shown in Annexure - XVII.

SOIL ANALYSIS REPORT					
Sl.no	Parameters	At Plant Site		Gare Agricultural	Barren Land
		Barren	Agricultural		
1	Colour, hazen units	Pale Brown	Pale Brown	Pale Brown	Pale Brown
2	PH Valve	5.3	5.4	5.85	7.63
3	Temperature (^{0}C)	-	-	32	34
4	Type of Soil	Sandy Loam	Sandy Loam	Silty Clay	Silty Clay
5	Moisture (% by mass)	0.46	0.76	0.80	0.25
6	Bulk Density, 9 gm /cm^3	1.57	1.5	1.55	1.68
7	Conductivity (Micro -mhos .cm)	48	53	54	58
8	Water holding capacity (%by mass)	24.08	28.08	26.02	32.80
9	Organic matter (% by mass)	0.38	1000	20	21
10	Chloride as Ci (% by mass)	0.2	0.2	0.2	0.2
11	Sulphate as SO_4	Nil	Nil	Nil	Nil
12	Calcium carbonate as $CaCO_3$ (by mass)	5.2	4.9	6.2	5.4
13	Calcium as Cao (%by mass)	3.6	6.2	3.3	3.0
14	Iron as Fe_2O_3	0.12	0.26	0.13	0.40
15	Phosphorus as P_2O_5 (%by mass)	0.017	0.048	0.01	0.05
16	Nitrate as N (% by Mass)	.18	0.19	0.21	0.22

INDIA
CHATTISGARH
RAIGARH DISTRICT
KELO PROJECT

Volume- 1

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XVIII

FISHERIES DEVELOPMENT PLAN

Introduction

18.01 The Kelo Project reservoir, spreading over 1206 ha. at FRL. 233.00 m provides an excellent opportunity for development of fisheries, as it is very nearer to the Raigarh town and the produce can very easily be dispatched to Nagpur, Howrah owing to the fast and direct rail communication available at Raigarh. This aspect is of a considerable value as West Bengal has a very good market, directly connected from Raigarh for the fish produced from the Kelo Reservoir, near Raigarh which is well connected by Main Road.

AQUATIC ECOLOGY

18.02 Fisheries is already popular in Raigarh district. Development of reservoir fisheries is recommended for the reservoirs.

Scientific techniques of Fish Enhancement for the small multiple–use Reservoirs -Estimated quantity of production.

18.03 Enhancement of culture based fisheries even in small reservoirs less than 1000ha has been found to be highly lucrative. Enhancement(FAO 1997) is defined as technical interventions in the existing aquatic resource systems, " which can substantially alter the environment , institutional and economic attributes of the system ". Qualitative and quantitative improvement of the newly formed reservoir can be achieved by exercising specific management options. Some of these options are:

1. Stock enhancement

2. Species enhancement
3. Environmental enhancement
4. Management enhancement
5. Enhancement through new culture systems

18.04 The last option is the one mainly followed in India.. This is expecte d to be one of the best options available under limited water intervention condition as is seen in Kelo Project Conditions.

18.05 Stocking of hatchery reared fish fingerlings of 4-6 cm in calculated quantities every year during the monsoon months ca n enhance production. This may be particularly in Kelo reservoir case, since habitat enhancement cannot be done but, water productivity is available during the monsoon flows, feed and energy inputs are not necessary. This limited environment can improve the downstream fish production too if a fish pass is provided.

18.06 The monsoon itself adds to the fish production of the rivers by way of fish eggs and larvae because flood flows initiate maturation process in fish, and spawning occurs. Annual yields from this category of operation for Indian inland waters is estimated to be at 0.18 million tons.

Rationale for enhancement proposal :

18.07 The rationale for enhancement of fish production in the Kelo Irrigation Project include the following:

1. That technological innovations, even though limited can improve the productivity of water that is now being channeled in the river.

2. Stocking of fish seed , which is produced in controlled hatcheries by hypophysation techniques can help in increasing the yields thereby providing liveli-hood for fishermen population of the villages adjacent to the project.

3. The species that can be stocked are endemic to the region: viz.,

   X The major carps :(Catla, rohu& Mrigal,) *Catla Catla, Labeo rohita and L.calbasu, L.fimbriatus and Cirrhinus mrigala.*

   X For cage culture : The larger cat fish and the live fish.

- By rearing the seed of these fishes in controlled hatcheries, healthy young ones (fingerlings) which can withstand adverse environmental conditions in the reservoir, can be introduced at known rate.

- Such techniques can give employment to SHG groups & other small scale fisher operators who depend on aquatic resources.

4. The fish varieties shown above, major carps are plankton feeders & herbivores. The second and third group are carnivores. They breed at the shallow bottoms and protect their young . Because of the nature of the bed of the reservoir, shallow and deep areas, these fish can adopt to that atmosphere. But these are carnivores and predatory. Hence they can be reared in fixed cages in the reservoir.

Thus extra feed and energy are not needed.

The estimation of stocking density :

18.08 In enhancement programmes, carrying capacity of the system , in this case, the proposed Kelo reservoir, is to be estimated on the basis of the following parameters.

1. Length and width i.e., the total capacity of the reservoir.
2. Water capacity at the time of stocking of fish and its continuance.
3. Productivity of this body.

18.09 The length of the river in the submergence portion would be around 12.0

- The width at the dam is 2000 m
- The width at 12 km upstream 300 m
- Average width of water spread 800m.
- Average depth is 10m
- Free catchment area is 9200 ha.

It is suggested that 1 cumec of water shall be released from the dam for the maintenance of fish and benthic fauna during the lean period also.

18.10 Water capacity at the time of stocking of fish seed - the hatchery reared seed would be released during monsoon floods on a continuing basis throughout the season but, in installments. Besides this there will be auto stocking of eggs and fry and finger lings from the natural breeding activity throughout the monsoon flood season, from the catchment area surface drainage.

* The water capacity in the reservoir will fluctuate according to flood releases. However minimum water availability would be maintained for supply of drinking water to Raigarh township.
* Of the estimated catchment of 920 sq. km, one can estimate an availability of one third during non-flood, which might be confined to deep pools.
* The ratio of catchment to reservoir (C/A) area at FRL is an index of allochthonous load into the reservoir . This is very low and is about 1.3 percent in the case of Kelo Project.
* The flushing rate (annual inflow storage capacity) is about 60.785 M cum.

18.11 Productivity of the body

* The overall productivity of the body appears to be poor because of terrain and low organic carbon . Therefore the C/N ratio of the sediment is obviously low.

* The command area is Compact surrounded by rivers on three sides below dam. There is good vegetation in the catchment. There is forest cover near-by. There are several tanks in the command area and seem to add to the productivity.

* Despite this, the captured fish observed by the team are mainly carnivorous catfishes, snake fish (live fish) and of a size range of 5-7 kg. This seems to suggest sources of food from benthic fauna in the flowing streams.

* The carrying capacity of this reservoir would be of moderate order. Still enhancement of the fish production appears to be a good option by way of stocking of desired species of fish at a rate of 200-300 fingerlings / ha, fingerling size of 20-30 cm. This is based on studies on small reservoirs with multiple uses and productivity status as shown below. For estimating the stocking rate the computation can be based on 60% of the full reservoir area. (Formula-I : [FRL+DSL] /2 & Formula –II (refer to Das et.al. 2002).

Status of productivity	Yield in kg/ ha
High	100 – 150
Medium	50 – 100
Low	30 - 50

18.12 Carla catla seems to grow well in the proposed reservoir. . So preference may be given to these species among the major carps. ; besides L.calabasu and Cirrhinus mrigala Among species of carnivores. Viz.,the cat fish and live fish channa marulius a Wallago attu and Aorichthys seenghala because they form brood pens in the rocky beds and protect their young. They can be stocked in fixed pens or cages in the reservoir.

Cage and pen culture

18.13 This is another suitable option for enhancement of fish in the reservoir. The cages and brush pens can be placed in the specifically marked areas between the rock boulders. Predatory fish fingerlings can be stocked. Pens can also used for grown carp fingerlings also.

Implementation

18.14 Implementation of this enhancement programme must be under the jurisdiction of the Department of Fisheries. Because fish seed production centers are to be manned by the trained staff. Stocking of reservoirs, monitoring the growth and catches should be entrusted to trained personnel. The results will start coming in by

the 2nd year of stocking. A data base is to be created.

Parameters for estimating the carrying capacity

Location	21^0 57' 0" Lat.
	83^0 23'20" E. long.
Length of weir	2604 m (including saddles)
Distance	8.0 km North of Raigarh town.
Max height of dam	24.22 m
Free catchment area	920.21 sq.km. (maximum)
Depth of reservoir (max)	24.22
Crest level of the proposed weir	+223.00
Normal rainfall	1373 mm
Soils	Red soils & sandy loams
Temperature	49.6^0 C (May) Max.
Design flood	8473 cumecs

Calculations for stocking

Ratio of reservoir to catchment : C / A - 0.013

The area of FRL - the stocking rate per hectare can be : 200- 300 fingerlings.
Area at FRL : A: 1206 ha
Formula one : 60% x1206 =723.6 ha Fingerlings 723.6x 200 nos =1,44,720
Formula two : area (FRL + Area DSL) / 2 = (1206+278)/2 = 742 ha
fingerlings to be stocked 742 x 200 = 1,48,400

In the case Formula – I is chosen Viz., 60% of the area with 200 nos as stocking rate
No. of fingerlings stocked : 144720
Estimated survival : @ 30% (min) : 43416
Estimated average growth : 750 g x 43416 = 32,562 kg
Average yield per ha = 32,562 / 1206 h a =27 kg

- For the cages and pens specific designs can be obtained by the Dept. of Fisheries by approaching Central Fisheries Research Institute CIFRI
- At least two hatcheries must be constructed at the adjacent townships for seed production and stocking of the reservoir. Transport from other hatcheries outside the district might increase cost and reduce the survival of the fry and fingerlings.
- Fishermen and Fisherwomen cooperatives can be in the participatory management and entrusted with the role of managing the hatcheries; managing stocking, monitoring growth; preventing poaching under the supervision of the local Department of Fisheries
- Private fish purchasers / exporters should be closely monitored because they seem to be over exploiting the brood stock.

18.15 The study revealed that the implementation of the Kelo project at the most have few effects on fisheries because of the dam and dry stretches of river during hot summer. Further, impoundment of water increase the scope for development of

reservoir Fisheries. In view of the good scope, it is proposed to develop Reservoir fisheries in the project area. To develop the fisheries wealth, good size of fish seed is to be stocked. Craft and tackle is to be provided to the fishermen to get good catches in hygienic-conditions. It is necessary to consider provision of transportation facilities to enable the fish to reach the market in fresh conditions. The cost for promoting and developing reservoir fisheries in the project area is presented in Table - 18.1.

Table - 18.1: KELO PROJECT
DEVELOPMENT OF RESERVOIR FISHERIES

Sl. No.	Item	Number Required	Amount Rs.in lakhs
1	Fish seed	15.00	3.00
2	Craft and tackle		
	a) Coracles	250	4.00
	b) Nets	500	1.50
3	Transportation		
	a) Cycles	120	2.00
	b) Mopeds	10	1.50
	c) Insulated	10	0.50
Total			12.50

18.16 Out of the total amount of Rs.12.50 lakhs, the outlay on transport (Rs.4.00 lakhs) could be arranged through Institutional Finance. Thus the total outlay required for Reservoir Fisheries will be only Rs.8.50 lakhs.

18.17 For promotion and better implementation of the reservoir fisheries, the licensing system should be adopted in this project. According to this system licenses are being issued to the fishermen by collecting the prescribed fee to catch the fish. This system will be introduced by getting the transfer of auction of fisheries rights of the project to the fisheries department from the water resources department. Stress will also be given for organizing self help groups of the fishermen community to arrange for the marketing of the fish.

Need for fish passage in the weir

18.18 Unless a fish passage is provided for, in the surplus weir to be constructed, the fish that are pushed by the rapid current and turbulence created during floods, will perish.

18.19 It is therefore strongly recommended to create a fish passage in the surplus weir design, with directional flow.

RECOMMENDED MEASURES
Fishermen population

18.20 Considering the fact that there are active fishermen involved in the capture

fisheries of the river, number of measures are required for strengthening the aquatic ecology. The fisheries sector needs to be strengthened by way of alternate technologies as follows

- One is Aquaculture ;
- Reservoir stocking at Kelo reservoir on a continuing basis ;
- Release of more quantum of water down stream; allocate specific quantum releases even in lean periods;
- Subsidizing all fisheries related activities like net materials, marketing, pond excavation, fertilizers supply, seed supply and feed supply ;
- Specific water allocation for aquaculture is a must, because aquaculture is more lucrative than the paddy cultivation or any Horticulture activity.
- The quantum of water required must be calculated on the basis of the number of farmers selected for aquaculture
- The pollution created in the river below near Raigarh township should be curbed for the survival of all variety of fish. The river near the township shall be protected from contamination by providing wire mesh guards on both the flanks to a height of 2 ½ meters for a length of 2 ½ km on both flanks. This may cost about Rs. 30.0 lakhs including construction of Dhobi ghats.

18.21 This quantum is a one-time requirement; occasional replacement is needed if evaporation loss is high.

Strengthening the natural tanks and adjacent areas

18.22 There are several natural seasonal tanks and streams in the command area which function in the monsoon rains because of the gradient in the terrain. A few which show surplus flows and also join to the main river bed in the down stream of the dam. The tanks need to be strengthened for development of pisciculture.

Fisheries Monitoring Plan

18.23 The most effective mitigation measure for the impact on aquatic ecology, due to change in water levels, currents and water quality is to ensure minimum ecological flows downstream of the diversion and maintain the river water quality. This ecological flow may be designed based on the habitats of the most called aquatic species in the river. Special care is required to ensure minimization of losses of sparing grounds. Since the project involves reservoir storage also, it is recommended that periodic water releases be optimized in a strategic way to maximize revenue and minimize environmental impact of the project. Likewise attention should be paid to mandatory releases to the downstream river. In order to demonstrate project authority's commitment to downstream users, it is proposed that flow measuring

devices both electronic and manual measurement basis are installed on Kelo streams. Also to preserve water quality downstream due to flushing from desilting chambers, the flushing is to be done over longer period and during high flow periods like afternoon period or depending upon flow patterns for each month. The baseline on fish catch alternated twice in the month of January and April 2006.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XIX

LAND ENVIRONMENT MANAGEMENT PLAN

Introduction

19.01 Government of Chattisgarh had proposed for construction of major irrigation project across Kelo river in Raigarh district to cater the irrigation needs of farmers, drinking water needs for Raigarh township and industrial needs for the nearby by industries. Due to construction of dam across the Kelo river water will be impounded duly submerging an area of about 1206.30 ha in which forest lands alone contributes an extent of 361.90 ha, balance being agriculture lands, built up lands, water bodies, waste lands etc. As already envisaged in Part III, the proposed project causes adverse impacts in the fields relating to bio diversity etc. Precious forest lands having good vegetation will be lost and hence stresses the needs for compensatory afforestation. The project construction will have other impacts due to quarry sites, muck disposal sites, loss of landscape, loss of green belts already existing. The present chapter focuses on the land management in the above fields. Catchment Area Treatment was already suggested in chapter 15 of this part.

TERRESTRIAL ECOLOGY

Compensatory Afforestation Plan

19.02 According to the norms of the MOEF, Govt of India, it is mandatory to take up compensatory afforestation in view of forest areas subjected to submergence under any river valley projects which normally impound considerable storages. In the case of Kelo Project across Kelo river, the impounding water is likely to submerge 361.90 ha. of forest lands. The project proponents has already paid compensation for double the extent of forest lands i.e., 724 ha towards compensation at the rates applicable. The land has been identified.

Cost of Afforestation

19.03 About 200 to 300 species per hectare are proposed to be planted in the land allotted in lieu of submergence. The afforestation activity comprises of various components such as demarcation and survey, planting material, transportation, planting and tilling and maintenance. The total cost of afforestation for one hectare is estimated as Rs.25,800. The details are presented in Table - 19.1.

Table - 19.1 : KELO PROJECT
COST ESTIMATION AFFORESTATION

Sl.no	Particulars	Cost Rs. Ha (500 plants)
1	Demarcation and survey	1000
2	Cost of Plant material @ Rs.12 per plant	6000
3	Digging of trenches 1.0m X 0.5m X 0.3m (0.15 cum)	3750
4	Digging of trenches 0.3m X 0.3m X 0.3m (0.027 cum)	675
5	Transplantation of plants Rs. 2.25 per plant	1125
6	Internal transport of plants @ Rs. 1.00 per plant	500
7	Planting of saplings in the pit and filling @ Rs. 1.50 per plant	750
8	Maintenance care and replacement of causalities, watch and ward Rs. 0.50 per plant per month for 4 years	12000
	Total per hectare	**Rs. 25,800**

19.04 The total cost of afforestation for the proposed extent of 724 ha of compensatory afforestation would be Rs. 186.792 lakhs. Plant species as is existing in the submergence area prior to the project may be proposed for afforestation.

Green belt Development Plan / Reservoir rim Treatment

19.05 361.90 ha of forest land is involved under submersion of the proposed reservoir in addition to other lands. The existing land ecology is adversely effected due to this storage. Hence this is to be made good by proposing on green belt along the periphery of the reservoir submergence. About 845 ha of land other than forest land will be under submergence. The reservoir FRL would be kept @+233.00m. During maximum flood period the MFC may be allowed to rise by nor more than 1.0mt over the FRL. Under such condition a strip of about 100 mt may be subjected to temporary submersion. This can be best utilised for green belt development. In view of the latest moisture availability.

Advantages of Green belt development

1. The trees planted presents soil erosion and movement of silt towards reservoir from the catchment.

1. It presents illegal encroachments

1. The trees will be useful as perches to the water birds for laying their effects and help in their breeding.

1. After growth these trees provide fuel, fodder, timber and others for the benefit of the society and the Government.

1. The Green belt help in maintaining ecological balance of the nature.

Plant Species Proposed

19.06 It is proposed to take up plantation for Green Development with Non Timber Forest Plantation (NTFP) species which will remain useful to local public for obtaining only usufructs. Some important species proposed for plantation are

1. Azadirachta Indica (Neem)
2. Cochlospermum religiosum
3. Dendro Calamus strictus (Bamboo)
4. Derris Indica
5. Dolichandrone Crispa
6. Emblica Ofrficianalis
7. Feroria Limonea
8. Fiscus bengha lesiss
9. Ficus religiosa
10. Hard wickia binata
11. Sapinows Emarginatus (Soapnut)
12. Sterculia Urens
13. Terminalia arjuna
14. Terminalia Catappa
15. Ficus Micro Carpa
16. Vitex negundo
17. Wrightia finctorea

19.07 The list is only indicative and other suitable species may be added by the implementing agency in consultation with Forest Department. Depending upon the site conditions and local preferences, the practice could be changed. Live fencing has been preferred for its durability, renew ability and easy maintenance with locally available material. An amount of 37.00 lakhs has been provided for green belt development. Total length of main canal branch canal and distributaries works out to 117 km. A total of Rs. 37.00 lakhs is provided for Green belt development to compensate the ecological status in the project area. The general considerations involved while developing the green belt are as follows:

- Local/native trees upto 10m or above in height with perennial foliage should be planted around various appurtenance of the proposed project;

- Planting of trees should be undertaken in/appropriate encircling rows around

the project site;

- Generally fast growing trees should be planted;

- Since the truck of the tree is normally devoid of foliage upto a height of 3m. It may be useful to have shrubbery in front of the trees so as to give coverage to this portion.

19.08 The plantation should be at a spacing of 5 m x 5 m. About 500 trees per hectare should be planted. The plantation and maintenance of the area should be done by Forest department. For initial 2 years weeding and soil consideration around the plants is recommended. Gap filling may be taken up in third year. Watch and ward for 3 years to be ensured.

Canal Bank Plantations

19.09 The proposed Kelo Irrigation Project envisages irrigation to an area of 22,800 hectares besides supplying drinking water to Raigarh town and for industrial purposes. The CCA of 22,800 hectares is proposed to be irrigated through canal network comprising main canal, branch canal major distributaries and minor distributaries for a length of about 350km. command area is proposed on the right flank of the river only and thus one main canal is proposed to take off on the right flank of the river, which splits up into branch, distributaries and minor canals. Much of the vegetation cover will be lost due to the area occupied by the canal system. Thus to compensate the adverse effect on the land environment in the command area develop flora. Canal bank plantation can be taken up along both the banks of main canal branch canal and distributaries for a total length of about 117 km. The plantation will be single row or multiple rows as per the width of land acquisitions. The model cost for raising canal bank plantations for 1 km of canal is shown in Table - 19.2.

Table - 19.2 : KELO PROJECT
COST OF RAISING CANAL BANK PLANTATION UNIT COST OF RAISING CANALBANK PLANTATIONSINGLE ROW - ESCAPEMENT 10 MTS.
No. of Plants per km - 100

Sl.no	Particulars of Work	Quantity	Unit rate in Rs.	Amount in Rs.
1	Clearing the brushwood and plinth	1 km or 100 plants	Rs. 2/- unit	200.00
2	Pits point (1M x 1M x 1M)	100 plants	Rs. 20 per point	2000.00
3	Cost of planting material 2 years old seedling	100 plants	Rs. 7 per plant	700.00
4	Planting and filling pits	100 plants	Rs. 5 per plant	500.00
5	Cost of minimum and maximum sections	100 plants	Rs. 5 per plant	500.00
6	Watering the plants in Summer months (February to may) 30 waterings	100	Rs. 30.00 per watering	900.00

7	Protection Bamboo	100	Rs. 10.00 per each	1000.000
8	Watch and Ward	100	1000.000	1000.00
9	Miscellaneous and Unforseen		500.00	500.00
	Total for First Year			**7300.00**
	2nd Maintenance			
1	Casually maintenance 25%	100 plants	25% of 3200	800.00
2	Watering and Replacement 30 waterings	100 plants	Rs. 30 per watering	900.00
3	Protection and repairs to the tree grains 40%	40 Nos	Rs. 10	400.00
4	Watch & Ward	100 plants	1000	1000.00
5	Miscellaneous and unforeseen			500.00
	Total for Second Year			**3600.00**
	3rd ,4th and 5th year for three years			
1	Watering 60watering in 3 years @ 20 watering year	100 plants	30.00	2250.00
2	Watch and Ward	100 plants	1000 per year	3000.00
3	Miscellaneous and Unforeseen expenses	100 plants	500 per year	1500.00
	Total			**6750.00**
	Grand Total			**17650.00**

19.11 Assuming single row plantations for main canal and branch canal and distributaries, the total plantation length works out to 234 km. Thus the total cost of raising and maintenance of canal bank plantations for 117 km length of canals is estimated as 42.82 lakhs.

Restoration and Landscaping of Project sites

19.12 The construction of the proposed project including its various appurtenances e.g. saddles spill way approach roads. labour camps. project colony etc. would disturb the existing topography and physiography. although, no major alteration of the area is expected as the layout has been so conceived that no major impacts on this account are anticipated, it is proposed to landscape the area, so that it integrates with the natural surroundings and the beauty of the area is restored.

19.13 Accordingly, it is proposed to develop small gardens at 2 locations below dam and project colony. Two view points along the periphery of the reservoir may also be proposed. The landscaping plan is detailed as below:

- Garden complex
- View points

The above referred measures are described briefly in the following paragraphs.

Garden Complex: A garden with local ornamental plants and trees should be created at two location, i.e., one each near the dam and project colony sites. All plants will be properly labelled with scientific and / or common names.

Creation of view points: Four view points will be created two on the upstream of dam flanks and others at suitable place along the periphery of the submergence area. These view points will be properly reinforced and fenced to avoid any undesirable incidence. It will be given a shed and plantation of ornamental plants will be done near it.

19.14 A lumpsum amount of Rs. 18.00 lakhs can be earmarked for development of various measures outlined for landscaping and restoration of construction sites.

Subsided Fuel Scheme

19.15 Technical staff workers and other group of people are likely to congregate in the area during construction phase of the project. It can be assumed that the technical staff will be of higher economic status and live in a more urbanised habitat. Therefore, these members will not use wood as fuel. However, workers and other population groups residing in the area may use fuel wood if no alternative is provided. For maintaining the biological conservation, they have to be provided with alterative fuel.

19.16 About 500 workers and 500 technical i.e., 1000 families are likely to congregate during construction phase. The increase in population is expected to be about 1500. The labour population is expected to use fuel wood alternate if facilities are not provided. The details of fuel wood requirements will be as given in Table 19.3.

Table - 19.3 : KELO PROJECT
DETAILS OF LABOUR FORCE AND FUEL WOOD REQUIREMENT

Year	No.of labour	Total Population	Fuel wood requirement m^3/year	No. of trees to be cut every year
I	500	1000	900	360
II	1000	1500	1350	540
III	500	1000	900	360
		Total	**3150**	**1260**

19.17 Thus about 1260 trees are to be cut during the construction period of about 3

years. The submerged area which comprises of moderate vegetation with all varieties of species, shall be cleared to impound water in stages year after year. The cut trees can be provided to the labour for utilization as fuel wood. The fuel wood available in the submerged area is quite adequate to the labour force working for the project and this has to be applied to the labour at subsidized rates also. It has to be ensured that proper kerosene supplies are made for utilization by the labour for other purposes.

Restoration of quarry sites and dumping areas

19.18 During construction of any river valley irrigation project, large quantities of construction materials are required. The quarries need to be stabilized after excavation of construction materials is completed. Following biological and engineering measures are suggested for the restoration of various quarry sites including borrow areas.

- Construction of rough stone guards to check soil-erosion in the area;
- Pits formed after excavation be filled with un-useful rock boulders, spills, sand and finally with farm yard manure.
- Gross slabs will be placed to stabilise and to check the surface runoff water along with loose soil.

19.19 Portion of the aggregate required for the construction of weir and other structures be obtained from the muck excavated for the foundations of the weir since the rock is suitable for aggregate as per the geological report. However, for stone and sand obtained from other quarries, restoration is needed. Major portion of the project comprises of earth dam. This requires about 14.0 lakhs cubic meters. Out of this about 2 lakhs cum of earth obtained from foundation excavations will be resused. Thus the quarries of earth (2 km distance) for about 12.0 lakh cum are to be restored after completion of work. Besides, rock and other aggregates are to be obtained from nearby quarries which are about 15 km away. About 1.30 lakhs cum of aggregate material is required for construction of spill way and head works out of this 30% of materials obtained from foundations will be utilised. Thus quarry restoration if needed for about 0.91 lakh. cum. A provision of Rs. 27.00 lakhs shall be earmarked for quarry slope stabilisation. The details of cost required for various measures are given in Table - 19.4.

Table - 19.4 :KELO PROJECT
COST ESTIMATE FOR RESTORATION OF QUARRY SITES

Sl.no	Activities / Purpose	Cost (Rs. in lakhs)
1	Filling up of land with soil	2.00
2	Cost of green manure	1.00
3	Cost of Saplings (1000 Nos / ha) @ Rs. 4.00 per sappling in 30 ha	2.40
4	Cost of fertilizers and pesticides	5.00

5	Fencing with RCC pillars and barbed wire	10.00
6	Maintenance activities including of cleaning of weeds etc Rs. 20000 for 3 years	0.60
7	Digging pits	3.00
8	Watch and ward 2 persons for 3 years @ Rs. 4000/ month including escalation	3.00
	Total	**27.00**

Muck Disposal

19.20 For River Valley projects, the quantity of muck generated is quite high for setting up of various structures. Muck generated from excavation of foundations and other project components is required to be disposed in a planned manner so that it occupies least possible space and is not hazardous to the environment. In the case of Kelo Project 15.0 ha of land is year marked for dumping of the muck generated for the dam and head works.

19.21 In Kelo Irrigation Project muck is generated due to the excavation of foundations for the weir on Kelo river (mostly rock). Excavation of foundations for spill way and head works. Even after utilization of useful rocks for aggregate and useful soils for filling banks for about 30% still about 4.30 lakh cubic meters of muck is to be disposed. Muck disposal areas are also identified carefully and 15 ha of land is ear marked for this purpose. Low level area which does not involve any land acquisition may also be identified is the above land is inadequate. The muck disposal areas may be developed in a series of terraces of boulder crater walls and masonry walls wherever necessary to (i) protect the area (muck) from flood water during monsoons and (ii) to create inspection paths. In between the terraces catch water drain will be provided. The terraces of the muck disposal areas are ultimately covered with fertile soils obtained from excavations. There on suitable plants will be plated adopting suitable bio-technical measures. The overall idea is to enhance / maintain aesthetic view in the surrounding area of the project in the post construction period and avoid any land or water source contamination due to muck disposal. Various activities proposed as a part of the management plan are given below:

Ist Phase

- Land acquisition (if require and if not already done);
- Civil works (construction of retaining walls/crater walls);
- Dumping muck;
- Levelling of the area , terracing and implementation of various engineering control measures;
- Spreading of soil; and
- Application of fertilizers.

2nd Phase

- Digging of pits

- Plantation turfing etc
- Fencing;
- Watch & ward
- Maintenance
- Construction of drains, etc.

19.22 While excavating canal net work about 21 lakhs cubic meters of muck is likely to be generated. Fifty per cent of the above can be avoided by suitably designing the alignment of canals following Balance Depth of Cutting (BDC) policy. Out of the balance certain quantities can be transported to the nearby embankment reaches for formations. Balance muck left over if any may formed as spoil banks with provision for vehicle crossing/over takings and suitably provided with plantations on top of the spoil banks, as part of canal bank plantations. As such no separate management plan for the muck generated from the canals may be necessary.

19.23 An amount of Rs. 15.00 lakhs may be provided towards the muck disposal measures suggested above.

Environmental Management in Road Construction

19.24 Approach road of about 3.00 km is proposed to be constructed as a part of access to the site from the 8th km on Raigarh Ambikapur state high way road. The various aspects to be considered while construction of the project road are briefly given below.

1. Area for clearing and grubbing shall be kept minimum. Desirable trees and shrubs are to be saved and if needed minimum cutting to be adopted.
2. Method of balance cut and fill formation shall be adopted wherever the road is formed in sloppy area;
3. Catch water drains, intercepting drains are to be formed if necessary;
4. Surface drains shall have gentle slopes;
5. Location of Culverts / Bridges should be so chosen as to avoid severed erosion at outlets and siltation at inlets;
6. Afforestation on roadside should be carried out to a sufficient distance on either side of the road.

19.25 Besides the above, the inspection roads along the main and canals and branch canals of Kelo Irrigation Project are the basic road communication systems to reach the proposed project for transportation of men and materials as well produce in the command area.

Tourism

19.26 For developing the project area as a tourist oriented place, the following measures are contemplated in the project report.

(a) Accommodation

19.27 Locating a tourist Bungalow i.e. Inspection bungalow complex, on top of right bank hillock top near Main Earth Dam:-

19.28 This will provide natural hill surroundings in such a manner that the tourist can have panoramic view of the project reservoir with surrounding hillocks & natural Aesthetic Beauty at a glance. This will attract a good number of the tourists. The tourist bungalow will be provided with two units each containing two living rooms with attached toilet & dressing rooms, in Indian & Western styles bath. Lounge, dining hall, drawing room, kitchen, store and pantry etc., will be common for both suits. This will be equipped with electricity and telephone facilities. The living room will be well furnished with proper provision of beds and bed linen. The officer incharge of the bungalow will be housed in the vicinity i.e., in 1 type quarter proposed for the purpose. So that, the may be easily available for necessary arrangements. A garage for motor car will also be constructed.

(a) Roads

19.29 Black topped approach road from km no. 8 of the Raigarh Ambikapur state highway will be provided upto the overflow spillway dam just D/S of the main earth and masonry non-overflow section running parallel to the dam. Heavy plantation shady trees will also be contemplated along both sides of the approach road in view of enhancement of the asthenic aspects of the dam site. Provision for erection of street light along the proposed approach road has also been made according to specifications. Later on full development of the project area as a commercial tourist center, provision for proper road was also made for pleasant drive outs on top of the main dam.

(a) Park and Garden:

19.30 A garden will be developed with flowers and shady trees in close vicinity of the tourist / inspection bungalow complex, for recreation of the tourists and creating the surroundings more Aesthetic.

(a) Water Sports:

19.31 Holiday makers will find recreation and rest at such project. This will develop an ideal place for water sports and recreational activities and will develop as a holiday resort.

(a) Boating:

19.32 Boats will be provided for recreation of the tourists and pisciculture operations.

(a) Swimming

19.33 Suitable swimming facilities will be provided at the dam site.

(a) Angling Fishing

19.34 Pisciculture will be developed and facilities for angling and fishing will be provided.

Financial Requirements

19.35 The total cost for the implementation of land management plan other than CAT and Command Area development works out to Rs. ---- lakhs as presented in Table - 19.5.

Table - 19.5 : KELO PROJECT
LAND MANAGEMENT PLAN - FINANCIAL REQUIREMENT

Sl.no	Details	Cost in lakhs
1	Compensatory Afforestation (excluding land)	186.792
2	Green Belt development plan / Reservoir Rim treatment	37.000
3	Canal Bank Plantation	42.820
4	Restoration of Land Scapes	18.00
5	Restoration of Quarry sites	27.00
6	Muck disposal treatment	15.00
	Total	**326.612**

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume -I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAEGMENT PLAN

XX

WATER QUALITY AND PUBLIC HEALTH MANAGEMENT PLAN

Labour Camps

20.01 The aggregation of large number of labourers and their family members during construction phase is likely to put significant stress on various facets of environment. Thus, the population is expected to be 1000 during peak time. This is expected to increase pressure on the existing infrastructure facilities in the area. The connected issues will be:

- Facilities in labour camps
- Sanitation and sewage treatment
- Solid waste management
- Provision of community kitchens

Facilities in Labour Camps

20.02 The spatial distribution or concentration of construction activities ensures that labour population is likely to be concentrated at the major sites i.e, the main dam saddles and weir portion. Contractors shall be pressed to make semi-permanent structures for their workers. The water requirements for domestic use may be collected from the river, since this water is generally good and can be used after chlorination.

Sanitation Facilities

20.03 One community latrine for 20 persons can be provided . The sewage from the community latrines can be treated in septic tanks. One septic tank for 500 persons should be provided. The effluents from these septic tanks can be disposed off through soak pits. Drinking water facilities and waste disposal sites will be located away from each other. Total construction time for the project is 2 ½ years. At peak stage there will be increase in population by 1000 including families. It has been estimated that about 50 community latrines and 2 septic tanks need to be constructed. The total budget required for these facilities will be Rs. 20.00 lakhs as shown in Table - 20.1.

Table - 20.1 : KELO PROJECT
COST ESTIMATE FOR SANITARY FACILITIES FOR LABOUR CAMPS

Sl. No.	Unit	Rate Rs/unit	Number	Total cost (Rs. lakhs)
1	Community latrines	20000	50	10.00
2	Septic tanks including sewage system for labour camps	500000	2	10.00
	Total			**20.00**

Solid waste management from labour camps

20.04 As mentioned earlier, the increase in population due to congregation of construction labour is expected to be about 1000. The average per capita solid waste generated would be of the order of 425 gm / day / person. The solid waste likely to be gene rated from labour camps shall be of the order of 0.425 tonnes / day.

20.05 Adequate facilities for collection, conveyance and disposal of solid waste needs to be developed. For solid waste collection, 4 number of masonry storage vats, each of 2 m^3 capacity should be constructed at appropriate locations near labour camps. These vats should be emptied at regular intervals and the collected waste can then be transported to landfill sites.

20.06 One covered mini truck to collect the solid waste from common collection point and transfer it to the disposal site should be put to service. A suitable landfill site should be identified and designed to contain solid waste from the project colony, labour colony, etc. A total provision of Rs. 13.25 lakhs needs to be earmarked for this purpose. The details are given in Table - 20.2.

Table - 20.2 : KELO PROJECT
DETAILS OF EXPENDITURE REQUIRED FOR SOLID WASTE MANAGEMENT

Sl.No.	Item	Cost (Rs. lakhs)
1	One covered mini truck for conveyance of solid waste to landfill site @ Rs. 10.00 lakhs / truck	10.00
2	Manpower cost for 2 persons @ Rs. 5000/- month for 2 ½ years including 10% escalation / year	3.25
	Total	13.25

20.07 Generally, from sanitary landfill sites, there is little risk from methane, generated due to the decay of organic or degradable component, as it slowly diffuses at low concentration through the covering material. To minimise groundwater pollution from leachates, bed of the disposal site (s) should be covered with an impervious material, so as to ensure that leachate does not lead to soil and water pollution.

20. 08 Paper and other material also flies off the landfill area due to wind action. This often creates a nuisance in the immediate vicinity of the landfill site. The landfill site, therefore needs to be skirted with wire fence of about 3 m high wire fence with paper catchers to avoid fly of papers. Once landfill operation is complete, the entire landfill site should be suitably capped by an impervious material.

Sewage from labour camps

Construction Phase

20.09 During project construction phase adequate measures need to be implemented to ameliorate the problem of water pollution from various sources. The sewage generated from the labour camps shall be treated in septic tanks and disposed of into Kelo river. The septic tanks shall be located so as not to pollute the drinking water sources. The effluents generated from the colonies shall be treated before disposal. The design aspect of Sewage treatment plants are presented in the following paragraphs.

20.10 A sewage treatment plant of $100m^3$/day is proposed to treat the sewage generated from the labour colony, canteen and toilets etc. The following is the scheme of treatment:

20.11 The sewage is passed through 2 sets of screens (10mm and 5mm sizes) arranged in drains. The screened sewage is collected in equalisation tank and sent for settling in a primary settling tank. The overflow is fed to aeration tank where sewage is subjected to aeration. The sewage from aeration tank is sent to secondary clarifier to allow solid liquid separation. The treated wastewater is then chlorinated to reduce the micro organism load and stored in a treated water storage tank for reuse for onland irrigation. The sludge collected in the secondary clarifier and primary settling tank will be applied on sludge drying beds and will be composted to make manure. The civil unit details of sewage treatment plant:

1. Equalisation tank - 5m X 5m X 2m
2. Primary settling tank - 3m Diameter X 2m depth + 0.5SWD
3. Aeration tank - 5m X 5m X 4m + 0.5SWD
4. Secondary clarifier - 3.5m Diameter X 3.5m depth + 0.5SWD
5. Chemical oxidation tank - 4m X 1.5m X 1.3m
6. Treated water storage tank - 8.5m X 8.5m X 3m
7. Sludge drying beds (2Nos.) - 2.5m X 2.5m X 1.4m

The mechanical units and other requirement details of sewage treatment plant:

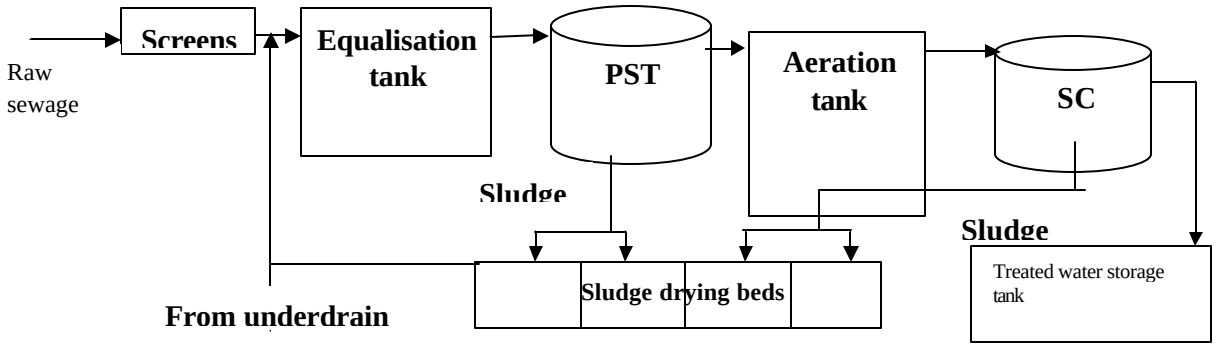
1. Blowers (2Nos) - $120m^3/hr$
2. Pumps (2Nos) - $10m^3/hr$
3. Media - $70m^3$
4. Screens (2 set) - 5mm and 10mm clear opening to fit into drain.

20.12 The design characteristics considered for sewage treatment plant are as follows:

Parameter		before treatment	after treatment
1. pH	-	6.5 to 8.0	6 - 8
2. TSS	-	300mg/L	100mg/L
3. COD	-	700mg/L	< 250mg/L
4. BOD	-	350mg/L	< 30mg/L
5. Oil and Grease	-	<5mg/L	<5mg/L

20.13 The total cost of the sewage treatment unit of 100 m^3 / day would be about Rs. 15.00 lakh. The treated sewage will be used for green belt development in the colony and on either sides of the access roads in the project area. The flow diagram for sewage treatment plant is presented below :

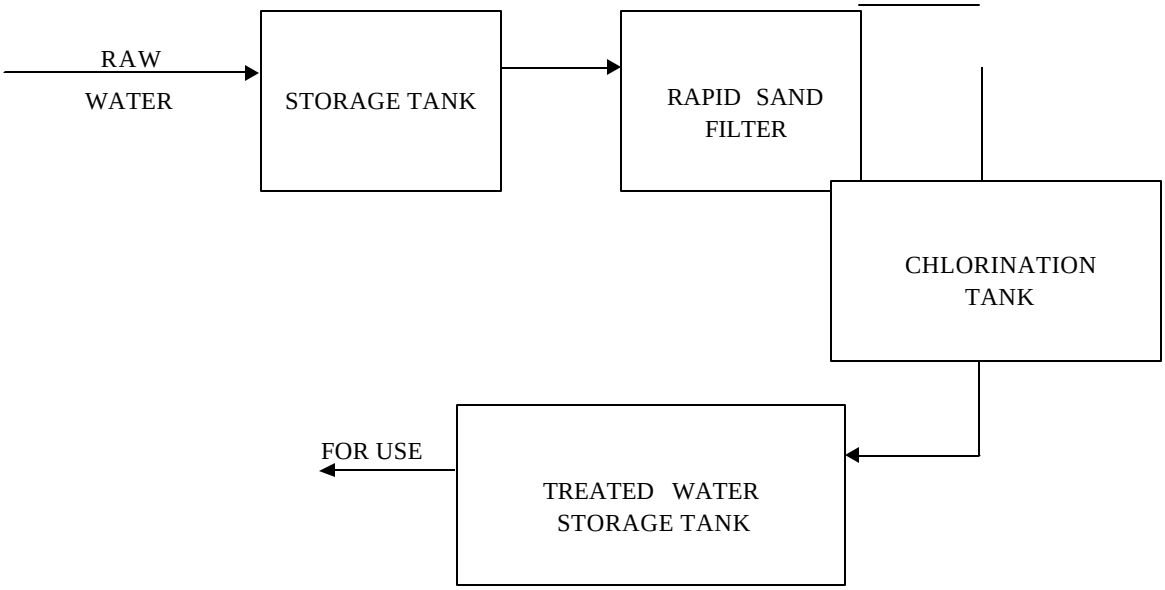
Flow Diagram For Sewage Treatment Plant



Water quality

20.14 The drinking water to the labour colony as well as project colony is proposed to be supplied after treating / filtering. The flow diagram for Drinking Water Treatment Plant is presented in Diagram – 20.1. The total cost of Drinking Water Treatment Plant is assessed to be Rs. 10.00 lakhs.

FLOW DIAGRAM OF WATER TREATMENT PLANT



20.15 In the post project construction operation phase, a project colony with 50 quarters is likely to be set up. It is recommended to commission a suitable Sewage Treatment Plant (STP) to treat the sewage generated from the colony. The cost will be included in the construction of project colony.

Public Health Delivery System

20.16 The increase in water fringe area provides suitable habitats for the growth of vectors of various diseases and they are likely to increase the incidence of water-related diseases. Malaria is one such disease. Malaria control measures which aim at destroying the habitat and interrupting the life cycle of mosquitoes by mechanical or biological or chemical means need to be implemented. The anti-malarial operations can be coordinated by various Primary Health Centres (PHC) in the nearby villages and Hospital at District Headquarters in association with the project proponents. The suggested measures are given in following paragraphs.

- Site selected for habitation of workers should not be in the path of natural drainage;
- Adequate drainage system to dispose storm water drainage from the labour colonies should be provided.
- Adequate vaccination and immunisation facilities should be provided for workers at the construction site.
- Labour camps and resettlement sites should be atleast 2 km away from a main water body or quarry areas.

Development of medical facilities

20.17 A population of about 1000 is likely to congregate during the construction phase. The labour population will be concentrated at one place near main dam site on the left flank of river. There are no medical facilities in the immediate vicinity of the project area except at Raigarh which is 8 km away. It is recommended that necessary

medical facilities be developed at the project site. It is recommended that a small dispensary should be developed during project construction phase itself at the dam site, so that it can serve the labour population migrating in the area as well as the local population.

Proposed Health facilities at construction sites and labour camp

20.18 It is possible that during the construction work, technical staff operating different equipment are not only exposed to the physical strain of work but also to the physical effects of the environment in which they are working. The workers and other technical staff may come up with common manifestations such as insect bites, fever, diarrhoea, work exhaustion and other diseases. In addition they may invariably come up with injuries caused by accidents at work site. Under all these circumstances, workers need immediate medical care.

20.19 The first aid post is to be provided at the major construction site, so that workers are immediately attended to, in case of an injury or accident. This first aid post will have atleast the following facilities.

- First aid box with essential medicines including ORS packets;
- First aid appliances splints and dressing materials
- Stretcher, wheel chair, etc.

Health Extension Activities

20.20 The health extension activities will have to be created in the villages situated in the nearby areas i.e., near dam site on right bank and on left bank. It is important to inculcate hygienic habits of environmental sanitation specially with respect to water pollution by domestic wastes. There would be possibility of the transmission of communicable disease due to migration of labour population from other areas at the construction site.

20.21 The doctor from the dispensary should make regular visits to the villages around submergence area and dam site and organise health promotional activities with the active participation of the local village Panchayat, NGOs and available local health functionaries. The health functionaries would undertake the following tasks as a part of health promotional activities.

- Collect water samples to ascertain the potability of water from different sources so as to monitor regular disinfection of drinking water sources.
- Maintain close surveillance on incidence of communicable diseases in these villages.
- Maintain close liason with the community leaders and health functionaries of different departments, so that they can be mobilised in case of an emergency.

20.22 The budgetary provision required for implementation of Public Health Delivery System is Rs. 104.30 lakhs. The details are given in the following paragraphs.

A. Expenditure on Salaries for the proposed dispensary at dam site.

Sl. No.	Details	Number	Monthly Emoluments (Rs.)	Annual Expenditure (Rs.)
1	Doctor	1	20000	24000
2	Nurse	1	8000	96000
3	Male Multi-purpose Health workers	1	6000	72000
4	Attendants	1	4000	78000
5	Drivers	1	4000	48000
	Total			**504000**
	FIRST AID POSTS			
1	Health Assistants	1	4000	60000
2	Dressers	2	3000	48000
	Total			**108000**
B.	**Expenditure on Material and Supplies**			
	Dispensary-Non-recurring			
1	1 Vehicles (closed jeep) and			500000
	Furniture, etc			100000
	Total			**600000**
	Recurring			
1	Drugs and Medicine			150000
2	Contingencies			20000
3	First-aid posts at construction sites (saddles, canals, etc.)			30000
	Total			**150000**

C. Infrastructure

Dispensary : Considering the number of rooms, staff quarters and open space etc. it is estimated that 5000 sq.ft of plot will be required for dispensary, out of which about 3000 sq.ft will be the built-up land which includes staff quarters, etc. The construction cost for RCC structure of 1000 sft built up area will be Rs. 1000 sq/feet excluding land cost. The cost of construction of Dispensary will be Rs. 10 lakhs. The cost of temporary quarters in the built up area of 2000 sq.ft. at the rate of Rs. 500 per sq.ft would be Rs. 10.00 lakh. Total cost of infrastructure will be Rs. 20.0 lakhs. The land can be purchased by the project proponents from the State Government.

2 First Aid Posts : These shall be of temporary nature and will be constructed with asbestos sheets, bamboo, etc. It will cost @ Rs. 50000 / First aid post. The total cost for constructing two First Aid Posts will be Rs. 100000.

20.23 The total cost for developing the infrastructure will be (Rs. 20.0 + Rs. 1.00 lakh) Rs. 21 lakhs.

20.24 The total cost of public health and water management will be as below :

D.	Recurring Expenditure		
i)	Salaries	Rs.	6.12 lakhs
ii)	Expenditure on materials & supplies	Rs.	1.50 lakhs.
	Annual Expenditure	Rs.	7.62 lakhs
	Total for 2 ½ years are Rs. 19.05 lakhs		
E.	Non-Recurring Expenditure		
i)	Infrastructure (Construction of Dispensary & 2 First aid posts)	Rs.	21.00 lakhs
ii)	Expenditure on materials & supplies	Rs.	6.00 lakhs
	Sub- Total (E)	**Rs.**	**27.00 lakhs**
Total cost of Public Health delivery system		**Rs.**	**46.05 lakhs**
F.	Cost of Sanitary facilities	Rs.	20.00 lakhs
G.	Solid waste management	Rs.	13.25 lakhs
H.	Sewage treatment unit	Rs.	15.00 lakhs
I.	Water Treatment plant	Rs.	10.00 lakhs
	Grand Total	**Rs.**	**104.30 lakhs**

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XXI

AIR AND NOISE MANAGEMENT PLAN

Blasting Operations

21.01 Normally charge weight per delay should be below 40 kg. The regulatory authority insists for limiting PPV of 10 mm/sec having frequency between 8 to 25 Hz as a damage criterion for buildings belonging to people nearby to project site. The estimated PPV at nearest village or habitation should be lower than threshold value. The frequencies below 8 Hz are considered serious for potential structural damage. It has to be seen that the frequencies below 8 Hz should not be generated in this case. The air over pressure (sound level) due to blasting should be well within limits.

21.02 The vibrations due to blasting can be further minimised by adopting the following measures.

- Ensure systematic burden and spacing
- Ensure designed depth and inclination of blast holes, keeping the sub-grade drilling to optimum
- Ensure proper free face for first row of holes

21.03 The recommendations of regulatory authority should be strictly followed. As the blasting pattern shall be minimal there is no danger to any structures from ground vibrations due to blasting in future.

X It should be seen that if at all drilling is done it should be wet drilling;

- X The vehicles used should be regularly overhauled;
- X The tippers or trucks carrying the burden should not be overloaded ;
- X It is beneficial if fuels of low Sulphur content is used;
- X The major noise generating operations should be undertaken only during day time;
- X The equipment, which generates high noise, should be provided with silencers (eg. Drilling equipment);
- X All the required measures should be taken care of regarding blasting;
- X Required protective gears should be provided to the workmen
- X The workmen have to be rotated in shift with respect to the nature of work to be taken up to avoid long term effect due to noise; and
- X The workmen should be provided with dust masks as are they likely to be exposed to huge dust.

21.04 Environmental Monitoring Plan during construction and operation phases is dealt with in Chapter - XXII.

Conclusions

21.05 With the above mentioned aspects and results it is clear that the activity will have minor and short term effect on environment during development phase and will have a lot of beneficial impacts during operation. In the post operational phase of the project there will be good improvement in aesthetics, greenbelt, air quality, water levels, etc. The establishment of the project has no detrimental effect on the surroundings but will in fact benefit them as it will develop the aesthetic value and increase the green belt area.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XXII

ENVIRONMENT MONITORING PLAN

The Need

22.01 Environmental monitoring is an essential component for sustainability of any water resources project. It is an integral part of any environmental assessment process. Any water resources development project introduces complex inter-relationships in the project area between people, various natural resources, biota and the many developing forces. Thus, a new environment is created. It is very difficult to predict with complete certainity the exact post-project environmental scenario. Hence, monitoring of critical parameters is essential in the project operation phase. An Environmental Monitoring Programme is to be designed with the following objectives:

- Assess the changes in environmental conditions, if any, during construction and operation of the project.
- Monitor the effective implementation of mitigatory measures.
- Warning of any significant deterioration in environmental quality so that additional mitigatory measures may be planned in advance.

Areas of Concern

22.02 From the monitoring point of view, the important parameters are water quality, land use, ecology, etc. An attempt is made to establish early warning of indicators of stress on the environment. Suggested monitoring details are outlined in the following sections.

WATER QUALITY
Construction Phase

22.03 It is proposed to monitor the effluent before and after treatment from septic tanks. The frequency of monitoring could be once in a month. Since 2 septic tanks have been proposed for labour camps, a total of (2 septic tanks X 12 months x 2 samples, ie. before and after treatment) 48 samples/year need to be analysed. The parameters to be monitored include pH, bio-chemical Oxygen Demand, Total Suspended Solids and Total Dissolved Solids. The cost of testing of one sample is expected to be Rs. 4000. Thus, total cost for analysis of 48 samples is expected to be Rs. 1.92 lakhs/year. Considering that the construction phase to last for a period of 2 ½ years and an escalation cost of 10% every year, the total cost over the entire construction phase works out to Rs. 5.20 lakhs. The analysis work can be done by a laboratory recognized by the State Pollution Control Board.

Operation Phase

22.04 The surface water quality of the impounded water and river Kelo needs to be monitored thrice a year. The proposed parameters to be monitored include pH, Temperature, Electrical Conductivity, Turbidity, Total Dissolved Solids, Calcium, Magnesium, Total hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc and Manganese. The sampling sites shall be:

- 1 km upstream of dam periphery
- Reservoir water
- 1 km downstream of the dam

22.05 The total cost of analysis will be 0.36 lakhs per year at the rate of Rs. 4000/- per sample. This analysis shall be done throughout the life of the project. The analysis work can be conducted by a reputed external agency recognised by State Pollution Control Board in association with the project proponents. With provision of observation till 5 years in the operation phase, the cost works out to Rs. 2.20 lakhs including escalation cost of 10% every year.

22.06 During project operation phase, a Sewage Treatment Plant (STP) is also proposed to be set up to treat the effluent from the project colony. Once every week, it is envisaged to analyse a sample each before and after treatment from the STP. The parameters to be analysed include pH, Boi-chemical Oxygen Demand, Chemical Oxygen Demand, Total suspended Solids and Total Dissolved Solids. The cost of analysis of 50 samples @ Rs. 4000 per sample works out to Rs.3.00 lakhs per year and the total for 5 years in the operation period will be Rs. 15.00 lakhs.

22.07 The analysis work can be conducted by a reputed external agency recognised by State Pollution Control Board in association w ith the project proponents.

AIR QUALITY AND METEOROLOGY
Construction Phase

22.08 The ambient air quality monitoring during construction phase can be carried out by an external agency, approved by State Pollution Control Board at damsite which is the major construction site. Every year monitoring is to be done for the following three seasons.

- Winter
- Summer - Pre-monsoon (summer)
- Post-Monsoon

22.09 The frequency of monitoring could be twice a week for four consecutive weeks at each station for each season. The parameters to be monitored are Respirable Particulate Matter (RPM) and Suspended Particulate Matter(SPM, Sulphur dioxide (SO2) and Nitrogen Oxides (NOx).

22.10 Every year, ambient air quality is to be monitored for (1 station X 4 weeks X 2 days X 3 seasons) 24 days. A total cost of Rs. 1.20 lakhs /year @ Rs. 5000 per day can be earmarked for this purpose. For the main dam construction phase of one year, the total cost required shall be Rs. 1.20 lakhs.

22.11 A meteorological laboratory can be setup at the ambient air quality monitoring station near dam site. Automatic recorders for temperature, humidity, wind speed & direction, rainfall needs to be commissioned at the site an amount of Rs. 10.00 lakh can be earmarked for this purpose including establishment in the construction phase. The cost of observations in the operation phase may be met with from the maintenance funds earmarked by the WRD.

22.12 Summary of the Environmental Monitoring plan during the construction phase has been provided in Tables - 22.1 and 22.2.

NOISE
Construction Phase

22.13 Noise emissions from vehicular movement, operation of various construction equipment may be monitored during construction phase at main dam construction site. The frequency of monitoring could be once every three months. For monitoring of noise generators an integrating sound level meter will be required for which an amount of Rs. 5.0 lakh needs to be earmarked.

INCIDENCE OF WATER-RELATED DISEASES
Project Construction Phase

22.14 Identification of water related diseases, adequacy of local vector control and curative measures, status of public health are some of the parameters which should be closely monitored three times a year with the help of data maintained in the government dispensaries/hospitals.

Implementation : Public Health Department & Dispensary constructed for labour camps.

Cost per annum : Rs. 2.0 lakh

22.15 The total cost required for monitoring over the entire project construction phase of 2 ½ years shall be Rs. 5.50 lakh. The cost also includes escalation @ 10% every year.

Project Operation Phase

22.16 Increased prevalence of various vector borne diseases and adequacy of local vector control and curative measures need to be monitored. The monitoring can be done three times in a year. The total cost for the construction period will be Rs. 2.70 lakhs.

Implementation :Dispensary at the project site
Cost per annum :Rs. 1.0 lakhs

Table - 22.1 : KELO PROJECT
SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME DURING PROJECT CONSTRUCTION PHASE

Sl. no	Item	Phase	Parameters	Frequency	Location	Cost (Rs. in Lakhs)
1	Effluent from septic tanks / STP	Construction	pH, BOD, COD, TSS, TDS	Once every month	Before and after treatment at each septic tank.	5.20
2	Water Quality	Operation	pH, BOD, COD, TSS, TDS	Thrice an year	Damsite 1 km upstream and 1 km downstream	2.20
3	Effluent from STP	Operation	pH, BOD, COD, TSS, TDS	Once every week for 5 years	Project colony	15.00
4	Air quality	Construction	SPM, RPM, SO2 and NOx	Once every season - twice a week four consecutive weeks	Dam site	1.20
5	Meteorological aspects and setting up of laboratory	Construction	Wind direction & velocity, temperature, humidity, rainfall	Once every season - twice a week, four consecutive weeks	Dam site	10.00
6	Noise and integrating sound levels meter	Construction	Equivalent noise level (Leq)	Once in three months	At major construction site.	5.00
7	Water-related diseases	Construction	Identification of water related diseases, adequacy of local vector control and curative measures, etc	Three times a year	Labour camps and villages adjascant to project area.	8.20
					Total	**46.80**

Table - 22.2 : KELO PROJECT
SUMMARY OF ENVIRONMENTAL MONITORING PROGRAMME DURING PROJECT OPERATION PHASE

Sl.no	Items	Parameters	Frequency	Location
1	Water	pH, Temperature, EC, Turbidity, TDS, Calcium, Magnesium, Total hardness, Chlorides, Sulphates, Nitrates, DO, COD, BOD, Iron, Zinc and Manganese	Thrice a year	♦1km upstream of dam site ♦Reservoir ♦1 km downstream of dam site.
♦2	♦Effluent from Sewage Treatment Plant (STP)	♦pH, BOD, COD, TSS, TDS	♦Once every week for 5 years in operation phase	♦- Before and after treatment from Sewage Treatment Plant (STP) at project colony.
♦3	♦Water-related diseases	♦Identification of water-related diseases, sites, adequacy of local vector control and curative measures, etc.	♦Three times a year	♦Labour camps and Villages adjacent to project area

♦

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT

KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XXIII

DAM BREAK ANALYSIS AND DISASTER MANAGEMENT PLAN

Introduction

23.01 Dams involving large investments of money are constructed for economic development of the country (Singh, 1996). Generally, dams serve multipurpose objectives. According to ICLD (International Committee on Large Dams), there are more than 35000 large dams existing throughout the world' and many more are under construction. Every development has to pay a price, and so is with the dams in terms of their failures. There are many instances of dam break. Jansen (1980) has listed historical information on various dam break cases. Three major causes of dam failure are, overtopping failure (inadequate spillway, misuse of road embankment etc.), foundation failure (fault movement, settlement etc.), and piping and seepage of embankment dams. Due to the presence of a dam, there is a feeling of safety and the area becomes thickly populated, and thus, a dam becomes a potential source of disaster due to the risk of its failure. When a dam fails, the sudden release of the reservoir water forms a catastrophic flood and it results in the catastrophic loss of life and property. Consequently, dam-safety programs have been developed in most countries of the world as a result of safety against dam breaks.

23.02 The characteristics of a dam break flood are different from those of an ordinary natural flood. Very high peak discharges during a short time, occurrence of bores or shock waves, fast and violent flooding of the banks resulting in strong two-dimensional effects, presence of mixed flow regimes, flooding of dry land with abnormal dissipative effects, and transport of debris/solid materials accumulated in the reservoir are associated with a dam break flood. The behaviour of the bed friction causing turbulence during such a flow is not well established, and so is with the dam failure. It leads to a difficulty in calibrating such models. Thus, the dam break flood analysis becomes a special problem to be dealt carefully.

23.03 Dam break flood analysis occupies a very important place in water resources engineering practices (Almeida and Franco, 1994). It is useful in (a) establishing the required dam spillway capacity, (b) environmental and safety impact evaluation of dams or other special structures built in a river valley, (c) valley planning and zoning, (d) implementation of operational emergency and safety procedures, such as warning systems and evacuation plans , and (e) solving special and unexpected problems arising from very high risk of a dam or other river obstruction failure.

23.04 Government of Chattisgarh has proposed a dam across Kelo river in Raigarh district at about 8 km upstream of Raigarh township . The project components relating to the dam are as below :

a) Main dam across Kelo river which is proposed as an earthen dam of Homogeneous section. The maximum height (Bed of river) is 24.22 meters. Length of the dam is 1270m.
b) Saddle dam -1 of 282 meters length, maximum height above ground level being 8.92.
c) Saddle dam – II of 910 meters length, maximum height of dam above ground level being 6.20 meters.
d) Masonry dam of 192 meters length including spillway length of 142 meters. The maximum height of this dam above ground level is 16.00 meters.

23.05 The gross reservoir storage at FRL of +233.00 m is proposed as 60.78 M.cum and the live capacity of the reservoir is 46.607 M.cum only.

23.06 As per MOEF guidelines for preparation of Environment Impact Assessment and Environment Management Plan reports, it is not mandatory for conducting Dam Break Analysis for dams less than a maximum height of 30.00 metres. Since the present main earthen dam is only of 24.22 meters maximum height, the Dam Break Analysis may not be necessary hence not taken up for the study.

Disaster Management Plan

23.07 The spill ways and sluices of the dam of Kelo Project should have adequate capacity to negotiate the probable maximum flood expected at the dam site, so that the dam does not get over topped due to impingement of PMF ensuring no chance of failure. The dam designed has to take into account all forces which are likely to act on them during its life time specifically is respect of seismic forces. Utmost quality control need to be taken during its construction ensuring no possibility of dam failure. The present chapter is focused on the strategy for Disaster Relief in the event of maximum flooding in the river against inundation even without dam failure.

Kelo River

23.08 Kelo river is one of the tributaries of Mahanadi river. The river orginates in the Dangra forests near Hirapur (v) about 70 km upstream of the proposed dam site. The catchment area comprises of about 40% of forests with moderate vegitative cover.

23.09 The modified Probable Maximum Flood (PMF) now computed and recommended to be adopted as designed flood is 8473cumecs. The project area does not fall within very heavy rainfall area. It is necessary to adopt good management practice for release of water above the flood line gradually so that the villages downstream of dam are not effected. Project authorities should develop their own materological experts for prediction of accurate rainfall in the catchment area and water levels in the reservoir. Necessary flood warnings shall be issued whenever warranted.

23.10 Generally, over flows into the reservoir occur during the monsoon periods i.e., from June to October. The rainfall in the catchment area will influence maximum surface water levels. The down pour and heavy rainfall can be taken as a signal for occurrence of heavy flows. At the same time occurrence of depressions due to the disturbances in Bay of Bengal also lead to slow recession of inflows. As such these five factors also have to be kept in mind to counter the maximum surface flood water levels.

Disaster Management

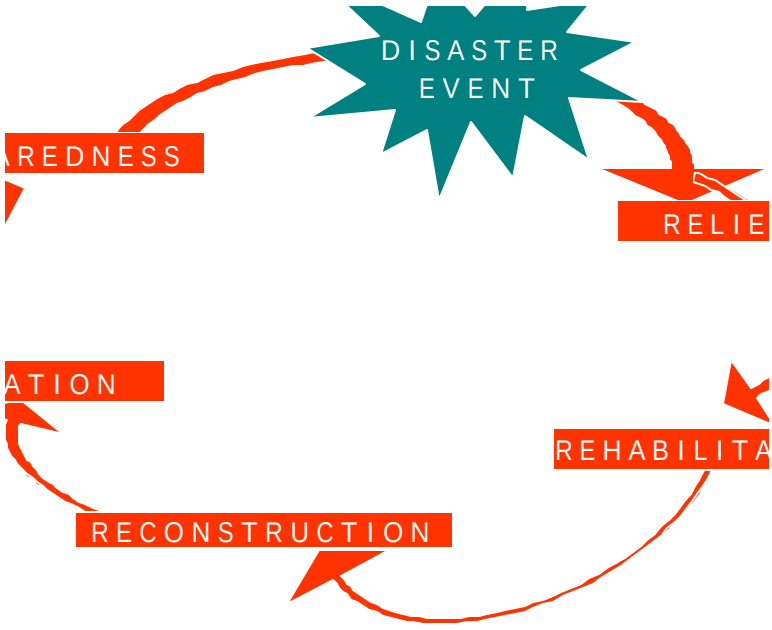
23.11 The disaster is an example of failed or unsustainable development which can only be prevented or mitigated by adoption of more sustainable development practices. Therefore, a disaster can be defined as a serious destruction of economic and/or environmental system entailing widespread losses which exceed the ability of the affected society to cope using only its own resources (UNDP 1997).

23.12 This calls for better planning and development which can prepare for and prevent or mitigate every sudden onset of disaster. The risk of such disaster is part and parcel of the economic, technological and social organisations. There are no perfect solutions. Such is the nature of disaster. Therefore, planning phases of the disaster cycle (reconstruction and

mitigative) have to be linked into the rest of the Cycle.

Disaster Management Cycle

23.13 The general conceptual frame work for Disaster Management Cycle is depicted below:



Dam Safety Surveillance Unit (DSSU)

23.14 Since prevention is better than cure utmost care should be taken in planning, designing and ensuring quality control measures during implementation phase. However, since disasters are most unpredictable in nature it is proposed an exclusive dam safety surveillance unit to take care all precautionary measure by undertaking dam surveillance round the clock throughout life time of the project. Some of the indicative functions of the DSSU are:

1. Constant and regular monitoring of surface water levels in river Kelo and the inflows into the reservoir.
2. Constant vigilance of maximum flood discharge during monsoon from upper reaches of the catchment, from the tributaries of river Kelo
3. Monitoring of the spill ways, embankments, etc.
4. Identification leakages, damages, etc. to the earth dam at various levels
5. Periodical review of cross sections of dam to take timely repairs of the Dam.

Delineation of Vulnerable Areas

23.15 The blocks / villages in the low lying areas below the Dam along the river which are prone to heavy submergence and many villages in these areas warrant special attention and requires relief and rescue operations. The blocks situated in the down stream of the Dam along the river spread which is very wide, and where there are no flood bunds to some of the blocks on either sides, are prone to high inundation. The vulnerable areas likely to get affected due to unprecedented flood discharge need to be identified and delineated.

Transportation Diversion Routes

23.16 In such situation there is every possibility of interruption to transportation during the floods when the flood level reaches flood warning levels and the more the water level raises the more inundation of road takes place. The regular traffic will be interrupted due to raising water level and total transportation system either by road or river will be cut off. Whenever such situation arises and the men and material to be transported, there is an imminent occurrence of traffic interruption of road due to inundation. Hence, it is necessary to take experience of the past at what level such obstruction will occur and how the situation should be overcome. Identifying the diversion routes is pre-requisite to organise the flood waters planning and boat conveyance. Available mini vans can be taken if the water level is high. Particulars of diversion routes have to be obtained from the concerned departments and the authorities concerned to plan out sending men and material and to take up rescue operations .

Use of Generators

23.17 During the disaster there is also a possibility of power failure due to which the batteries connected to the HAM sets & Motor sets will be discharged and the communication systems will be affected. Charging of batteries for use by HAM sets and Motorola sets can be done by using the generators available locally in the private and public organizations.

Monitoring Relief Operations

23.18 It was the practice that senior officers from State level were sent by the Government to over-see and monitor the arrangements and effective implementation of the relief operations. The Officers having experience in disaster management in the past and having knowledge of environmental conditions and acquaintance of the areas are to be

deputed. Therefore, it is necessary to have the data of the Officers deployed from other districts who have worked during the past disasters to suggest the Government and request for their services in the hour of need. It is also necessary to plan out deployment of the staff and services and goods available within and outside the district for effective and quick management of situations.

Air dropping Food Packets

23.19 Air dropping of food packets, medicines have to be resorted to during the inundation. As such, the places where air dropping of food packets have to be taken up has to be identified and listed in advance. There will be sale and consumption of dead fish and meat of dead animals during floods. Sufficient propaganda should be made not to consume such fish or meat during floods season as they may lead to spread of epidemics.

Supply of Drinking Water

23.20 Adequate arrangements are also to be made well in advance for supply of drinking water sachets and milk packets.

Post -flood Operations

23.21 Flood relief operation in the affected areas have to continue for longer periods. Post flood operations also should be taken up for rehabilitating the evacuated people, restoration of power supply, telecommunications and improving sanitary conditions by way of spraying bleaching powder, lime, phenol etc. To save the lives of the cattle, awareness should be created among the villagers that they should not tie the cattle and they should leave the cattle freely.

Role of Participant Agencies

23.22 During pre-post inundation periods various agencies both government line departments and private agencies are involved in relief operations and each one agency has to perform their duties and responsibilities as given below :

1. CENTRAL WATER COMMISSION

23.23 The Central Water Commission will have to play a pivotal role as every action of disaster management is solely depended on its forecast. The CWC will collect water levels of Kelo river and tributaries at various stations and furnish to the concerned Joint Collector. Based on this information, water level at dam site will be assessed 48hrs before, and steps taken accordingly to alert the low-lying areas for avoiding damage to public and private properties, human cattle loss etc. It will also issue advance flood forecast and warnings well in advance to the District collector Raigarh.

.

2. ELECTRICITY / TELECOMMUNICATIONS DEPARTMENT

23.24 The Divisional Engineer should take steps for disconnection of power supply to the villages which are affected. After receding of water, both departments should visit the affected areas, clear lines of electricity / telephone poles, inspect damages caused and restore public utilities as quickly as possible.

3. POLICE DEPARTMENT

23.25 The Police Department shall be kept on "ALERT" from the time of level of reading first working to. It must install public confidence that their properties and belonging are properly guarded in the event of evacuation. It should also install VHF sets in all the earmarked places by deputing personnel for operation of sets/passing of messages. In addition to this, two constables to each Mobile Team should be deputed for rescue and relief operations. During post disaster operation, the monetary relief released for disbursement to the victims should b escorted.

4. FIRE SERVICES

23.26 The Fire Service Department during disaster has to evacuate the people who are trapped on building tops on the tree tops and also on hillocks. People can be shifted to safer places where water cannot enter. The people can be resettled from collapsed buildings etc., with the help of their staff. In special case the Department has also to take up supply of Drinking water to the relief camps.

5. MEDICAL & HEALTH DEPARTMENT

23.27 The Medical & Health Department has to play a very vital role during the disaster. All the activities will be taken up under the over-all supervision of the District Medical & Health Officer, D.M & H.O. During floods season, the Department shall ensure that all ambulances and other vehicles are road worthy, fill up all vacant posts in the vulnerable blocks either by transfer or by deputation from other blocks. They shall procure and stock sufficient quantities of required medicines by indenting the same and shall be able to supply the same to all the concerned PHCs by the end of June. The Department shall constitute and provide medical staff to the Village Teams, Zonal Teams and the Mobile Teams and the orders for the same shall be issued well in advance.

23.28 They shall also organize Medical Teams to be posted at all the relief camps. During the month of June itself the department shall take up health education in all the vulnerable villages and ensure that general sanitation in these areas is maintained effectively. During disaster they shall ensure that the teams shall be available in all the vulnerable villages and take up the detection and treatment of Gastro-enteritis, Diarrhea and fever cases, distribution of ORS Packets, Chlorine tablets for spot chlorination, checking of public water supply systems, spraying of bleaching powder as disinfectant, sanitary

.
disposal of wastes shall be taken up by the medical teams. Mobile Medical Teams shall move by boats if needed and by other means of transportation to render medical aid to marooned villages.

23.29 Post disaster relief measures include surveillance of Malaria, Gastro-enteritis, Diarrhea & Dysentery and spraying of disinfectant to prevent epidemics. Maintenance of Public Water supplies, erecting temporary toilets shall be organized at relief camps to prevent epidemics.

Village team shall consist of the village Leaders, panchayat members, teachers and paramedical personnel i.e. ANM's for undertaking medical relief measures.
ZONAL TEAMS shall consist of 3 to 4 para-medical personnel covering a group of villages to undertake the medical relief.

6. ANIMAL HUSBANDRY

23.30 The Animal Husbandry Department should stock sufficient quantities of medicines and fodder in advance to swing into emergency during menace besides chalking-out detailed programme for precautionary measures by constituting teams to prevent cattle diseases, epidemics and estimation of loss to the live-stock. The Animal Husbandry Department shall ensure that all the Veterinary Doctors at block Level are available at headquarters and shall ensure that there is no spread of animal diseases and ensure that precautionary vaccination shall be taken up well in advance. They should also shall conduct survey on cattle loss and submit report in the Detailed Data Sheet.

7. AGRICULTURE DEPARTMENT

23.31 One of the major tasks after the disaster will be assessment of damage to standing crops. Besides preliminary survey by the Revenue Department, the Agriculture Department shall conduct comprehensive survey on the crop losses/lands due to sand-cast. It shall distribute seeds and educate farmers on methods for reclamation of eroded lands.

8. WATER RESOURCES DEPARTMENT

23.32 The main role of the Water Resources Department is that they shall collect hourly reading of water levels at different places and accordingly alert their staff for attending to strengthening of weak bunds, opening surplus courses to drain-off excess water. Patrolling has to be done near the weak points of Irrigation sources to avert any breaches. Whenever necessary, immediate repairs to the breaches are to be attended on priority basis. During the peak monsoon season the irrigation Department shall form village level teams at all major sources for monitoring the breaches. They shall also ensure that the senior officers are stationed strategically to take up remedial action as and when required in the flood prone blocks.

.

9. R & B DEPARTMENT

23.33 Immediately after receding of floods, the Engineering personnel of R&B Department shall visit entire area, estimate damages caused to Roads, Culverts and Buildings etc. Besides removal of fallen trees/collapsed tenements, whenever necessary, immediate repairs have to be taken on war-footing basis to restore vehicular traffic. Further, topo sheets have to be kept ready with Sub-Collectors to coordinate air dropping of food packets by the Pilots.

23.34 The R&B Department shall ensure that the alternative routes shall be in roadworthy condition and if needed, to take up urgent repairs in advance. They have also to ensure that in the areas inundated with water all the buildings are still livable and certify the same before evacuated people return back to these areas. The villagers shall be allowed to go back to their houses only after certification about the livability of the houses and buildings by the R&B Department. The Department shall particularly maintain all Government buildings and ensure that none of the building shall be damaged beyond a point for all these buildings would be inhabited by a lot of Government staff who will be monitoring the flood.

10. PANCHAYAT RAJ DEPARTMENT

23.35 Similarly, the Engineering personnel of PR Department should visit the affected area, inspect losses to their department infrastructure like school buildings, roads, tanks, drinking water sources and estimate of loss may be submitted to the concerned authorities. It should also take up immediate repairs to restore public utilities, wherever necessary.

11. PUBLIC HEALTH / GRAM PANCHAYAT

23.36 In the District there are notified Gram Panchayats and non-notified Gram Panchayats. Each non-notified Gram Panchayat shall ensure a minimum stock of 2 bags of bleaching powder, 20 bags of lime and all other notified gram Panchayats shall maintain a stock of 10 bags of bleaching powder and 50 bags of lime for the purpose of sanitation. Similarly Gram Panchayat, shall maintain 20 bags of Bleaching Powder and 100 bags of lime and around 10,000 chlorine tablets. This stock shall be maintained since July onwards.

23.37 During post disaster, the affected areas will be full of debris and slush scattered all over the houses as well as roads and drains. At this juncture, the Public Health / Gram Panachayat have to swing into action for cleaning up and spraying of Bleaching powder in the entire area to prevent out-break of epidemics.

23.38 The Public Health Department also shall ensure that protected water is supplied to the victims in relief centers. They shall also take up the supply of water in sealed polythene sachets of 250 ml, 500 ml or any other convenient capacity. The sachets can be packed

.

into cartons and transported to the places where relief camps are being run.

12. WELFARE DEPARTMENTS

23.39 The Social Welfare / Tribal Welfare Departments have to reserve three months advance stocks of essential commodities in their Hostels functioning in the vulnerable areas. During the disaster, they are responsible for preparation of food and water packets and to load them in to the Helicopters for air dropping.

13. NCC / SCOUTS & GUIDES

23.40 The services of NCC / Scouts and Guides can also be utilised as the victims will have to face much difficulty in shifting their household goods and other belongings to the safer places. Their services will be of great utility in terms of providing man power support to the administration for running relief camps and providing other services.

14. TREASURIES & ACCOUNTS DEPARTMENT

23.41 As financial constraints may hamper the disaster management efforts, it is inevitable to relax the Treasury Rules during devastating floods period. The Sub-Treasury Officers concerned should take immediate action to release monetary relief on the basis of requisition by the Sub-Collector / RDO under TR-27.

15. ROLE OF PRESS & MEDIA

23.42 The role of Press & Media is particularly important as it helps in allaying fears of public. The Press & Media should be in close touch with the administration from the commencement of season for flashing of news items in the daily news papers/ Radio & TV about the impeding disaster situation. This would help educate the people about the possible hazards, steps to mitigate the distress and role Government / NGOs are playing. This at times may be in the form of interviews / short lectures and be broadcasted periodically through AIR / TV.

16. ROLE OF NGOs

23.43 As and when any catastrophe takes place, the service oriented NGOs will take part in the relief operations. At this point, it is very important to avoid duplication of relief being extended by them. Hence, to avoid this, the Sub-Collectors involved in relief operations shall make a request inviting them to contribute their help in cash, so that the same can be utilised for purchasing the needy items being assessed at the dimensional Main Control Room from time to time to the flood victims. The NGOs have to consider this and to come forward with their succor. This will also help in money being used in the optimum manner basing on the local needs, instead of NGOs preferences and their experiences in the past that might not be different and might be not replicable in the present

.

arena. NGOs help should be sought also in terms of providing Distress Counseling and also providing manpower support to the administration. During post disaster the Sub Collectors shall convene a meeting of all NGOs and request them to adopt a particular village or affected area for concentrated efforts. Role of NGOs is quite crucial also in terms of smooth running of Relief camps.

INDIA
CHATTISGARH STATE
RAIGARH DISTRICT
KELO PROJECT

Volume - I

ENVIRONMENT IMPACT ASSESSMENT
AND
ENVIRONMENTAL MANAGEMENT PLAN

PART - IV
ENVIRONMENT MANAGEMENT PLAN

XXIV

COST OF ENVIRONMENTAL MANAGEMENT PLAN

Introduction

24.01 Based on the assessment of Environmental impact on land, water, flora and fauna a detailed Environment Management Plan excluding Rehabilitation and Resettlement plan has been formulated for protecting the environment and ecology in respect of the proposed Kelo Project in Raigarh District. The R&R Plan has been discussed and details furnished in volume II of the report. The Environment Management Plan proposed in the present study (Vol.I) covers Catchment Area Treatment, Command Are Treatment, Conservation of Bio-diversity, Land Management, Public Health Aspects and fishery development aspects. The present chapter is thus focused on the financial requirements for implementation of the proposed EMP as envisaged in the report. The various components of EMP and their costs are narrated below:

Catchment Area Treatment

24.02 Catchment Area Treatment (CAT) is a crucial and essential component of the EMP. The main propose is to prevent further degradation of land and deterioration of natural eco system in the catchment area (free catchment area) of the reservoir, arrest soil erosion and thus prevent or minimize siltation. This programme includes treatment of agricultural lands through formation of graded bunds, and vegetative barriers. Execution of gully control works by construction of rock fill dams, check dams etc. During the catchment area analysis it is noticed that certain sub-watersheds need gully control works and other soil conservation

measures. Required treatments are proposed for the catchment area of the reservoir which worked out to Rs. 335.00 lakhs, out of which cost of bunding etc. will be borned by beneficiaries. The cost to be borne by Department will be Ra. 150.00 lakhs.

24.03 The command Area Development programme is aimed at preparing the agricultural lands of the beneficiaries to receive the Irrigation waters from the distributaries which are fed by the canal network from the reservoir. The Command Area Development works are of two types. The excavation of field channels right up to the last holding and the formation of drainage outlets is done by the Water Resources Department. The beneficiary farmers are required to undertake systematic land development and form internal field channels and drains within their holdings. Conjunctive use of ground water has been proposed. The expenditure to be incurred both by Water Resources Department for Command Area Development would be of the order of Rs. 1236 lakhs. This programme may be phased over the 1st 2nd and 3rd years of the project so as to be aligned with the work on canals and distributaries.

Conservation of Bio – Diversity

24.04 The project are a involves submersion of forest lands to an extent of 361.90 ha which needs compensatory Afforestation. Compensation towards double the submersion land i.e., 724 ha has been paid to Forest department for procurement. The EMP has proposed for compensatory Afforestation, Green belt development canal bank plantations and three gardens in lieu of loss of land scape. The EMP also proposed for the development of reservoir fisheries. Provision has been made towards restoration of quarry sites and muck disposal plans. The total financial requirements towards conservation of Bio-diversity including Land Management and fisheries development works out to Rs. 600 lakhs .

24.05 The impoundment of water through construction of the project results in incidence of water borne and vector borne diseases in the project area due to increase in migration of labour during construction phase as well as impoundment of water after construction. The existing health delivery system need to be suitably strengthened to cope up with the anticipated increase of health hazards during construction of the project and need suitable mitigative measures. To meet the growing health hazards during construction and post-construction periods, Spraying of insecticides, larvaecides, etc have been proposed. Provision for protected drinking water supply to the labour colonies, malaria surveillance, construction of sanitary latrines, and improvement in health delivery system solid waste management, effluent treatment plants, have also been proposed. The total cost of water quality and public health delivery system in the project area district during the project period is estimated as Rs. 477.0 lakh.

Environmental Monitoring Programme

24.06 Environmental monitoring is an essential component for sustainability of any water resources project. Monitoring of critical parameters is essential in the project operation

phase. The critical parameters include water quality, air quality and meteorology, noise and public health aspects. The analysis work can be conducted by a reputed external agency recognized by the State pollution control Board in association with the project proponents. The total cost of the programme is estimated about Rs. 90 lakh.

Resettlement and Rehabilitation

24.07 The Department of land resources (DLR), Ministry of Rural Development (MORD), Government of India formulated a policy entitled "National Policy on R&R for PAF – 2003. The policy has been modified in 31st October 2007. The cost of R&R plan as per the above policy and along with Chattisgarh state Gazette notification of 2007 has been worked out. The cost of R&R and land acquisition worked at to Rs. 1686 lakh towards acquisition of private lands totaling to 750.00 ha.

Proposed Outlay on EMP

24.08 The total cost of different components of the EMP in respect of Kelo Major Irrigation Project works to Rs. 2553 lakhs, which is the basic cost. A further allowance of 15 percent is made towards price escalation allowance is (10%) and physical contingencies (5%). Thus adding an amount of Rs. 382.95 lakhs towards the above component, the aggregate outlay on EMP amounts to Rs. 2935.95 lakhs excluding R&R component. The cost towards Resettlement and Rehabilitation is Rs. 1686 lakhs. Adding price escalation and contingencies at 15%. The Resettlement and Rehabilitation cost would be Rs. 1938.90 lakhs. The component wise break up of EMP cost is given in Table - 24.1.

Table – 24.1
KELO PROEJCT
TOTAL COST OF EMP

Rs. in lakhs

Sl.no	Component	Total out lay	Beneficiary share	Net
1	Catchment Area Treatment	335	185	150
2	Command Area Development	2963	1727	1236
3	Conservation of Bio-diversity	600	-	600
4	Public Health Management	477	-	477
5	Environment Monitoring Programme	90	-	90
	Total Base Cost	**4465**	**1912**	**2553**
	Add 15% for price escalation & Contingencies	669.75	286.80	382.95
	Grand Total	**5134.75**	**2198.80**	**2935.95**

Table - 4.5 : KELO RIVER BASIN

OBSERVED STAGE - DISCHARGE DATA (Discharge in cumecs)

Sl.no	Months	2001-2002			2002-2003			2003-2004			2004-2005			2005-2006			2006-2007			2007-2008		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
1	June	-	-	-	9.29	34.40	16.30	10.00	20.00	13.40	12.30	58.00	-	-	-	-	15.60	48.20	27.20	6.17	124.00	19.40
2	July	-	-	-	8.47	65.50	22.10	8.23	52.80	27.00	21.70	85.00	21.70	19.60	111.00	54.10	11.10	218.00	57.90	4.73	802.00	59.40
3	August	21.90	160.00	53.20	15.70	49.20	33.80	27.70	102.00	53.90	30.40	394.00	38.40	28.10	180.00	68.80	28.00	117.00	60.30	14.80	242.00	48.00
4	September	12.40	54.20	27.10	12.70	114.00	46.00	37.40	180.00	95.20	22.60	49.10	124.00	27.70	98.10	42.10	17.70	94.40	41.10	14.00	162.00	41.10
5	October	9.25	60.70	19.40	10.70	58.30	15.40	23.90	81.40	40.10	24.20	51.80	27.60	31.90	98.10	38.00	11.10	19.30	14.80	8.16	32.90	13.10
6	November	7.94	18.40	11.40	17.30	22.40	20.10	23.30	86.70	32.10	23.90	30.80	32.80	30.20	36.20	32.90	17.10	22.80	19.10	6.77	24.00	9.10
7	December	-	-	-	12.10	17.30	14.70	18.10	23.00	19.90	16.10	23.30	27.70	26.20	30.70	28.20	15.00	20.20	17.30	-	-	-
8	January	8.03	9.79	8.30	8.84	12.80	10.60	19.00	20.70	19.70	12.40	16.70	19.10	20.20	25.60	23.90	2.25	2.73	2.51	-	-	-
9	February	7.94	9.22	8.69	9.92	13.70	12.20	18.80	20.60	19.40	12.90	16.40	14.60	17.10	19.00	17.90	2.09	4.09	2.49	-	-	-
10	March	8.53	10.30	9.12	11.00	13.40	11.90	12.20	18.80	16.80	11.10	12.40	14.30	16.10	18.00	16.60	1.63	2.33	2.06	-	-	-
11	April	9.19	10.30	9.69	11.10	12.10	11.70	14.10	17.90	15.20	10.10	11.40	11.70	13.60	17.10	15.30	0.49	1.63	0.87	-	-	-
12	May	8.69	9.65	9.26	11.10	12.20	11.90	12.10	14.20	13.20	-	-	10.10	12.10	24.60	14.80	-	-	-	-	-	-

Table – 5.6 : KELO PROJECT

LIST OF ALGAL SPECIES RECORDED FROM THE RESERVOIR AND COMMAND AREAS OF THE KELO IRRIGATION PROJECT DURING THE RAINY & WINTER SEASONS.

Names of Algae	Division
Chlamydomonas sp.	Chlorophyta or green algae
Chlamydomonas reinhardi	Chlorophyta or green algae
Chlorella vulgaris	Chlorophyta or green algae
Chlorella pyrenoidosa	Chlorophyta or green algae
Chlorococcus sp.	Chlorophyta or green algae
Gonium pectorale	Chlorophyta or green algae
Pandorina sp.	Chlorophyta or gree n algae
Pandorina morum	Chlorophyta or green algae
Eudorina elegans	Chlorophyta or green algae
Volvox sp.	Chlorophyta or green algae
Hydrodictyon sp.	Chlorophyta or green algae
Pediastrum duplex	Chlorophyta or green algae
Pediastrum boryanum	Chlorophyta or green algae
Tetraspora sp.	Chlorophyta or green algae
Synedra acus	Chlorophyta or green algae
Scenedesmus acuminatus	Chlorophyta or green algae
Scenedesmus dimorpha	Chlorophyta or green algae
Scenedesmus obliques	Chlorophyta or green algae
Scenedesmus quadricauda	Chlorophyta or green algae
Spirogyra sp	Chlorophyta or green algae
Ulothrix sp.	Chlorophyta or green algae
Oedogonium sp.	Chlorophyta or green algae
Cladophora sp.	Chlorophyta or green algae
Chaetophora sp.	Chlorophyta or green algae
Chara sp.	Charophyta
Euglena proxima	Euglenophyceae
Euglena intermedia	Euglenophyceae
Euglena pisciformis	Euglenophyceae
Euglena [illegible]	Euglenophyceae

Euglena oxyuris	Euglenophyceae
Euglena viridis	Euglenophyceae
Vaucheria sp	Bacillariophyceae
Ankistrodesmus falcatus	Bacillariophyceae
Asterionella sp.	Bacillariophyceae
Navicula cuspidata	Bacillariophyceae
Navicula viridis	Bacillariophyceae
Navicula cryptocephala	Bacillariophyceae
Melosira granulata	Bacillariophyceae
Melosira various	Bacillariophyceae
Diatoma vulgare	Bacillariophyceae
Pinnularia sp	Bacillariophyceae
Cyclotella sp. *Triceratium sp*	Bacillariophyceae Bacillariophyceae
Chroococcus sp.	Cyanophyceae
Microcystis aeruginosa	Cyanophyceae
Gleocapsa sp.	Cyanophyceae
Gleotrichia sp.	Cyanophyceae
Anabaena constricta	Cyanophyceae
Rivularia sp.	Cyanophyceae
Lingbya sp.	Cyanophyceae
Oscillatoria limosa	Cyanophyceae
Oscillatoria tenuis	Cyanophyceae
Oscillatoria chlorina	Cyanophyceae
Oscillatoria princepes	Cyanophyceae
Oscillatoria chlorina *Oscillatoria putrida*	Cyanophyceae Cyanophyceae
Oscillatoria splendida	Cyanophyceae
Nostoc sp.	Cyanophyceae

Table – 9.1 : KELO PROJECT
MAJOR POLLUTANTS, THEIR SOURCES AND EFFECTS ON HUMAN HEALTH, VEGETATION, MODULES AND AESTHETICS

Pollutants	Major sources	Human Health	Vegetation	Materials	Aesthetics/Nuisances	Comments
CO_2	Transportation, Industrial processes	Reacts with haemoglobin, reducing mental attentiveness, physical exertion and exacerbating cardio vascular disease symptoms	None	None	None	Past knowledge was based on study of high exposure for short periods with healthy, young individuals. New data show possible health effects for susceptible persons at CO levels in the blood found in urban populations
NOx	Transportation space heating/cooling, power generation	Interfere with respiratory function producing long term (chronic) disease symptoms	Reduction of growth of broad leaves plants (tomatoes, beans)	Accelerated deterioration of dyes and paints	Creation of a brownish color in urban air	Conclusion are based on limited exposure of healthy adults to low doses, extensive animal studies, and only limited data relevant to ambient condition
HC	Transportation, Industrial processes	Interfere with respiratory functions and cause eye irritation	None	None	None	Indirectly polluting through the production of photochemical oxidants upon reaction with NO & NO_2 in the presence of sunlight
Photo Oxidants	Transportation space heating/cooling, power	Same as HC	Severe reduction in death and	Ozone causes the cracking of rubber and	Ozone has a distinct although not terribly offensive odour.	O_3 is the most common type and the key indicator for

Table – 9.1 : KELO PROJECT
MAJOR POLLUTANTS, THEIR SOURCES AND EFFECTS ON HUMAN HEALTH, VEGETATION, MODULES AND AESTHETICS

Pollutants	Major sources	Human Health	Vegetation	Materials	Aesthetics/Nuisances	Comments
	generation		eventual death of leafy vegetables, field and forage crops, shrubs, fruit and forest trees caused by Ozone and PAN	the accelerated deterioration of nylon, rayon, dyes and paints.		Photo Oxidants. Health effects are based on limited and inadequate data. Ozone, PAN are formed by atmospheric reactions
SOx	Space heating/cooling, power generation, Industrial processes	Little effect on pure gas form; similar effects as particulates when combined with them	Reduction of growth of broad leaves plants	Corrosion of iron, metal, accelerated deterioration of building stone, cotton, paper, leather, paints etc.	Scattering of sunlight to produce haze production of unpleasant odours	SO_2 is readily converted to SO_3 and then to H_2SO_4
Particulates	Space heating/cooling, power generation, Industrial processes, oil erosion	Interfere with respiratory function, possible contribution of lung cancer	Reduction of plant growth by physical blockage of light on the leaf surface	Soiling of fabrics and building and corrosion of metals when combined with SO_2	Creation of smog plumes, scattering of sunlight to produce colorful sunsets & helps formation of fog	The effects of particulates are difficult to separate from those of SO_2