CHAPTER 6

Environmental Impact Assessment (EIA) and Environmental Management Plan

6.1 INTRODUCTION

The present era of fast development and growth is aimed at raising the quality of human life by providing greater opportunities for employment, better provisions of basic amenities and comforts, healthy environment ensuring physical and mental well-being of humans. Also growth and development lead to several environmental problems like pollution of the air, water and soil, depletion of natural resources, energy crisis, occupational health problems, and global problems like climate change, ozone layer depletion, and loss of biodiversity. Thus, development is bound to have certain environmental impacts. It was about 40 years back when it was realized that before a development project is started, prediction and assessment of its impacts should be done, so that measures could be taken to minimize those impacts. This concept was formulated as a methodical procedure known as **Environmental Impact Assessment (EIA).**

6.2 IMPACTS

The changes caused by a development project on the landscape and ecology of the area and on the quality of water and air along with that on various socio-economic aspects of human life is defined as impact.

Impacts could be categorized in different manners:

(A) **Positive and negative impacts:** Some of the development actions have beneficial impacts while others have deteriorative or adverse effects. Accordingly they are designated as positive and negative impacts.

For example, most development projects are aimed to raise the quality of life. Thus, there are usually positive socio-economic impacts like better employment opportunities, better infrastructure facilities, better medical facilities etc. However, sometimes the project (*e.g.* a big dam) has serious negative socio-economic impact on the local inhabitants who are uprooted from their native place. Their displacement and rehabilitation are big issues to be tackled.

Similarly, pollution caused by various emissions from a project has negative impact, whereas the same project could be useful from ecological point of view if it involves development of vegetation or a forest that provides habitat for some wildlife. Thus, every project or development has certain positive and negative impacts, which have to be assessed.

(B) **Reversible and irreversible impacts:** Some of the impacts caused by the development projects are for a short-term and could be reversed over a period of time by adopting appropriate control or remedial measures.

For instance damage caused to a water body near the development area would be considered reversible if we are able to restore its quality using proper treatment technologies.

However, if a development activity involves destruction of a forest and loss of habitat of some endangered or endemic species, it is an irreversible impact. Thus an irreversible impact is one which is a long-term impact that cannot be restored.

Therefore, irreversible impacts should be very carefully assessed.

(C) **Light, moderate and severe impacts:** The magnitude of the impacts caused by a development project needs to be assessed. It could be light, moderate or severe. The magnitude of such impacts could be represented in different ways:

(*i*) By putting round symbols varying in size:

∘ Small ○ Medium ◯ Severe

(*ii*) By assigning numerical values:

+/–1 Small positive or negative impact

+/–3 Medium positive or negative impact

+/–5 Severe positive or negative impact

In different systems, different numerical scales could be taken. In the above example, a scale of 1 to 5 has been taken, where 1 is very little impact and 5 represents severe impact.

6.3 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment (EIA) is a procedure to plan some developmental activity with well-defined environmental goals so that damage due to the activity both during developmental stage and production stage have minimum impact on the natural system and the population in the area.

The National Environmental Policy Act (NEPA) U.S.A. in 1969 first of all provided the guidelines for environmental impact assessment through Council for Environmental Quality (CEQ).

In India, the gazette notification of EIA was issued in 1994 vide which the Ministry of Environment and Forests provided guidelines for project proponents to have EIA and prepare an Environmental Impact Statement prior to clearance of the project.

Goals of EIA

(*i*) To fulfill the responsibilities towards the coming generations as trustees of environment.

(*ii*) To assure safe, healthy, productive, aesthetically as well as culturally pleasing surroundings.

(*iii*) To provide widest range of beneficial uses of environment without degradation or risk to health.

(*iv*) To preserve historical, cultural and natural heritage.

(*v*) To achieve a balance between population and resource use for a good standard of living.

(*vi*) To ensure sustainable development with minimal environmental degradation.

6.4 EIA METHODOLOGY

The basic steps followed in EIA are screening, scoping, base line data, impact identification, prediction, evaluation, mitigation, EIS preparation, review and environment audit, involving public participation at various stages, as shown in Fig. 6.1.

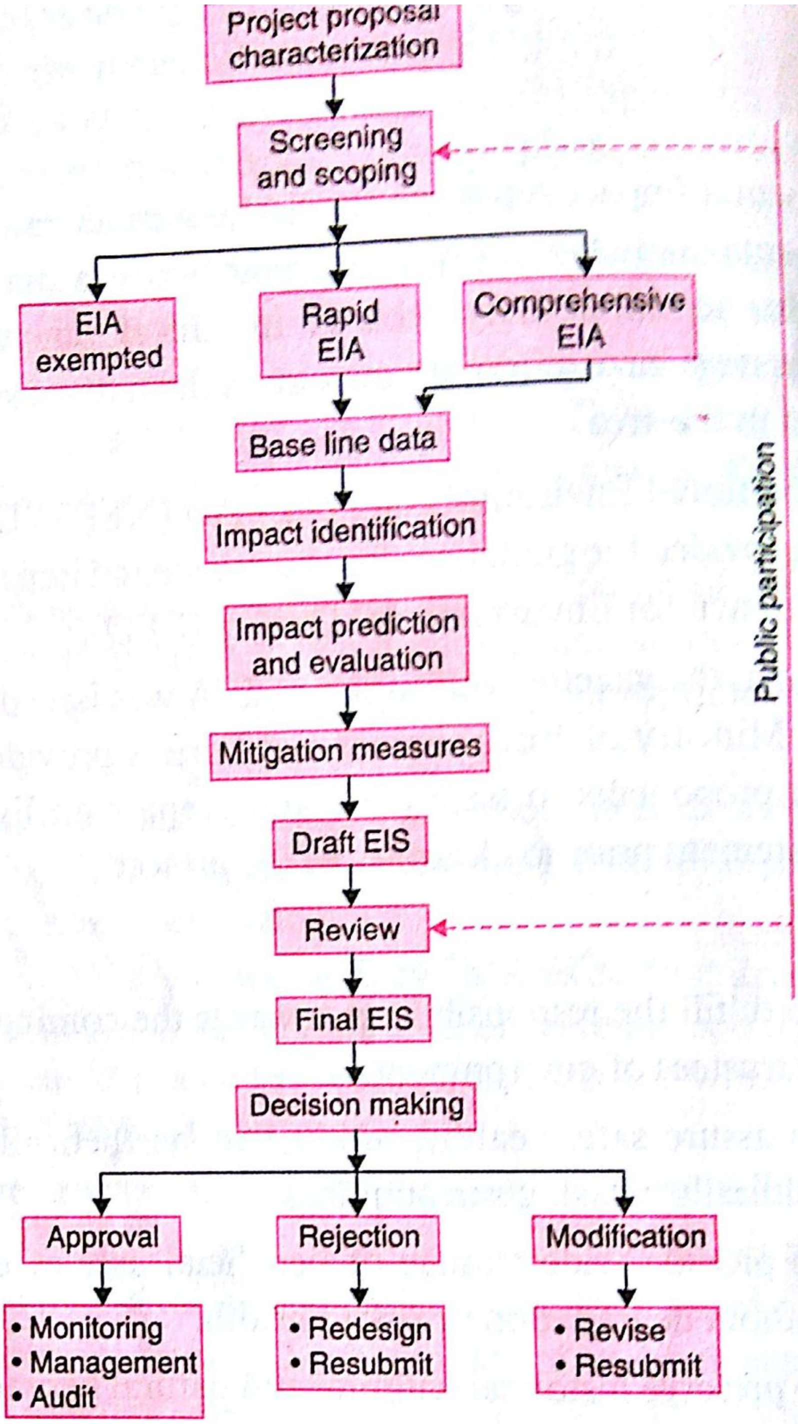

Fig. 6.1. EIA methodology flow-chart

(*i*) **Screening** is done to see whether the project needs an EIA for clearance or not. Further, there are some prohibited areas where generally development projects are not allowed *e.g.*, Coastal Regulation Zone (CRZ), Dahanu Taluka in Maharashtra, Aravalli range, Reserve forests etc.

(*ii*) **Scoping** involves determination of the extent of EIA required for the project. Depending upon the project, basically two types of EIA may be carried out. When the EIA report is based on a single season data (other than monsoon period), it is called *rapid EIA*. When the EIA report is based on detailed seasonal data, it is called *Comprehensive EIA*.

(*iii*) **Baseline data** gives a holistic picture of the overall environmental setting of the project location showing any significant environmental items prior to initiation of the action; any potentially critical environmental changes and information about the site to the decision makers and reviewers, who might be unfamiliar with the general location of the project area.

The following environmental parameters are usually considered while preparing the baseline data:

(*a*) Site location and topography.

(*b*) Regional demography – population distribution within 10 and 50 kilometer radius; land-use and water-use pattern.

(*c*) Regional landmarks like historical and cultural heritage in the area. For this archaeological or state register can be checked.

(*d*) Geology – Land form, soil type, landscape etc. are studied.

(*e*) Hydrology – Groundwater and surface water resources are quantified; water quality, pollution sources etc. are studied.

(*f*) Meteorological – Temperature extremes, wind speed and direction, dew point, atmospheric stability, rainfall, storms etc. are recorded.

(*g*) Ecology – The flora, fauna, endangered species, successional stage etc. are enlisted.

For a particular project, some of the parameters may be important while for others, some other parameters could be important.

(*iv*) **Impact identification:** It includes the details of project characters and baseline environmental characteristics to ensure the identification of full range of environmental impacts.

During identification process, the positive and negative, direct and indirect significant and insignificant impacts are considered.

(*v*) **Impact prediction:** Here magnitude of changes going to occur due to the project are predicted by using mathematical models or mass balance models.

(*vi*) **Impact evaluation:** Impact evaluation is done by considering the costs and benefits of the project. Long-term effects and side-effects of the project are also evaluated. Indirect valuation of environmental parameters are also done. *e.g.*, loss of a rare species, degradation of a lake etc.

(*vii*) **Mitigation:** Once the impacts are predicted and evaluated, mitigation measures are to be suggested to avoid, reduce or rectify the adverse changes due to the project.

Review and a draft impact statement is prepared at this stage.

(*viii*) **Decision analysis:** Public participation is involved by arranging group discussion or by adopting questionnaire method to arrive at a decision about the project and its evaluation.

(*ix*) **Environmental impact statement (EIS):** Based on the data obtained and review suggestions a final EIS is prepared as per the format provided by the Ministry of Environment and Forests in our country.

The EIS clearly mentions the objectives of the project, its environmental impacts, impacts that are unavoidable, mitigation measures to minimize the impacts, alternatives to the proposed action etc.

(*x*) **Environmental audit:** It compares the impacts predicted in EIS before the project was started and actual impacts after implementation of the project.

6.5 METHODS OF BASE-LINE DATA ACQUISITION

Base-line data on the site location, geology, hydrology, meteorology, ecology and any historical or cultural heritage are collected by primary or secondary methods. **Primary data** is collected by actual visit to the site and study of various parameters, while **secondary data** could be collected by consulting data available on the parameters from other sources.

(*i*) **Secondary data collection:** Various government agencies and boards have the relevant data available with them on a time-scale-basis. While Meteorological stations possess the data on annual rainfall, humidity, temperature, evaporation, soil temperature, wind speed and wind direction, the Agriculture Departments can make available the data on cropping patterns and irrigation. Archaeological Departments can provide us the required data on any historical or cultural heritage of the area. Base-line data on ground water level, surface water resources are also available in various Water Boards. Census data provides useful base-line information on population, demography, socio-economic status, etc.

(*ii*) **Primary data collection:** This can be done by actual visit to the area and collection of data by survey method. Scientific methodology can be adopted for assessment of all relevant parameters and questionnaire method can be used to collect data on socio-economic aspects, occurrence of some diseases, information on some important natural, cultural or historical heritage, etc.

(*iii*) **Use of remote sensing and GIS for data acquisition:** Satellite data available through remote sensing and use of Geographical Information System (GIS) are very useful modern techniques for acquisition of base line data on vegetation, land-use, land-cover, water bodies, major soil types, water-logging, deforestation, urbanization, irrigation systems, water resources, industrial growth etc. The data acquired on satellite imageries and digitized and overlayed by GIS to get a comprehensive account of various parameters. Ground truthing is however, necessary to confirm the interpretation of the images.

6.6 IMPACTS OF DEVELOPMENT ON DIFFERENT ENVIRONMENTAL COMPONENTS

Development activities have impacts on different environmental components:

(*a*) **Human resources:** Human beings are largely affected by the project both in a positive and negative manner.

- **Socio-economic status** of the local population or in catchment area is influenced because of development of infra-structure facilities like roads, transportation, settlement colonies with proper hygienic conditions, medical facilities, educational, recreational and commercial facilities.

  Employment opportunities improve and earnings increase which promote further investments, savings and development.
- Sometimes, however, the local population has to be displaced from the site of development project, *e.g.*, that in case of construction of a huge hydro-electric project. Due to submergence many villages have to be vacated, which

disturbs and seriously affects the outsees. Proper rehabilitation policies for resettlement of the outsees should be adopted. With great consideration of their socio-economic and psychological conditions.

- **Human health** may have to face serious adverse impacts due to gaseous emissions, particulates, effluent discharges and toxic and hazardous solid wastes generated from industries, big thermal power plants, mining activities etc. While polluted air, water and soil pose several health hazards, the people actually working in such sites are more adversely affected by occupational health hazards.

  Sometimes there are epidemics of water-borne or such vector-borne diseases like Malaria, Schistosomiasis etc. in areas where development projects lead to water-logging or submergence (*e.g.*, big dams).

(*b*) **Air:** Quality of air is affected by various development projects during construction phase and operational phase. Suspended particulate matter, SO_x, NO_x, volatile hydrocarbons, CO, CO_2, heavy metals etc. are emitted by different processes, which deteriorate air quality and affect human health, other living organisms as well as materials.

Wind speed and wind direction, along with other meteorological conditions play significant role in determining the magnitude of impact on the population.

Noise pollution due to various development projects also have very serious long-term or short-term impacts.

(*c*) **Water:** Development activities influence water quality of the region. Water is also required for various activities. Thus both water extraction and water pollution are closely associated with various projects. Various toxic chemicals and debris enter into water bodies with effluent and run-off, thereby adversely affecting water quality and aquatic life. Huge organic load entering into water bodies deplete the dissolved oxygen and lead to fish mortality. Bioaccumulation of various toxic heavy metals in aquatic plants and their magnification through the aquatic food chain ultimately affect human health.

Sometimes groundwater aquifers are contaminated due to development activities and their remediation is a difficult task. Sometimes the course of natural rivers are changed due to a project, which can later have serious implications. Where water is used as a coolant, thermal pollution of the water bodies is a major impact.

(*d*) **Flora and fauna:** Big development projects involving large areas like hydropower plants (big dams), mining activities, big industries often involve clearing of natural vegetation. Since hydropower projects are usually located in hilly areas, the forests are cleared or submerged leading to loss of natural flora and loss of habitat for the fauna. If such a project is proposed in a site inhabiting rare, endangered or endemic species, every effort should be made to change the site, because loss of such flora and fauna would be irreversible impact.

Pollution caused by various projects also have adverse impacts on flora and fauna leading to large scale mortality of many species.

6.7 PREDICTION OF IMPACTS

Before a project is started, the possible impacts of the project actions are predicted in advance under the EIA methodology as discussed earlier.

Two important models of impact prediction are:

(*i*) **Mechanistic/Mathematical model:** The cause and effect relationships of various activities due to the project are expressed in the form of a flow chart.

The various components and their relationships in the flow chart are then expressed in the form of mathematical equation.

This is frequently done for predicting socio-economic impacts.

We can predict the impacts of a thermal power plant or an industry by predicting how much emissions would be there and what would be the distribution/transmission pattern, that would affect people/flora/fauna. Mathematical models are quite useful in making such predictions, in which we include mathematical expressions of various important parameters influencing dispersal of the pollutants in the air under the prevailing meteorological and topographic conditions.

Prediction of impact of a project on downstream water quality is also successfully carried out using mathematic models.

(*ii*) **Mass-balance model:** This is usually adopted where physical changes are involved. Here a systems approach is taken and all inputs into a system are balanced by the outputs under steady state conditions. Thus, at steady state:

$$\text{Inputs } (I_1 + I_2 + I_3) + \text{Outputs } (O_1 + O_2 + O_3) = \text{Zero}$$

This works on materials balance theory. So while we know about the inputs, we can predict the outputs.

6.8 ENVIRONMENTAL IMPACT STATEMENT (EIS)

The EIS is prepared by the project proponents at the time of submission of the proposal, which is known as the *draft EIS*. After evaluation and review by the Impact Assessment Agency, the *final EIS* is prepared.

The following points are usually incorporated while preparing the EIS:

- Effect on land including land degradation and subsistence.
- Deforestation and compensatory afforestation.
- Air pollution and dispersion along with possible health effects.
- Water pollution including surface water and ground water pollution.
- Noise pollution due to the project.
- Loss of flora and fauna due to the project during construction.
- Socio-economic impacts including displacement of native people, cultural loss and health aspects.
- Risk analysis and disaster management plan.
- Recycling and reduction of waste.
- Efficient use of inputs including energy and matter.

EIA is done with an aim to select the best alternative through which adverse impact on the environment can be nullified or minimized without compromising with the economic and social benefits of the development project.

Thus, the main purpose of EIA is precisely to estimate the type and level of damage caused to natural environment in a well-defined time scale so that remedial measures can be initiated on those aspects requiring action at the right time.

6.9 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

After impact prediction and evaluation an environmental management plan (EMP) is prepared so as to minimize the negative impacts, increase the positive impacts and restore the damages done to different environmental components. A comprehensive list of measures to be taken is included in the EMP which includes mitigation measures and future guidelines for maintenance of a good quality environment, as discussed below:

6.9.1 TECHNOLOGICAL SOLUTIONS

There are technological solutions to many of the adverse impacts caused by various development activities. Cleaner technologies are emerging that produce much less pollutants in the environment. Recovery and recycling processes further help in minimizing the adverse impacts. Selection of appropriate technology with appropriate use of raw materials in the process are important in reducing the impacts.

6.9.2 PREVENTIVE METHODS

In order to prevent or avoid damage to the environment by a development activity, the harmful or hazardous substances produced should be handled properly and removed from that site to some safe area where they could be properly disposed of.

To prevent the loss of habitat of some wild-life due to a project, measures are taken in advance for safe and timely migration of such species to another nearby forest (which could be an artificially afforested area).

To prevent the loss of top fertile layer of the soil during mining operations, layer by layer dumping of the soil is done during digging, which are later restored.

To prevent the adverse visual/aesthetic impact of some projects several measures are taken that include use of sensitive building designs with proper colour matching with local environment, use of silt traps and planting of vegetation covers.

6.9.3 CONTROL METHODS

The control the damage due to various emissions coming from development projects like industries, power plants or highway projects with stone-crushing units various control methods are available. Particulate matter can be controlled using cyclone separators, bag house filters, wet scrubbers or electrostatic precipitators. Various gaseous pollutants can be adsorbed or condensed using suitable methods. Boundary walls around stone crushing units and use of frequent water spray help prevent the particulate emissions moving to nearby areas.

6.9.4 TREATMENT METHODS

To convert the harmful substances produced by various industrial projects, into less harmful nature or to reduce their concentrations to safe permissible limits, treatment methods are available. For treatment of the waste waters we have primary treatment, secondary treatment and tertiary treatment technologies by using which, the suspended solids, organic wastes and some harmful methods and excess nutrients are removed from the waters. Both aerobic and anaerobic treatment methods are available.

6.9.5 GREEN BELT DEVELOPMENT

Trees and shrubs are known to act as sinks of many toxic gases and particulates. They also absorb CO_2 and release O_2, thus purifying the air. Recently, they are also reported to attenuate noise. Therefore, development of green-belts around development sites has been made mandatory. There are hundreds of types of species available, but we have to select those species in our green-belt, which are adapted to that climate and soil type, and which have a higher capacity to tolerate and absorb the toxic pollutants. Succulent and broad-leaved trees generally show greater air pollution tolerance index (APTI). There are several species that are hyperaccumulators of heavy metals. Such species should be selected for green-belt in sites where metal contamination is predicted.

6.10 RAINWATER HARVESTING

Rainwater harvesting is a technique of increasing the recharge of groundwater by capturing and storing rainwater. This is done by constructing special water-harvesting structures like dug wells, percolation pits, lagoons, check dams etc. Rainwater, wherever it falls, is captured and pollution of this water is prevented. Rainwater harvesting is not only proving useful for poor and scanty rainfall regions but also for the rich ones.

The annual average rainfall in India is 1200 mm, However, in most places it is concentrated over the rainy season, from June to September. It is an astonishing fact that Cherapunji, the place receiving the second highest annual rainfall as 11000 mm still suffers from water scarcity. The water flows with run off and there is little vegetation to check the run off and allow infiltration. Till now there is hardly any rain-water harvesting being done in this region, thereby losing all the water that comes through rainfall.

Rainwater harvesting has the following objectives:

(*i*) to reduce run off loss
(*ii*) to avoid flooding of roads
(*iii*) to meet the increasing demands of water
(*iv*) to raise the water table by recharging ground water
(*v*) to reduce groundwater contamination
(*vi*) to supplement groundwater supplies during lean season.

Rainwater can be mainly harvested by any one of the following methods:

(*i*) by storing in tanks or reservoirs above or below ground.
(*ii*) by constructing pits, dug-wells, lagoons, trench or check-dams on small rivulets.
(*iii*) by recharging the groundwater.

Before adopting a rain-water harvesting system, the soil characteristics, topography, rainfall pattern and climatic conditions should be understood.

Traditional Rainwater Harvesting

In India, it is an old practice in high rainfall areas to collect rainwater from roof-tops into storage tanks. In foot hills, water flowing from springs are collected by embankment type water storage. In Himalayan foot-hills people use the hollow bamboos as pipelines to transport the water of natural springs. Rajasthan is known for its *'tankas'* (underground tanks) and *khadins* (embankments) for harvesting rainwater. In ancient times we had adequate *Talaabs*, *Baawaris*, *Johars*, *Hauz* etc. in every city, village and capital cities of our kings and lords, which were used to collect rain-water and ensured adequate water supply in dry periods.

Modern Techniques of Rainwater Harvesting

In arid and semi-arid regions artificial ground water recharging is done by constructing shallow percolation tanks. Check-dams made of any suitable native material (brush, poles, rocks, plants, loose rocks, wire-nets, stones, slabs, sacks etc.) are constructed for harvesting runoff from large catchment areas. *Rajendra Singh of Rajasthan popularly known as "water man" has been doing a commendable job for harvesting rain-water by building checkdams in Rajasthan and he has been honoured with the prestigious Magsaysay Award for his work.*

Groundwater flow can be intercepted by building groundwater dams for storing water underground. As compared to surface dams, groundwater dams have several advantages like minimum evaporation loss, reduced chances of contamination etc.

In roof top rainwater harvesting, which is a low cost and effective technique for urban houses and buildings, the rain-water from the top of the roofs is diverted to some surface tank or pit through a delivery

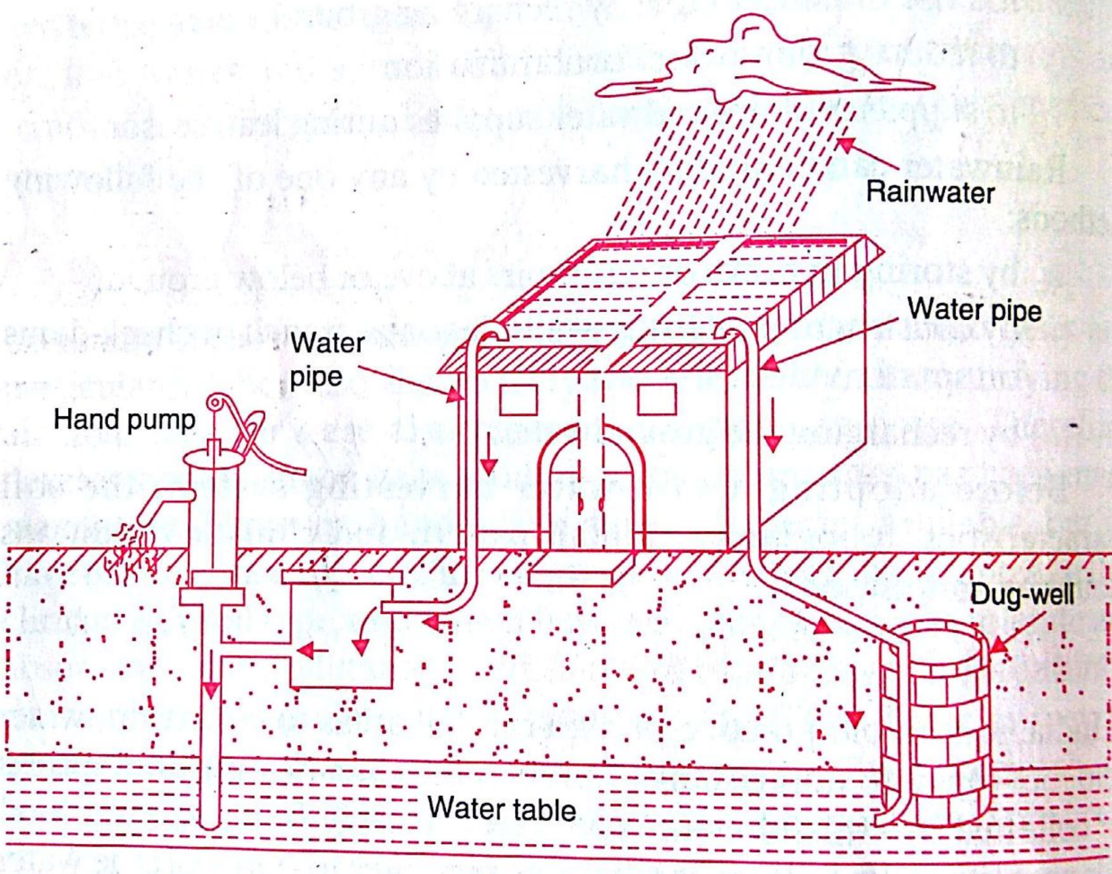

Fig. 6.2. Roof-top rainwater harvesting by recharging (*i*) through hand pump or (*ii*) through abandoned dugwell.

system which can be later used for several purposes. Also, it can be used to recharge underground aquifers by diverting the stored water to some abandoned dug-well or by using a hand pump (Fig. 6.2).

All the above techniques of rainwater harvesting are low-cost methods with little maintenance expenses. Rainwater harvesting helps in recharging the aquifers, improves groundwater quality by dilution, improves soil moisture and reduces soil erosion by minimizing run-off water.

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WATERSHED MANAGEMENT

The land area drained by a river is known as the river basin. The **watershed is defined as the land area from which water drains under gravity to a common drainage channel. Thus, watershed is a delineated area with a well-defined topographic boundary and one water outlet**. The watershed can range from a few square kilometers to few thousand square kilometers in size. In the watershed the hydrological conditions are such that water becomes concentrated within a particular location like a river or a reservoir, by which the watershed is drained. The watershed comprises complex interactions of soil, landform, vegetation, land use activities and water. People and animals are an integral part of a watershed having mutual impacts on each other. We may live anywhere, we would be living in some watershed.

A watershed affects us as it is directly involved in sustained food production, water supply for irrigation, power generation, transportation as well as for influencing sedimentation and erosion, vegetation growth, floods and droughts. Thus, management of watersheds, treating them as a basic functional unit, is extremely important and the first such Integrated Watershed Management was adopted in 1949 by the Damodar Valley Corporation.

Watershed degradation: The watersheds are very often found to be degraded due to uncontrolled, unplanned and unscientific land use activities. Overgrazing, deforestation, mining, construction activities, industrialization, shifting cultivation, natural and artificial fires, soil erosion and ignorance of local people have been responsible for degradation of various watersheds.

Objectives of Watershed Management: Rational utilization of land and water resources for optimum production causing minimum damage to the natural resources is known as watershed management. The objectives of watershed management are as follows:

(*i*) To rehabilitate the watershed through proper land use adopting conservation strategies for minimizing soil erosion and moisture retention so as to ensure good productivity of the land for the farmers.

(*ii*) To manage the watershed for beneficial developmental activities like domestic water supply, irrigation, hydropower generation etc.

(*iii*) To minimize the risks of floods, droughts and landslides.

(*iv*) To develop rural areas in the region with clear plans for improving the economy of the region.

Watershed Management Practices

In the Fifth Five Year Plan, watershed management approach was included with a number of programmes for it and a national policy was developed. In watershed management, the aspects of development are considered with regard to the availability of resources.

The practices of conservation and development of land and water are taken up with respect to their suitability for peoples' benefit as well as sustainability. Various measures taken up for management include the following:

(*i*) **Water harvesting:** Proper storage of water is done with provision for use in dry seasons in low rainfall areas. It also helps in moderation of floods.

(*ii*) **Afforestation and agroforestry:** In watershed development, afforestation and crop plantation play a very important role. They help to prevent soil erosion and retention of moisture. In high rainfall areas woody trees are grown in between crops to substantially reduce the runoff and loss of fertile soil. In Dehradun, trees like *Eucalyptus* and *Leucaena* and grasses like *Chrysopogon* are grown along with maize or wheat to achieve the above objectives. Woody trees grown successfully in such agroforestry programmes include *Dalbergia sissoo* (Sheesham), *Tectona grandis* (Teak) and *Acacia nilotica* (Keekar) which have been used in watershed areas of river Yamuna.

(*iii*) **Mechanical measures for reducing soil erosion and runoff losses:** Several mechanical measures like terracing, bunding, bench terracing, no-till farming, contour cropping, strip cropping etc. are used to minimize runoff and soil erosion particularly on the slopes of watersheds. Bunding has proved to be a very useful method in reducing runoff, peak discharge and soil loss in Dehradun and Siwaliks.

(*iv*) **Scientific mining and quarrying:** Due to improper mining, the hills lose stability and get disturbed resulting in landslides, rapid erosion etc. Contour trenching at an interval of 1 meter on overburden dump, planting some soil-binding plants like *Ipomoea* and *Vitex* and draining of water courses in the mined area are recommended for minimizing the destructive effects of mining in watershed areas.

(*v*) **Public participation:** People's involvement including the farmers and tribals is the key to the success of any watershed management programme, particularly the soil and water conservation. People's co-operation as well as participation has to be ensured for the same. The communities are to be motivated for protecting a freshly planted area and maintaining a water harvesting structure implemented by the government or some external agency (NGO) independently or by involving the local people. Properly educating the people about the campaign and its benefits or sometimes paying certain incentives to them can help in effective people's participation.

Successful watershed management has been done at Sukhomajri Panchkula, Haryana through active participation of the local people.

Watershed management in Himalayan region is of vital importance since most of the watersheds of our country lie here. Several anthropogenic activities accelerate its slope instability which need to be prevented and efforts should be made to protect the watershed by preventing overgrazing, terracing and contour farming to check runoff and erosion etc. On steeper slopes with sliding faces, straw mulching tied with thin wires and ropes helps in establishing the vegetation and stabilizing the slopes.

Unit - IV

Bioremediation :

The use of microbes to remediate (or) restore the contaminated sites is termed as bioremediation. It is a clean up technology that uses naturally occuring organisms to degrade & transform various hazardous chemicals to less harmful & non-toxic compounds. Bio remediation of a contaminated site typically works in one of the two ways.

In one case micro organisms eat/digest organic substances as a source of food & energy.

In the second, less common case, specialized microbes are added to degrade the contaminants.

Bioremediation techniques :

Bio remediation test technologies have been broadly decided into two categories.

(i) Insitu ii) Ex situ :

In-situ Bio remediation : remediation process is stimulated within the affected env.

(a) Bioventing : Aerobic degradation of soil contamination is stimulated by delivering of O_2 to the sub surface, is accomplished by injecting air through unsaturated soil at low flow rates (or) boring holes in the soil. The addition of nutrients especially N_2 & P enhances the aerobic bacterial degradation & converts the toxic organic substances into harmless simple compounds like CO_2 & H_2O. This Technology was designed primarily to treat soil contamination by fuels, non-volatile organic compounds (VOC's), pesticides & herbicides.

Bio simulation: In-situ bio remediation involves stimulation of degradative activities of indigenous micro-organisms in the sub-surface by the addition of water based solution carrying nutrients, electron acceptors & other amendments. This technology was designed primarily to treat soil & ~~ground~~ ground water contamination by fuels, VOC's & Pesticides.

Bio augmentation:

It is the controlled addition of specifically formulated bio-cultures to assist those found naturally in the soil. The selected micro organisms must be carefully matched to the waste contamination present in the soil. Bioaugmentation ensures that the proper number & sufficient type of microbes are present in the soil, which effectively attack the waste constituents & break them into their basic compounds.

Ex Situ Bioremediation : Unit - IV.

The process of remediation is stimulated outside the effected environment.

(i) land farming: The technologies involves the application of contaminated materials that has been poured onto the soil surface & periodically tilled to mix the material. It involves ploughing, tilling of contaminated soil on site with the application of water, nutrients & microbial culture. It is designed primarily to treat contamination by fuels, VOC's, pesticides, halogenated organics & herbicides.

Slurry phase treatment: This technique involve the treatment of excavated soil & sediment in the controlled env. of a bioreactor.

Bioreactor is provided with an adequate aeration & mixing with acceptors & nutrients, specialized micro-organisms, Temp & pH are also adjusted to provide suitable environment in the reactor vessel.

This technique is used to treat contaminants like petrochemicals, solvents, pesticides, penta-chlorophenols, PCB's, poly chloro phenol, coal tar.

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