CHAPTER X
MITIGATION MEASURES

10.1 INTRODUCTION

Guwahati, being the nerve centre of all the major economic activities of the North Eastern India, holds the key position to attract people from the entire region. As a result, the growth of population in this city is inevitable. However, as topography here is rugged and it encircles this city – there is no plain habitable area. This has lead to move the urbanization to hills as well as to the low-lying areas. Urbanization of the area under study and the city which is very fast growing has forced the society to reside in environmentally risky areas such as steep hills slope prone to landslide as well as susceptible to soil erosion. While on the other hand, growing construction activities are increasing the impervious cover leading to the reduction of recharge and thus causing depletion of ground water level.

10.2 MITIGATION MEASURES

The term ‘mitigation’ means measures taken in advance of a hazardous event, which are aimed at decreasing or eliminating its impact on society and environment. Effective mitigation measures reduce or minimize the effects of disasters. In some circumstances, mitigation
measures prevent disasters from occurring; hence they act as disaster prevention.

Mitigation measures if taken at the right time - would reduce the hazard, also the environment and communities' interaction could be restricted. A rigorous and systematic risk management analysis process would help communities to identify the most cost-effective combination of measures for the possible risk, which is envisaged.

Mitigation will consist of a number of related actions, many of which would consist of no more than awareness development, ensuring effective management and control of site or operational activities. At the other end, some measures will form a permanent and integral element of the development and its operation. Considering the mitigation measures, appropriate means of monitoring their effectiveness should be considered. Despite the best intensions, a lack of effective implementation will lead to unnecessary conflict and may lead to delays in execution of the measures. Furthermore, commitment to mitigation should also include post-project monitoring of the performance of any permanent mitigation measure.

Planning the mitigation measures, the usage of GIS can be successfully implemented - which would help in risk and vulnerability assessment maps, study of loss pattern etc. This technology proves to be very powerful, helpful for analysis and determination of risk areas zoning and likely effects during disasters. The maps can also be successfully used
in establishing response priorities, developing action plans, quick disaster assessment, for carrying out search and rescue operations effectively, zoning them accordingly to risk magnitudes, population details and assets at risk. The GIS and Remote Sensing facilitate record keeping and obtaining status of on going works, which are the most critical task in disaster management, and this can be the best usage of this technology.

10.2.1 Soil Erosion Control Measures

There are four basic principles for soil erosion control. They are, (a) dissipate the power of rain by intercepting by vegetation, mulch or other materials, (b) minimize the rate of runoff by increasing infiltration and by maximizing the use of water by plants, (c) prevent runoff generating excessive power by controlling slope, and stopping the accumulation and concentration of flows, and (d) increase the resistance of the soil by increasing its structural strength by raising fertility (via organic cycling) and incorporating sound tillage practices. The ultimate success of soil erosion control measures depend on how the nature of the erosion problem has been identified and on the suitability of the conservation measures selected to deal with the problem. Erosion-control measures proposed must be relevant to the present situation and a sound landuse/land cover plan is important for soil conservation, whereby the land is used for what it is best suited under present or proposed economical and social conditions, land tenure arrangements and production technology.
As per the field study, it can be affirmed that the accelerated soil erosion from the hills in the study area is still limited within sheet erosion. Rill or gully erosion is not seen anywhere. Depending on the climatic condition of the area, the following measures will be fruitful remedy to check soil erosion and to control further deterioration.

A. Forestry Measures: Forests are the most effective means of conserving soil and moisture. The leaves and branches of trees, shrubs and grasses help break the force of the falling rain and, together with the plant litter on the ground, keep the rain from eroding the soil particles and splashing them about and thereby sealing up the millions of pores of the soil surface.

At many isolated spots in the hills of the study area, it is seen that due to illegal falling of trees, forest density has reduced drastically, i.e., the spots are practically degraded and are in denuded stages. Moreover, there are natural blanks resulting out of geological processes. These areas have physical characteristics, which can be maintained permanently by afforestation, reforestation and enrichment planting, so that the area is protected.

Keeping in view the tropical condition, its organic content, loose structure and vegetation with respect to altitude, the following species are suggested to fill up the blanks suitably.
(i) **Hollock (Terminalia myriocarpa):** It is an indigenous species, well grown in the area. As its timber is good for furniture, plywood and cabinet work, its demand in urban and rural areas is high.

(ii) **Borpar (Ailanthus grandis):** This is a tall tree with conical crown having optimum yield of wood. It is generally used for semi-chemical pulp.

(iii) **Gamari (Gmelina arborea):** It is an excellent all purpose timber and has maximum demand in the market. It can be conveniently used for vacancy filling.

(iv) **Khokan (Duabanga grandiflora):** Grows well in the foothills and is good for covering landslips, exposed soil etc. Timber is used for panelling and also as fuel wood at short rotation.

(v) **Bogi Poma (Chukrasia tabularis):** Grows in well-drained soil in the plains and help to cover the ground. An excellent veneer making timber, it is good for plywood.

(vi) **Toon (Toona ciliata):** Grows well in lower hill forest and is an extremely hard species to handle. Timber has good demand for panelling.

(vii) **Sisoo (Dalbergia sissoo):** This species is easy to grow and produce very high-grade timber.
(viii) Neem (Azadirachta indica): This is generally grown in nursery beds and then transplanted. Its timber is used for house building, furniture and in oil mills. Its seed gives a fine oil of great economic value. Widely used as disinfectant.

(ix) Amari (Amoora wallichii): It is a good shade bearer and thrives in moist areas of plains where water does not accumulate. It grows straight up with a compact crown. Suitable for vacancy filling and has heavy demand in plywood.

(x) Titasopa (Talauma phellocarpa): Grows in lower hills and timber has good demand for furniture making.

B. Agronomic Measures: Considering the critical period of erosion, the system of strip-cropping at the periphery of the terraces can be worked out. For this purpose, the following types of crops can be grown - which are not only akin to natural vegetation, but are also erosion resistive, in addition to their economic value.

(i) Field Crops (Leguminous)

1. Green-gram Phaseolus aureus Rexb.
2. Rice bean Vigna sinensis L.
3. Soyabean Glycine rux L. Merril
4. Pigeon pea Cajanus cajan L.

(ii) Commercial Crops

1. Groundnut Arachis hypogaea L.
2. Sesame Sesamum indicum L.

(iii) Horticultural Crops

1. Papaya Carica papaya L.
2. Guava Psidium guajava L.
3. Assam lemon Citrus limon L.
4. Lettuce Lactuca sativa L.
5. Tapioca Manihot esculenta Crantz

(iv) Condiments and Spices

1. Cardamom Elettaria cardamomum
2. Ginger Zingiber officinale Rose
3. Pepper Piper nigrum L.

(v) Grass: Grass is considered to be one of the best tools in soil conservation. Considering the climatic condition, growing of the following three types of grass is suggested in the courtyard as well as in the backyard.

1. Citronella Cymbopogon winterianus Jowitt
2. Vetiver Setaria zizanioides Nash
3. Dinanath Pennisetum pedicellatum Trin
C. Other Measures:

(i) Mulching: Applying mulch to an area can greatly enhance erosion control. A healthy layer of mulch, improves water intake, absorbs the impact of falling raindrops, and traps water to slow its movement and hence the area is less likely to lose precious topsoil to a downpour. It also helps to retain soil moisture. Locally available straw may be used for mulching until a permanent cover can be established.

(ii) Waterways: The purpose of waterways in a conservation system is to convey runoff at non-erosive velocity to a suitable disposal point. These waterways are normally protected by grass and may be referred to as grassed waterways. Grass waterways are normally shallow and can be made wide to obtain the maximum spread of water over a wide cross-section. The cross-section of waterways depends on the slope, soil texture and the area to be drained.

(iii) Geotextile: Geotextiles are any textile like material, woven, non-woven or extruded, used in various surface stabilization and surface improvement applications for soil erosion control. Biodegradable geotextiles are generally used for short-term applications. They are generally coir (coconut fiber), jute or straw mats and logs, and lasts several months, sometimes two years or more-ideally until mature vegetation is established.
10.2.2 Landslide Control Measures

Landslide mitigation works are conducted in order to stop or restrict the landslide movement so that the resulting damages can be minimized. They are broadly classified into two categories: (a) control work and (b) restraint work. The control works involve modifications of the natural conditions of landslides such as topography, geology, ground water and other conditions that indirectly control portions of the entire landslide movement. The restraint works rely directly on the construction of structural elements. Specific measures applicable in the present study area are mentioned below.

A. Landslide control works:

(i) Surface drainage control works: The surface drainage control works are implemented to control the movement of landslides accompanied by infiltration of rainwater and spring flow. They include two major steps- drainage collection work and drainage channel works. They are designed to collect surface flow by installing corrugated half pipes or lined U-ditches along the slopes, and then they are connected to the drainage channel. The drainage channel works are designed to remove the collected water out of the landslide zone as quickly as possible, and are constructed from the same material as the drainage collection works.
(ii) Soil removal works: This is one of the methods where the most reliable results can be expected and generally applies to small to medium sized landslides. Generally, the soil removal is focused on the head portion of the slide.

(iii) Buttress Fill works: The buttress fill placed at the lower portions of the landslide in order to counterweight the landslide in order to counterweight the landslide mass. It is most effective if the soils generated by the removal works are used.

B. Landslide Restraint works:

(i) Anchor works: The anchor works utilize the tensile force of the anchor bodies embedded through the slide mass and into stable earth, and are connected to thrust blocks located on the ground surface. The thrust blocks are anchored with a tendon that counteracts the driving forces of the landslide to restrain the slide movement. The advantage is that large restraint forces can be obtained from a relatively small cross sectional tendon.

(ii) Retaining Walls: Retaining walls are constructed to prevent smaller sized and secondary landslides that often occur along the toe portion of the large landslides. Because of the large-scale earth movement and numerous springs that are expected in landslide terrain, crib walls are common instead of conventional reinforced concrete retaining walls.
C. Other measures:

(i) Regular monitoring of the hill slopes should be done in order to predict slope failure.

(ii) Large-scale hill cutting, removal of vegetal cover, construction activities in steep hill slope should be stopped immediately by implementing legislation. In steep slope areas, if necessary, people should be evacuated from such areas.

(iii) Mass participation in solving this problem should be ensured through awareness programmes. People, who stay in slopes, should be educated about the danger of landslide and necessary suggestions must be given in hazard prone areas for stabilizing the slope.

(iv) In case they plan to reside in these slopes, the cutting of the hill slopes must be avoided and cantilevers type of projections need to be encouraged (Figure 10.1 and Figure 10.2). Otherwise slope stabilized construction methodology may be adopted (Figure 10.3 and Figure 10.4).
Figure 10.1: Cantilevers type of projection on hill slopes

Figure 10.2: Cantilevers type of projection on hill slopes

(Courtesy: www.archrecord.construction.com)
Figure 10.3: Uphill dwelling placement
(Source LSA Associates, 1995)

Figure 10.4: Downhill dwelling placement
(Source LSA Associates, 1995)