Chapter 6

Potential of GIS Technology for Monitoring Impacts of Development Activities

6.1 Introduction

Creating infrastructure to provide support services is a government responsibility and, during the planning process, the government established norms to cover geographical areas with these services. Whereas, in the plains, the services can reach a greater number of inhabitants; due to (i) a higher density of population and (ii) easy accessibility (few geomorphic impediments). In hilly regions, the placement of these services in tune with the inhabitants' requirements is more difficult. Sometimes even the geomorphic features render accessibility seasonal (such as a river in spate or a snowy ridge acting as seasonal obstacles). GIS applications have potential for assessing support service requirements and their placement. This application has advantages over the conventional mechanisms, as multi-criteria analysis is not only feasible but much faster with GIS.

All the villages in the watershed are without electricity. Though the Pranmati *Gad* (stream) itself is harnessed for a hydel, the electricity generated meets the requirements of the semi-urban Tharali area. Previously there was no motorable road within the watershed. The nearest motorable road is close to its southern tip at Tharali. Now a motorable road is sanctioned by the government. This road takes off from the Tharali roadhead, passing through Kaira, Dungri, and Ghinapani, and will be connected to the road from Ghat in the northeast, across the watershed. Although the road starts on the left bank of the Pranmati Gad, it soon spans across and goes upwards along the right bank. As a consequence, it cuts across the large landslide to the south of Kaira village. The maintenance cost of such a road, over a constantly mass wasting slope, is going to be high, and, since it traverses dense forests, the impact on the environment is going to be negative.

The change in motion in safety engineering is leading the engineers to attempt development by explicitly estimating the risks. This step is necessary for public (non-technical) involvement in safety decisions, especially where technology choices are an issue (Covello et al. 1983). The potential of GIS for evaluating the feasibility and environmental impacts of different development interventions is demonstrated in this section.

6.2 Methodology

Methods of Soil Mapping

Two methods were employed to investigate soil: One, soils of the area were sampled randomly and classified by a conventional reconnaissance soil survey and, two, farmers' perceptions about soil from their practical experiences were solicited. With random sampling of soils, the area has been classified by the TMU system for soil mapping. Because of poor horizon development in the colluvium type of soil, TMU (based on slope, soil depth, and texture) provides useful mappable units. Considering the hill-specific characteristics, gravel per cent is included in the mapping unit, whereas the slope is dropped since major agricultural land lies under either slopes with low (6-13°) or moderate (13-25°) gradients, but forest lands are very intricate in terms of the nature of slopes. Thus, soil texture, depth, and gravel per cent were the criteria—with decreasing priority. Soil sampling was carried out by auger with low observation intensity for the forest area (1 per 25-50ha) and comparatively high intensity for agriculture (1 per 15ha). Farmers' perceptions about soil provides the simplest way of mapping soil (exclusively for agricultural land) and is quite representative of field observation.

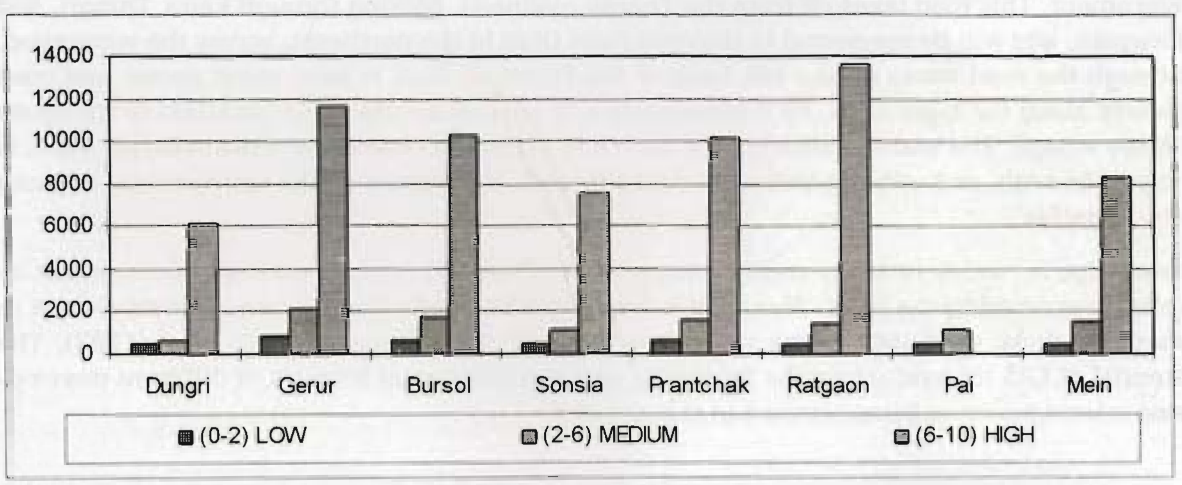
Soil Erosion

Soil loss from agricultural land was studied by means of a 'runoff plot' experiment (in 1993-94). It is simple and inexpensive (Djorovic 1978) and also convenient in remote hilly terrain. Since the average terrace size (10 x 3 m) is small, the experimental plot size (2.5 x 2.5m) was kept much smaller than the normally recommended plot size (20 x 2.5m). Runoff water was collected in a plastic drum and soil loss was calculated from the sediment load of a sub-sample of runoff water. Selected village-wise average soil loss (kg/ha) was generated from the data from three classes of terrace slopes (<2° : low, 2-6° : medium, 6-10° : high) (Fig. 4); only the outward terrace slope angle was considered. Crop-wise and elevation-wise the soil-loss study was also carried out in different villages.

Areas Viable to Agricultural Extension

Marginal lands at high elevation, on steep slopes and in shallow soil cover areas are also being cultivated, and as a result pasture lands and forest areas are being exploited. Expansion of agriculture is likely in future. Presently, wastelands or low altitude pasture are subject to encroachment (Map 23).

Figure 4: Field Soil Loss (kg/ha-1)
In Fifferent terrace slope classes



Erosional Impact of Agricultural Practices

This area is within one of the high (>1000 EI_{30}) mean annual erosivity' (EI_{30}) regions of India (Babu et al. 1978). Soil loss studies have been carried out, mainly in cultivated areas. The permissible limit of soil loss for agricultural practice is commonly fixed between two to 12 metric tonnes/ha/year. Considering the mountain ecology, poor soil growth (only a few areas have soil depths of over 150cm), less active soil masses due to the presence of gravel and boulders, and slow rates of soil formation, the lower limit (2,000 kg/ha/year) is appropriate for assessing soil loss from the watershed. Although the average slope of cultivated land ranges from 5° to 30°, the actual slopes of cultivated terraces are usually less than 10° (Plate 1). The rate of soil loss is found to be significantly higher from terraces with steep slopes (more than 6°) (Plates 10 and 3). Soil loss was also found to be significantly high from fields where potatoes grew, and greater than average from land under non-indigenous crops (e.g., rice) compared to land under indigenous crops (e.g., millet, finger millet, and amaranth). The magnitude of decrease in cultivable wastelands is an ideal index for reckoning the extent of its colonisation (Singh 1990), as these are the areas in which horizontal expansion of cultivated land takes place.

Plate 10: Agricultural fields in narrow and steeply sloping areas of the watershed during millet/cereal cropping. Note that the terraces are outwardly sloping and narrow.

Micro-hydel Proposal

Large hydro-electricity plants disrupt the natural drainage system and the agricultural as well as social systems. Even medium-large (50kVA) hydels involve a great deal of capital and generally their benefits accrue to urban areas. In a remote area which is devoid of modern transport services only micro-hydels are suitable. These would also cause least disturbance to water mills or natural drainage. Thus, a feasibility study for micro-hydel (<20kVA) was carried out and, based on discharge, gradient, and locational utility, seven sites were found suitable (Map 24). One such micro-hydel is operational in one village in the watershed with the active participation of the villagers (Plate 11). In fact, it is operated and can also be repaired by the villagers (Saxena et al. 1994b). The Pranmati *Gad* carries a lean season water discharge of nearly 0.25 cumec. One of the prominent tributaries, Kich *Gad*, has a good potential for micro-hydel power generation. Near Ratgaon, Pranmati *Gad* carries nearly 0.8 cumec of water in lean season and further down at Kaira Bagar the lean season discharge is nearly 1.5 cumec. The power potential of the watershed, estimated on the basis of minimum discharge, is in the order of 3,000kVA.

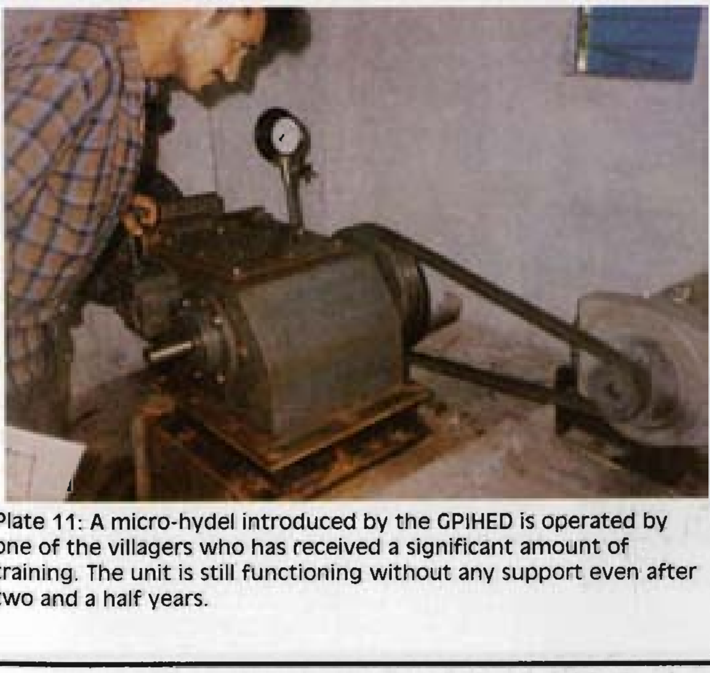


Plate 11: A micro-hydel introduced by the GPIHED is operated by one of the villagers who has received a significant amount of training. The unit is still functioning without any support even after two and a half years.

A 400kVA hydel power project at the entry point of the watershed is almost non-functioning due to the poor maintenance. However, a 200 kVA hydel project is being built by the U.P. Government (through the Non-Conventional Development Agency).

Road Feasibility Study

Since the entire watershed has a rock structure dipping at 50 to 65° towards 45°E of N, the slope aspect was interpreted into: (i) dip (not too stable), (ii) anti-dip, and (iii) along-strike faces. In the case of along-strike slopes, they are of two types, one with the rocks sloping outwards (which are considered to be very unstable for road construction) and the other with rocks sloping inwards (considered relatively stable). This criterion is the basis of risk assessment for road construction activities (Map 6).

6.3 Results

Micro-hydels and Water Mills

There are a number of water mills constructed on the streams near the villages. Water mills are used for grinding food grains. Seven micro-hydel sites (Map 24) have been proposed and one is operational on an experimental basis (Saxena et al. 1994b). Promotion of the generation and use of hydro-electricity would largely benefit the rural people both economically and socially (through child and adult education and mass communications) (Plate 12).

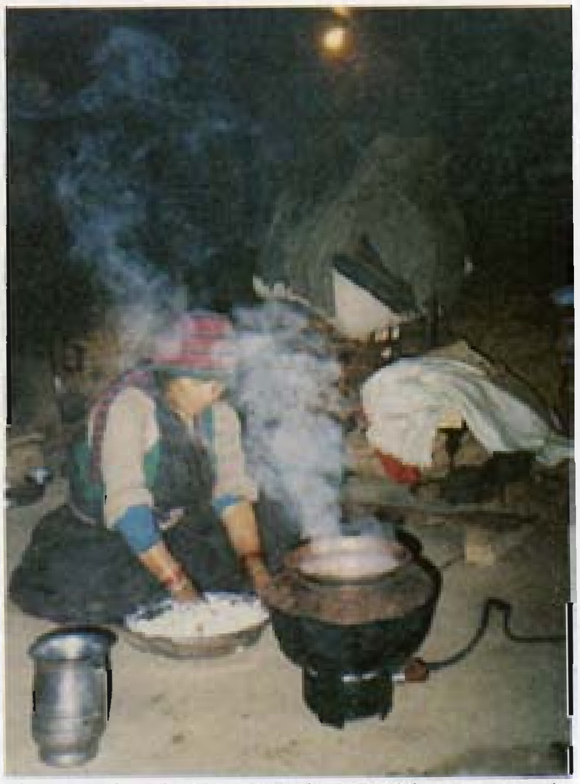


Plate 12: Light has brought cheer to this woman and reduced her drudgery. We expect the introduction, of electricity will reduce the pressure on forests and allow their regeneration

Road Construction

The route of the proposed road was evaluated and classed into three safety categories: very unsafe, unsafe, and comparatively safe zones (Map 6). The road should be built in the safe zone, which would mean following mainly the east bank of the Pranmati *Gad*, whereas the present plan is for the western bank. One way to avoid the erosional impact of the road is to set up cableways connecting villages to the nearest point on the road. Construction of footbridges could also solve the problem of connecting villages across the river. Land-use or land-cover analyses of a 250-metre buffer zone for the proposed road means that the forest area lying in this zone is likely to be adversely affected by road construction, while loss of agricultural land would force farmers to encroach on forest lands. A recent major landslide is being intersected by the proposed road (Map 6) which will aggravate the problem (Plate 13).

Plate 13: The recent landslide which the proposed road is to pass through. Mules and men face these hurdles to survive.

Food Processing

Edible oil is mainly extracted from mustard seeds with some contribution from *til* (sesame seed). The area is self sufficient in edible oil at present. Most of the oil is extracted by diesel-driven machine, since no electricity is available here. Traditional extraction processes are hardly seen due to poor yield and the labourious nature of extraction. Potatoes are overwhelmingly the predominant cash crop. Amaranth comes second as a cash crop. It has good market value, being used as an ingredient for a local sweetmeat. Since two to three per cent of the area is covered by leguminous plants and a substantial proportion of farmyard manure (FYM) is given to potatoes, the soil gets little nitrogen and other elements for other crops. Groundnut cultivation was introduced quite recently as an alternative or a supplement to potatoes. Yields are encouraging (nearly 19 Q/ha), but farmers are reluctant to accept this crop—largely due to the lack of market facilities.

Agroforestry, Fodder, Fuelwood

As such, no agroforestry is traditionally practised in this area. However, some oak trees growing in agricultural wastelands and on field bunds provide green fodder and the twigs are used for fuelwood. Green fodder is also collected from nearby mixed pine and oak forests. The stalks, straw, and husks of millet, finger millet, wheat, and paddy are used as dry fodder. Buffaloes are usually stall fed, whereas cows and goats are grazed on village community lands. Villagers take livestock to alpine pastures from June, and they return in September. Suitability classes of agriculture are shown in Map 25.

Support Services and Infrastructure

The distribution of schools and hospitals is shown in Map 26. Postal delivery service is available to all the villages, Bunga, and Gerur. Rural banking exists at Dungri. Medical services are not particularly satisfactory. A paramedical centre (Dhadar) and Ayurvedic clinic (Dungri) exist. There is a veterinary unit at Dungri. Primary schools are adequate in number but not well distributed, considering the difficult terrain that children face in reaching school

6.4 Conclusions

Development without proper planning is bound to reach unsustainable limits, especially in a world where population pressure and the drive to modernisation co-exist. External inputs to mitigate local problems and develop the area are not likely to be long lasting. Thus, development interventions must capitalise upon and add to indigenous development intervention capacities. Technological inputs, coupled with financial investments, are desired in the Himalayas, both for the people settled in the region and those residing outside. Careful planning is required to facilitate sustainable development (Saxena et al. 1994a).