

25 Operational use of remote sensing and GIS for forest rehabilitation planning

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ABSTRACT

The focus of forest resource management in Malaysia is currently geared towards managing the second growth or second rotation forest in the Permanent Reserve Forest (PRF). To effectively manage the resource much information needs to be collected in particular on the extent and distribution of these forested areas. Even though information on the PRF is systematically collected and recorded, much more need to be gathered as regards the second growth forest. Some of this information can be collected with the help of remote sensing and GIS technologies. This paper highlights the operational use of remote sensing and GIS for forest rehabilitation activities in the second growth forest. Remote sensing technique is used to identify degraded second growth forest, which needs to be rehabilitated. The information was integrated with other spatial information in GIS database which enables analysis to be carried out and decision be made based on various assumptions and scenarios to suit the current suitable forest management (SFM) practices.

INTRODUCTION

Today, among the world's biggest concerns is conserving the existing forest resources to ensure the forest's sustainability for generations to come. Most of the resources are found in tropical countries many of which are developing. A developing country will exploit its natural reserves as much as possible to develop economic and social activities. However, after a series of international conferences and declarations, these developing countries began to realize the importance of sustainability of the forest. Hence steps and measures are being taken to manage the forest sustainably and at the same time derive its benefits. In relation to this, Malaysia, together with other tropical countries rich in

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flora and fauna diversity is committed in taking action to ensure that the remaining forests are managed and ultimately be certified as sustainable managed forests.

At present, most of the natural forests left for harvesting are located in the hill areas, which, due to their poor accessibility has resulted in the need for forest planning. This is where decision-making requires information that is timely, fast, reliable, accurate and easy to manipulate (Ismail *et al.* 1993). Since Malaysia is approaching its second harvesting cycle, information on the status of the forest is very important. Immediately after logging, the status of a forest, whether poor or rich, will determine any rehabilitation treatments that should be carried out. The decrease in the productivity of natural forests following initial logging (Chin 1989) has created interest in planting timber trees in logged forest (Pinso & Moura Costa 1993).

Generally in forestry, conventional remote sensing methodology is based on qualitative analysis of information derived from 'training areas' (i.e. ground-thruthing). This has certain disadvantages in terms of the time and cost required for training area establishment, and the accuracy of results obtained (Rikimaru 2002). To overcome this problem, a new technique was developed by the ITTO where forest status is assessed on the basis of canopy density. The methodology is presently identified as the forest canopy density mapping model or FCD Model.

STUDY AREA

The study was carried out in Tekam Forest Reserve, which is situated northeast of Kuala Lumpur in the district of Jerantut, Pahang, Malaysia. Tekam Forest Reserve is also part of the main range called Banjaran Titiwangsa that stretches in the middle of Peninsular Malaysia. The study area, which covers an area of 10 x 10 km, lies between 102° 32' 24"–102° 37' 48" E and 03° 57' 36"–04° 03' 00" N as shown in Figure 1. It is accessible from the logging road and adjacent oil palm roads. The forest type of the area is Hill Dipterocarp. Topography of the area is undulating steep and rugged hill slopes with most of the slope gradients exceeding 45°. The elevation of the terrain ranges from 60 to 800 m. The forest, which was first logged in 1976 and recently in 1986, consists of trees of various ages. There are 27 compartments within the study area covering 7 690 ha.

MATERIALS AND METHODS

Acquisition of spatial data

Spatial data collection started with compilation of satellite image, maps and some ancillary data. The topographic maps and forest maps are required to obtain information such as land use, contours, river network, roads, compartment boundaries and years of logging. However, to detect changes and to obtain a recent picture of the study area, a satellite image was purchased from the Malaysian Centre of Remote Sensing (MACRES). In this study, the satellite image available was Landsat TM, which was captured in 1998 and is shown as Band 543 in Figure 2. Information about the forest of the study area was obtained from Forestry Department.

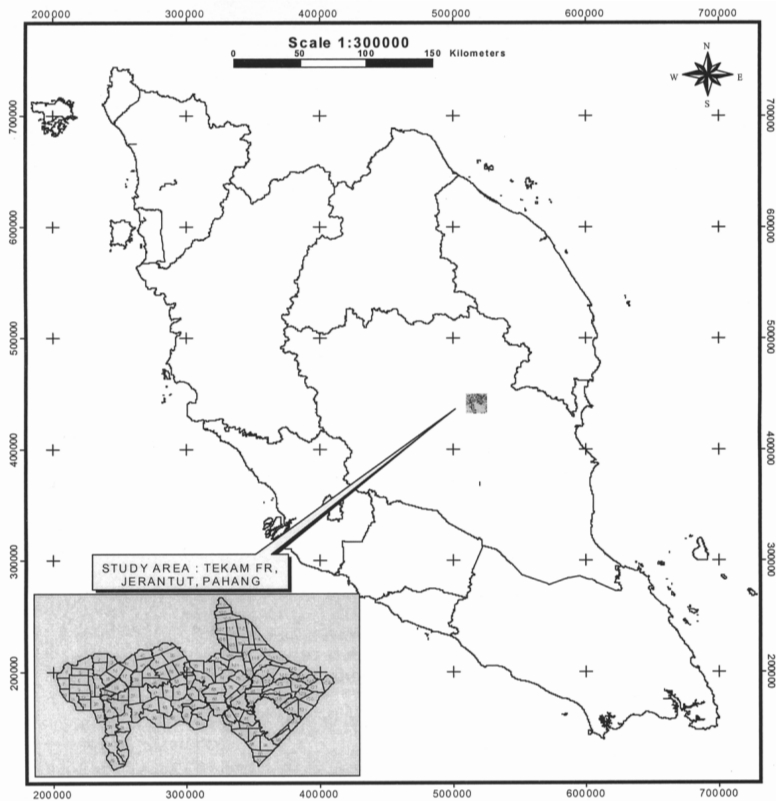


Figure 1. Location of study area

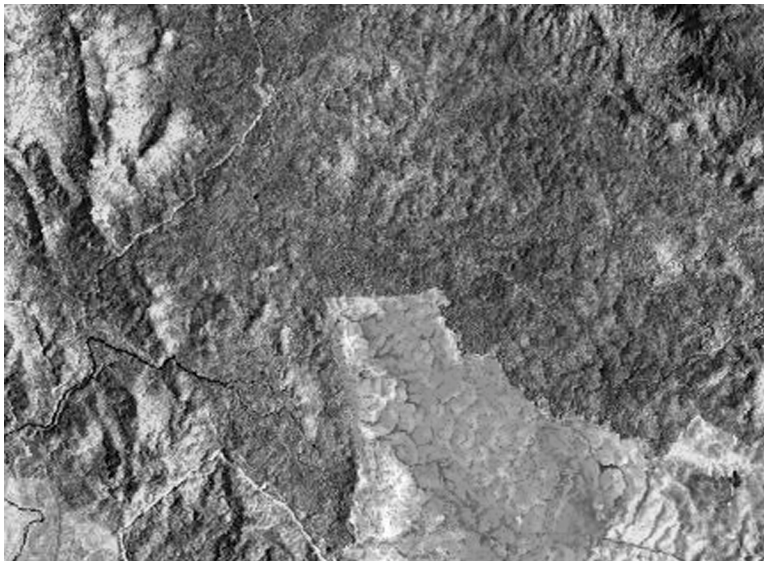


Figure 2. Raw image of Landsat TM Band 543 for Tekam Forest Reserve

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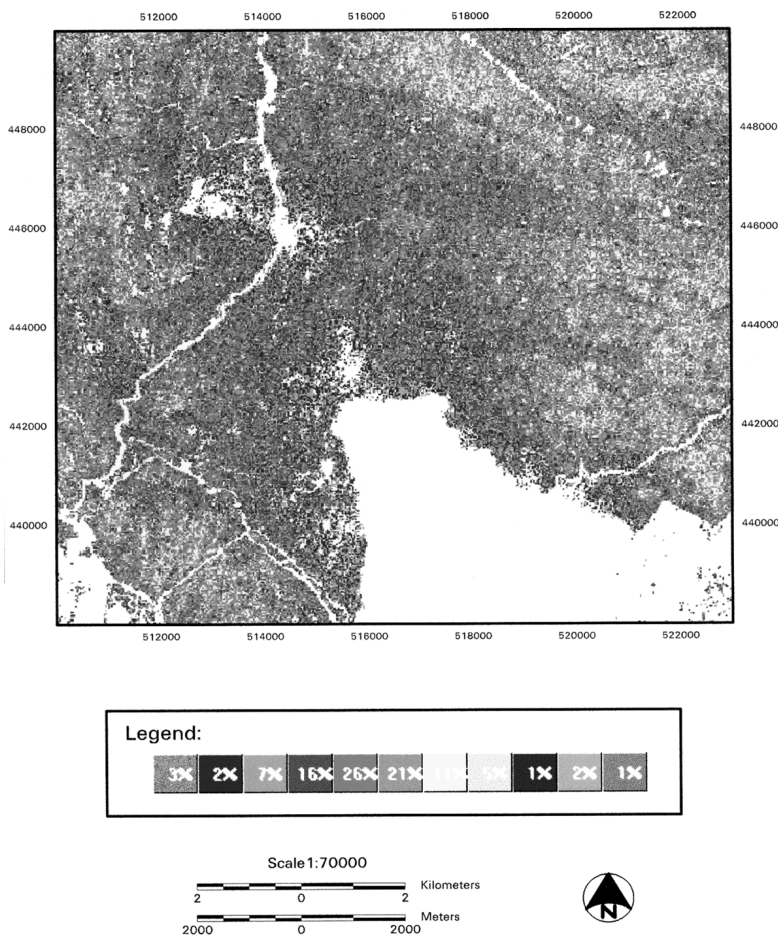


Figure 3. Unsupervised classification of the study area

Image processing

Raw satellite images need to undergo all related pre-processing operations. These pre-processing operations of the remote sensing images are particularly important. Indeed, the quality of this pre-processing will contribute substantially to the accuracy of the final thematic products. In this study, image processing has been adopted using a newly developed model called FCD (forest canopy density). Forest canopy density model (FCD) is based on the growth phenomenon of the forest, which is a quantitative analysis. FCD utilizes forest canopy density as an essential parameter for characterization of forest conditions. The degree of forest density is expressed in percentages. It also indicates the degree of degradation and, hence, the intensity of rehabilitation treatment that may be required. The source of remote sensing data for FCD-mapper is Landsat TM. FCD-mapper is a semi-expert system computer software package compatible with windows-type personal computers. In this study, the image was first processed for noise reduction

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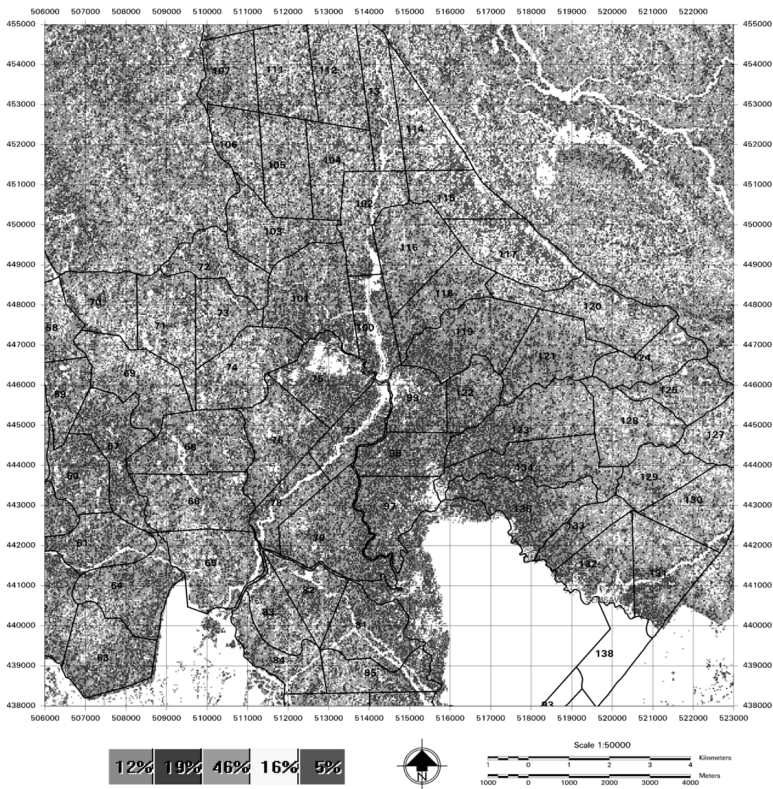


Figure 4. Supervised classification of the study area

because clouds or cloud shadow or water area could adversely influence the statistical treatment and analysis of imagery data. Then, range normalization of the Landsat TM data for each band was carried out. The FCD model comprises biophysical phenomenon modeling and analysis that utilizes data derived from four indices:

1. advanced vegetation index (AVI)
2. bare soil index (BI)
3. shadow index or scaled shadow index (SI, SSI)
4. thermal index (TI)

The four index values were calculated in percentage for each pixel. Using the above four indices and modeling operation, the FCD of the study area was determined. Then, unsupervised classification using the FCD model was carried out. Altogether, ten classes were assigned and the result of the classification is shown in Figure 3. However, when ground truthing was carried out, it was found that only five different classes could be identified. This information was then keyed in to perform supervised classification and the result is shown in Figure 4. The flowchart of the procedures for the FCD mapping model is illustrated in Figure 5.

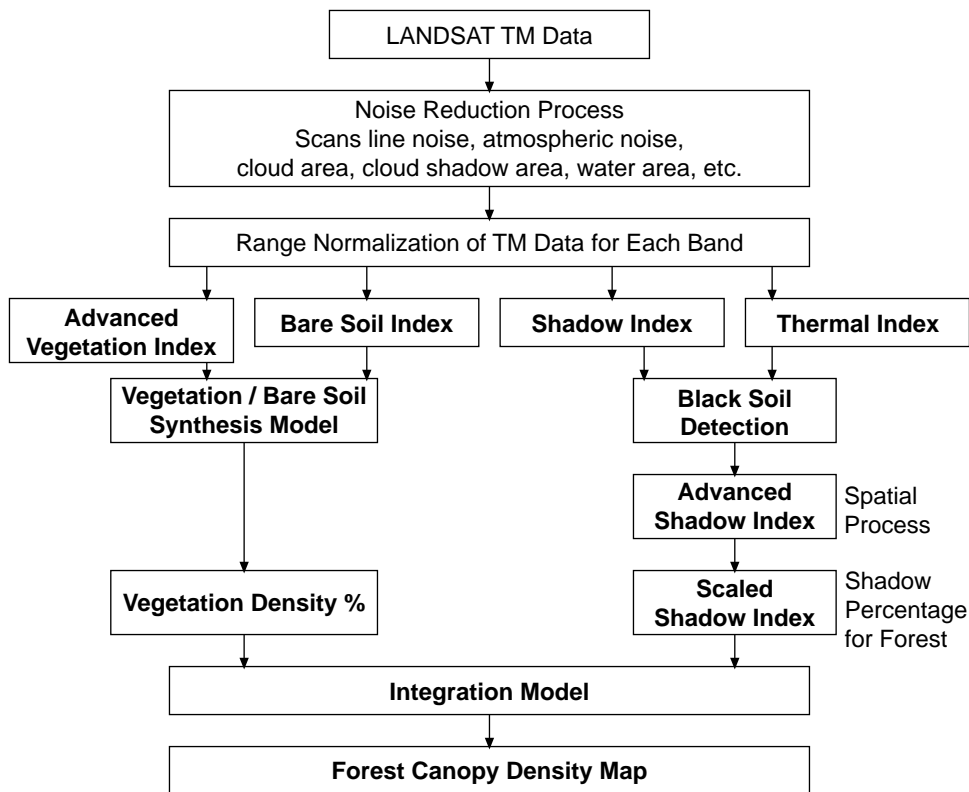


Figure 5. Flow chart of FCD mapping model (Rikimaru 2002)

Ground thruthing

Ground thruthing was carried out to verify the compartment boundaries, forest class and also to observe any special features that could not be detected by the image. For each forest class, several ground thruthing plots were established and various data were collected from each plot. Basically, ground thruthing gives a description of the forest features, such as layers of trees, dominant tree spp., elevation, location, understorey vegetation and tree diameter at breast height (dbh). Once these data were collected, they would be keyed into the computer to define the classified image and related maps were produced.

RESULTS AND DISCUSSION

Results from the FCD supervised image in Figure 4 are summarized in Table 1. When supervised classification was carried out based on ground thruthing data, it was found that all ten classes assigned in the unsupervised classification could be reduced and categorized into five classes. From these five classes, forest density class of 30–50 percent has the highest density percentage, i.e. 46 percent whilst class >70 percent has the lowest, i.e. 5 percent. Forest density class 15–30% has 19% density whereas class <15 percent has 12 percent. If these two classes are combined, the total density percentage is 31 percent of the whole study area. For rehabilitation purposes, only these two classes are considered.

From the ground thruthing, it was found that class <15 percent has no big trees (dbh >60 cm) and consists of skid trail, roads and decking site but class 15–30 percent has a few big trees. However, both classes have many saplings and seedlings, showing that the volumes of seedlings and saplings in the study area are high and these might provide a sufficient volume for the next harvesting cycle. The result also indicates that the area might have had rehabilitation treatment before and therefore the forest growth is ensured. Nevertheless, rehabilitation treatments are still needed, especially in the areas of the class <15 percent which are near open spaces like skid trail, roads and decking sites.

Table 1. FCD results based on supervised image

FCD classes (%)	Colour	Density (%)
>70	Green	5
50–70	Yellow	16
30–50	Brown	46
15–30	Blue	19
<15	Light blue	12

From the results, it can also be concluded that the number of big trees in the study area is low. This is because the percentage of the forest canopy density, which is more than 70% is only 5 percent of the total study area. This is further emphasized by the FCD percentage class 50–70, where only 16% of the study area falls under this category. Again, if these two categories are added up, only 21 percent of the whole study area consists of bigger trees.

CONCLUSION

The study clearly shows that the forest canopy density technique could be used to classify logged-over forest into different forest canopy density classes. This information will enable forest managers in identifying degraded areas that need to be rehabilitated and in planning treatments or rehabilitation techniques that should be carried out in these areas.

BIBLIOGRAPHY

- Alias, M.S., Zulkifli, M., Mohd Puat, D. & Ibrahim S.** 2001. *Canopy density mapping—a new tool for forest management*. Paper presented at the 13th Malaysian Forestry Conference. 20–25 August 2001. Johor Bahru, Malaysia. 12 pp.
- Chin, S.C.** 1989. Managing Malaysia's forests for sustained production. *Wallaceana* 55:1-11.
- Ismail, H., Khali Aziz, H. & Azman, H.** 1993. *The use of remote sensing and geographic information system in tropical forest in Peninsular Malaysia*. Paper presented at the 21st International Forestry Student Symposium, 22–24 November 1993. Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia. 8 pp.
- Khali Aziz, H.** 2002. *Classification technique of second growth forest. Preliminary results for Sungai Tekam Forest Reserve study area*. Paper presented at the RM8 Second Growth Forest Project Committee Meeting. 17 April 2002, FRIM, Kepong, Malaysia.

- Nezry, E., Yakam-Simen, F., Romeijn, P., Supit, I. & Demargne, L.** 2000. *Advanced remote sensing technique for forestry applications: a case study in Sarawak, Malaysia*. Invited paper at Multi-Conference on Systemics, Cybernetics and Informatics, 23–26 July 2000. Orlando, USA. 6 pp.
- Pinso, C. & Moura-Costa, P.H.** 1993. Greenhouse gas offset funding for enrichment planting—a case study from Sabah, Malaysia. *Commonwealth Forestry Review* 72: 343-349.
- Rikimaru, A.** 2002. *Concept of FCD mapping model and semi-expert system*. Paper presented at the International Workshop on Tropical Forest Cover Assessment and Conservation Issues in Southeast Asia. 12–14 February 2002, IIRS, Dehradun, India. 10 pp.
- Safiah Yusmah, M.Y., Khali Aziz, H., Rodziah, H. & Abd. Azhan Shah, I.** 2001. *Forest type classification using AIRSAR image data*. Poster presented at the International Conference on Forestry and Forest Products Research, 1–3 October 2001, Kuala Lumpur, Malaysia.
- Van Oorschot, G., Van Winkel, I. & Moura-Costa, P.** 1996. The use of GIS to study the influence of site factors in enrichment planting with dipterocarps. In S. Appanah & K.C. Khoo, eds. *Proc. Fifth Round-Table Conference on Dipterocarps*, pp. 267–278. Kepong, Malaysia, FRIM.

26 Policies and practices for the rehabilitation of degraded lands and forests in leasehold forestry, Nepal

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ABSTRACT

This paper aims primarily to share experiences gained in Nepal in the rehabilitation of degraded forest lands and forests and its impacts on the local communities. The government policy is to lease out patches of degraded forest lands to small groups of poor families ensuring long-term land tenure for a maximum of 40 years, with extension for another term. From 1993 to 2001, a total of 7 000 ha degraded forest lands has been leased out to 1 655 groups covering 11 255 poor families. Moreover, leasees are given minimum inputs, forage seeds and planting materials, with training and simple technology. The processes of rehabilitation of degraded lands, with total participation of poor families are: protection from grazing and fire, invigoration of natural regeneration of desired species and their proper management, promotion of hedgerows along contours, and planting of perennials and preferably leguminous forage species, fruit trees and multipurpose tree species. The government policy is that all the benefits from the leasehold forests can go directly to the leasehold families by a group decision or sale of surplus products without sharing with government agencies. An assessment showed that vegetation that covered only 32% of degraded land in a newly handed-over area steadily increased to 50% in the 2-year-old group, 68% in the 4–5-year-old group and 78% in the 6–7-year-old group. Likewise, the most significant measurable difference in the vegetation between 1994/95 and 2000 is the tremendous increase in species diversity. Leasees directly benefited from huge amounts of fodder, fuelwood and other non-timber forest products from these forests in reduced collection times, especially by women who are the main workers in the hills. With the increased production of forage, poor families have now increased the number of goats and milking buffaloes that give them a good source of income. Despite many challenges, this leasehold policy is successful and the government has converted it from project to programme, implemented in 30 districts.

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INTRODUCTION

Context of degradation of natural resources in Nepal

Of 23 million population, 52.7% people of Nepal reside in hills and mountains (CBS 2002). And, over 60% of the households in these regions are living below the poverty line. Fragmentation of lands, declining productivity and deteriorating farm incomes have forced families to become increasingly reliant on common access resources, i.e. forest resources. The forest provides various goods and services to the rural people, which consist of forest products like timber, fuelwood, fodder, leaf-litter, agricultural implements and several other types of non-timber forest products (NTFPs). These days, collection and sale of NTFPs have become a good source of income and employment to a large number of the rural poor in hills and mountain regions. Intangible goods and services include the forest's role in soil conservation and enrichment and environmental and biodiversity conservation. In Nepal, fuelwood is a major source of energy for the rural population. About 94% of fuelwood comes from the forest. Moreover, there are no other visible sources for substitutes of fuelwood in the near future (HMG 1989).

In hills and mountain regions, there is strong linkage between agriculture and forestry. Farmers collect dry leaf litter from the forest and use it as animal bedding material. Mixed with animal dung, it is converted into compost and applied to farmland. To sustain the subsistence farming system of one hectare of agricultural land, it requires 1.33–2.8 ha of unmanaged productive forest (Wyatt-Smith 1982, Mahat *et al.* 1987).

Livestock raising is an important agricultural enterprise and also the source of off-farm income. Free grazing of animals in the forest is a very common practice and it is widespread all over the country. Trampling by animals in the forest compacts the soil and negatively affects the sprouting and natural regeneration of valuable species. Further, heavy pressure on the forest for firewood, fodder and grazing is the main cause of forest degradation.

Of 14.72 million hectare land area, forest covers about 4.27 million ha (29%) and shrubs 1.56 million ha (10.6%). From 1978 to 1994, the forest area declined at an annual rate of 1.7 percent. Both forest and shrubs together have decreased at an annual rate of 0.5 percent (DFRS 1999). It is estimated that about 240 million cubic meters of topsoil are lost every year. Similarly, Nepal's forest area, which was 45% in 1964, declined to 37% in 1986 and further to 29% in 1998.

The incidence of poverty is higher in the rural setting than in urban areas. It is severe in remote parts of the hilly and mountainous regions, which are most exposed to environmental risks. The resulting situation is that high levels of poverty are manifested in and reinforced by further depletion of the natural resource base.

The degraded forest lands, which are handed over to the poor families, are poor sites, exposed rocky, stony places, dry land with severely eroded topsoil, shrubland, barren land and riverbeds (Figure 1). Soil analysis shows that the majority of leasehold sites are acidic, deficient in nitrogen and phosphate and low in organic matter with poor to very poor soil fertility and minimum depth of topsoil. A large number of native plant species available in degraded sites have low nutritional status and productivity, which is estimated at 0.5-1 tonnes of green matter ha⁻¹. However, some of the indigenous species that are present in sample plots, such as *Heteropogon contortus*, *Pogonatherum* species, *Desmodium* species and *Flemingia* species, have been said to increase milk and butter production, indicating therefore that they have substantial nutritional value (Pariyar 1996).

The grassland area has little plant cover and low productivity. Shrubland, on the other hand, consists of relatively better sites, with moderate soil fertility, thicker topsoil and better moisture retention capacity (Pariyar 1996, Singh 2000).



Figure 1. Degraded lease land

Government policies

Poverty alleviation is the prime objective of the government programmes (NPC 2001). The Agricultural Prospective Plan (1995) has a long-term vision for economic growth and poverty reduction. The overall strategies supported by the plan include integrated development of the agriculture and forestry sectors, reduction in economic and social disparities among communities and regions, empowering local bodies and cooperatives for sustainable development of different economic sector, and expanding social and economic services to the backward communities and regions

The Master Plan for the Forestry Sector (MPFS) in 1989 aims to fulfill the needs of the people for fuelwood, timber, fodder and other forest products on a sustainable basis and to protect the land against degradation. In order to meet the objectives the MPFS has adopted six primary development programmes. The National and Leasehold Forestry Programme is one of them. The main strategy of the Master Plan is to enlist the active participation of the people and hand over the forest to them to the extent that they are interested and capable of managing the forest resources (HMG 1989).

The concept of leasing degraded forest to any persons and institutions was introduced in 1978. However, a trivial attempt was made to bring it into field reality. The MPFS 1989 focuses on leasing forest land for industrial plantation. The amendment of Forest Rules 1978 in 1989 opened the arena of leasehold forestry to hand over forest lands to families living below the poverty line stating that '*Majesty's Government (HMG) may prepare project related to the leasehold forest for the communities living below the poverty line and hand over the leasehold forest to the beneficiaries of such project*'. This policy was given further continuity in the Forest Act 1993 and the Forest Regulation 1995 which has replaced the previous forestry laws.

The community-based leasehold forestry has been actually implemented since 1993 which allowed for the leasing of forest land to poor communities.

The Ninth and Tenth Five-Year Plans (1997–2007) recognizes the role of leasehold forestry in poverty alleviation and stated that '*support to poverty alleviation will be*

provided by promoting leasehold forestry through the identification of policy related and legal problems seen in the sectors'. As per the spirit of government policy, leasehold forestry policy has been made simplified and conducive.

His Majesty's Government has recently approved the Leasehold Forest Policy 2002. This policy has explicitly defined the land to be leased and simplified the handing-over process to the leasee.

Potential lease land

- shrublands
- areas recovered from encroachers
- rehabilitated forest area
- forest areas having less than 20% crown cover
- sensitive areas for soil conservation

The policy is to amend the forestry laws to decentralize authority to the District Forest Officer (DFO) for approval of lease application, hand over lease land, redefine the poor families in consultation with the National Planning Commission (NPC) and other concerned organizations, and develop mechanisms of benefit sharing from the existing old trees in the lease land, and exemption to submit financial feasibility reports for the groups of poor families.

Translation of policies into practices

The concept of leasehold forestry for the poor has come into practice through the Hills Leasehold Forestry and Forage Development Project (HLFFDP) since 1993. The main objectives were to improve environmental conditions by rehabilitating degraded lands, and to raise the incomes of the poor families. The mechanism is to lease out small patches of 5 to 10 ha degraded forest lands to the small groups of 5–10 households for a period of 40 years. The target groups are the families living below the poverty line (and also called small and marginal farmers), i.e. families with less than 0.5 ha of private land and/or per capita income of less than \$50 per annum.

This is an integrated programme involving the Department of Forest (DoF), the Department of Livestock Services (DLS), the Nepal Agricultural Research Council (NARC) and the Agricultural Development Bank, Nepal (ADB/N). The DoF is the lead agency and responsible for coordination in the central level. The District Forest Officer (DFO) coordinates the project at district level and initiates the leasing process. The DLS is responsible for technical support to leasehold groups for fodder and pasture development, and the animal health services. The ADBN is responsible for the identification of the poorest households and credit to the leasehold farmers for the income generating activities. The NARC is responsible for carrying out the applied research on forage and providing inputs such as grass and legume seed, rootstock and improved breeding stock.

The government policy documents focus on rehabilitation of degraded lands, environmental conservation and poverty reduction through people's participation (APP 1995, MPFS 1988 & Tenth Five-Year Plan, 2002–2007). APP recognizes the need to expand livestock production in the hills with enough supply of fodder and forage from the forest. Similarly, the MPFS recognizes that the management of community forest would play the primary role in the restoration of public forest land in the hills. The

leasehold forestry is an appropriate instrument to tackle the issues outlined by the policies in the development objectives.

To translate the leasehold forestry concept into practice the first step is the identification of the degraded blocks of forest land to be leased out, followed by the identification of families below the poverty line. Assisting them in the preparation of their management plan for the lease land improvement, and providing technical support and minimum inputs for the rehabilitation of degraded land are the joint responsibilities of the line agencies.

In order to develop suitable technology for the different eco-zones, an Integrated Research, Development and Extension Training Programme (IRDET) has been developed and applied in leasehold sites. These initiatives include a farmer-based field network that integrates research, development and extension work.

The IRDET focuses on:

- minimum tillage and line planting;
- use of leguminous fodder trees, shrubs and pasture species;
- strategic use of starter fertilizer;
- cut and carry management;
- protection of the lease land from grazing and fire;
- protection and management of multi-purpose species in natural regeneration as well as plantation.

For action research, detailed information on the local preference for common fodder species, land formation and soil composition, vegetation analysis, and socio-economic conditions was collected. The farmer's perceived constraints and preferences for developing fodder for livestock on their lease land were analysed.

For research purpose leasehold sites have been classified into three altitudinal zones, namely (a) low altitude 400–1 200 m altitude, (b) transitional zone 1 201–1 800 m, and (c) high altitude 1 801–2 500 m altitude.

The NARC was the leading organization for research. Other line agencies (forestry, livestock services and microcredit) were involved in the selection of sites and development of strategies. Leasehold members were consulted, motivated and brought into the consensus through the process of orientation. All necessary technical as well as material supports were provided by the NARC. Local beneficiaries were involved in site preparation, sowing, planting and weeding and protection of sites from grazing and fire. Moreover, the concerned leasehold groups now own all the products of action research. Singh (2000) stated that the involvement of beneficiaries in action research gave them exposure on:

- preparation of contour line with the help of A-frame;
- land preparation method with minimum tillage;
- identification and selection of suitable forage and tree species for degraded land rehabilitation and improvement of soil fertility;
- proper sowing, plantation and curing as well as harvesting techniques;
- sharing of forage species for goats, cattle and buffaloes.

In order to develop processes, the following research trials were conducted in the leasehold sites.

Pasture legume establishment trials: In each eco-zone, twelve research plots were established. *Stylosanthes guianensis* (cv. Cook) was tested in low and transitional altitudes with and without fertilizer including minimum tillage (Figure 2). This trial included (i) primary turf skimming not deeper than 20 cm and covering 30 cm bands along hill contours at 70 cm intervals; (ii) lime sowing (5 kg ha^{-1}), inoculation; (iii) lime pelleting of the seed (10 kg ha^{-1}); and (iv) a basal dose of (starter) fertilizer applied, N:P₂O₅, and S at the rate of 45:115 and 30 kg ha^{-1} . Local grasses were occasionally cut from between five and ten inches on both sides of the turf in order to increase green fodder production and control competition. This procedure was repeated three to four times each year. The productivity data were collected each year. Parameters collected including sward height, plant tillering, and green matter (GM) yield.



Figure 2. Minimum tillage and contour planting

Similarly, in the moist sites of high altitude white clover (*Trifolium repens* cv. Khumaltar) was tested under minimum tillage lime coating, inoculation, proper sowing depth and use of starter fertilizer (NPK+S) 34:75:0 + 30 kg ha^{-1} with and without fertilizer (Figure 3).



Figure 3. Forage production in the lease land

(*Trifolium repens* cv. Khumaltar) showed the potential to produce 3–5 GM tonnes ha^{-1} under occasional grazing in the moist sites with minimum tillage, lime coating, inoculation, proper sowing depth and use of starter fertilizer 34:75:0 + sulphur 30 kg ha^{-1} .

Introduction of minimum tillage (20 x 30 cm at 70-cm intervals) along contours in hills and mountains reduces the inputs requirement and the soil erosion risk. Biologically a forest killer, the annoying and invading weed, *Eupatorium* species, has been easily replaced by the introduction of stylo and molasses in the degraded and bushy areas.

Nitrogen fixing trees/shrub establishment trials: At four sites in low and transitional altitudes seedlings of *Bauhinia purpurea*, *Leucaena divertifolia*, *L. pallida* and *L. leucocephala* were planted along the contours at five-meter distances (plant to plant and row to row). Planting technology included three treatments: T1, the recommended method (50 x 50 x 50 cm pit size + DPA 250 g and sulphur 150 g); T2, the current improved practice (30 x 30 x 30 cm pit size); and T3, the indigenous method (20 x 20 x 20 cm).

Farmers also planted other local multipurpose tree species. The parameters were plant height, number of branches per plant and survival rate. *Bauhinia purpurea* and *L. leucocephala* in three years attained the height over 2–3 m and over 68% survival up to 1 700 m altitude under proper pit size and management of 50 x 50 x 50 cm + starter fertilizer (250 g DPA+ 150 g sulphur per pit).

Fodder hedgerow establishment trials: Seven leguminous shrub species were introduced in a low altitude belt in the degraded lease land using the simple method, along the contours and working the soil with a pickaxe. Results show that four species, *Crotalaria* species, *Flemingia congesta*, *Cajanus cajan* and *Tephrosia candida*, are promising. Some of these species also produce green fodder in the dry season. Farmers preferred *F. congesta*, which provides a large amount of green fodder throughout the year.

The poor farmers, involved in action research, are knowledgeable and skillful in the rehabilitation of degraded lands. They are now working as extension agents. However, poor farmers lack money to purchase and apply fertilizer not only for lease land but basically for cereal crops. In such a situation, application of fertilizer in degraded land is questionable for forage development. Action research was also targeted to identify local species for degraded sites, proper time of sowing, establishment of multipurpose trees, suitable hedgerow species and effectiveness of different fodder and hedgerow species on degraded lands.

Still, suitable species above 1 700 m altitude have not been explored for rehabilitation of degraded lands. Due to the harsh climatic condition, the growth and regeneration of vegetation is much slower. Large areas of grass and bushy rangeland are distributed in this region; thus, livestock rearing is the prime enterprise for them. But stall feeding of livestock is not an attractive option.

The leasehold forestry project has developed very simple techniques to restore the degraded lands; these techniques are easily adopted by the poor families. This mechanism usually includes the protection of degraded lands from fire and grazing, and includes plantations of multipurpose tree species, leguminous and perennial forage species. However, very small patches of land are planted with such species. Tree plantation is not very successful. In the low altitude moist sites, regeneration of grasses, shrubs and woody species is flourishing. Studies of species diversity in two sites between 1995 and 2000 show a tremendous increase in species diversity, i.e. in a 9-ha leasehold forest, an increase of 57% and in a 76-ha lease land, an increase of 86% (NFRI 2000, Ohler 2000).

From 1993 to 2001, a total of 7 000 ha degraded forest land has been leased out to 1 655 groups covering 11 255 poor families of about 78 000 population. Many case studies confirm the positive impacts of rehabilitation of degraded land on the livelihoods of the targeted beneficiaries by increases in the species diversity over time. Forest lands have become more structured, and multi-layered resulting in easy availability of fodder and fuelwood, reduction of fodder shortage period and increased stall feeding practices. Moreover, there is increased income and diversification of income sources from livestock (goats to buffaloes), and off-season vegetable farming which has increased the food security periods of the leasee.

The assessment showed that the structure of vegetation has changed, the number of tree saplings increased, but the average height and size decreased, because the new saplings are below the average height. Much change has occurred in the ground vegetation with decrease of local weeds. An assessment on the vegetation cover showed that in a newly formed group only 32% of the ground was covered with vegetation which steadily

increased to 50 percent in a one- to two-year-old group, to 68 percent in a four- to five-year-old group and 78 percent in a six- to seven-year-old group (Figure 4) (Ohler 2000, Singh & Shrestha 2000).

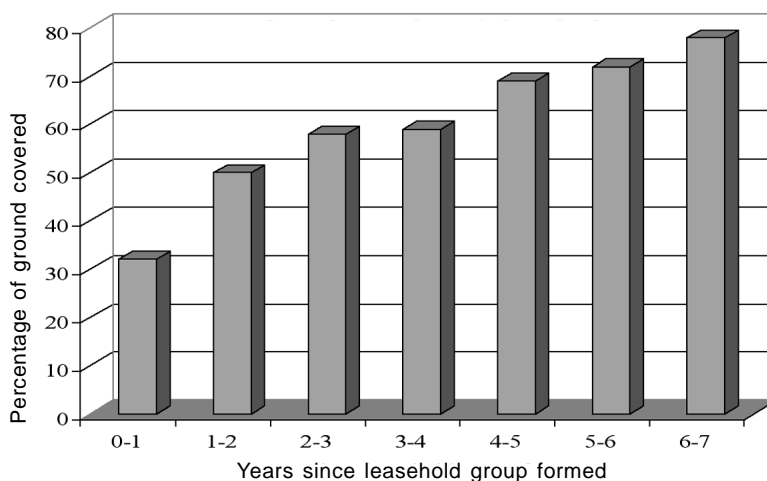


Figure 4. Ground cover change in lease land

Due to the increased vegetation on the leasehold forest, farmers have progressively been able to harvest forest products (fodder, animal bedding materials and fuelwood). It is noted that most of the lease lands were idle before handing over. This is a good indicator of the progressive improvement in the degraded forest lands.

Yadav and Dhakal (2000) concluded that many leasehold sites, which were barren at the time of handing over, have now been developed into green lush areas covered with trees, grasses and natural regeneration. This has improved the ecological balance in the area through revegetation and soil stabilisation. It has achieved poverty reduction in an environmentally sustainable manner.

The project data indicate that at least 60 000 ha of degraded lands are still available for leasehold forestry in project areas, which would be sufficient for at least 80 000 families. At the national level, enough degraded forest could be available to hand over a half to one hectare of the land to each of the approximately 0.9 million poor households (households with less than 0.5 ha of land) in the hills and mountains (Yadav & Dhakal 2000).

PROBLEMS AND CONSTRAINTS

- Leasehold forestry for the poor is limited to the handing-over of degraded forest.
- Simple technology and suitable species for degraded sites above 1 700 m altitude have not been devised. Thus, the present technology may not be applicable in such sites.
- Chemical fertilizer is an expensive imported input, which is not readily available in all the locations and sites, particularly in remote hills and mountains. Further, poor farmers are not in a position to afford the use of fertilizer even in the degraded sites as starter as recommended by the research.

RECOMMENDATIONS

- The Forest Act and Regulation should be amended to bring leasehold policies into practice in spirit.
- The protection of natural regeneration seems to be more effective for tree establishment in degraded sites than new plantations. Indigenous local species are most likely to succeed under high degraded and harsh climatic conditions. Whenever possible, tree establishment should be carried out through natural regeneration, direct seeding, transplanting, protection and ground cover management. Focus should be given on the nitrogen-fixing species of grasses and trees, which are important for soil improvement.
- A more integrated approach is required to improve degraded lands by the execution of different activities, assuring better coordination and unification of the inputs of the agencies concerned; such a holistic approach will result in more impact than isolated interventions.
- Protection from grazing and fire invigorates natural regeneration, which is the cheapest option for the rehabilitation of degraded lands both in hills and mountains.
- Technology developed for the rehabilitation of degraded lands should be simple and affordable. The approaches could be replicated and tested on different eco-zones. The methodology developed under the IRDET can be replicated and tested over a wide range, provided appropriate technological support is given.

CONCLUSION

Community-based leasehold forestry intervention has contributed greatly to the rehabilitation of degraded forest lands and improved the economic conditions of the village poor. There is steady increase in vegetation coverage both from protection and supplementary planting of forage and multipurpose tree species using simple technology. This technology can be easily and widely adopted for the rehabilitation of degraded lands in the hills and mountains. Assessing the good impacts of the leasehold forestry, the government has extended this modality in 30 remote and challenging districts to address both poverty and environmental issues. The project approach has been changed into programme approach as a regular programme of the government rather than of donors. The Tenth Five-Year Plan (2002–2007) has also taken it as a national priority sector programme.

There is a need to reconsider the integration of leasehold forestry and community forestry for long-term viability. This will minimize conflicts in future. It will also help address the current burning issue of social equity in community forestry. Leasehold forestry is a relatively new approach of degraded forest management; it is likely that new issues will keep coming up, for which amendments to the policies, acts and rules may be needed from time to time. If the legal environment is made conducive, this programme can safely flourish on a national scale, addressing the issues of poverty and environment.

REFERENCES

- CBS.** 2002. *Statistical pocket book*. Kathmandu, Nepal, National Planning Commission Secretariat Central Bureau of Statistics.
- DFRS.** 1999. *Forest resource of Nepal (1987–1998)*. Kathmandu, Nepal, Department of Forest Research and Survey, Ministry of Forest and Soil Conservation.
- HMG.** 1989. *Master plan for the forestry sector*. Kathmandu, His Majesty's Government of Nepal.
- Mahat, T.B.S., Griffin, D.M. & Shepherd, K.R.** 1987. *Human impact of some forests of the middle hills of Nepal: forest in the subsistence economy of Sindhupalchok and Kabhreplanchok*. Mountain Research Development.
- NARC.** 2000. *Annual report*. Khumaltar Lalitpur, Hills Leasehold Forestry and Forage Development Project, Nepal, Nepal Agricultural Research Council, Pasture and Fodder Research Division.
- NFRI.** 2000. *Impact assessment of the Hills Leasehold Forestry and Forage Development Project on vegetation and social development in Bhagawatisthan site*. Project Internal Document 14/2000. Kathmandu, Nepal.
- Ohler, F.M.J.** 2000. *The impact of leasehold forestry on livelihoods and environment*. Kathmandu, Nepal, Hills Leasehold Forestry and Forage Development Project.
- Ohler, F.M.J.** 2001. *The impact of leasehold forestry on marginal mountain farms of Nepal*. Paper prepared for the International Symposium on Marginal Mountain Farms, Kathmandu, Nepal.
- Pariyar, D.** 1996. Forage resource development on degraded land in Nepal: a new approach. In D.J. Miller & S.R. Craig, eds. *Rangelands and pastoral development in the Hindu-Kush Himalayas*. Proceedings of a Regional Experts Meeting, November 1996. Kathmandu, Nepal, International Centre for Mountain Development.
- Singh, B.K.** 2000. *Rehabilitation of degraded forestlands by the poor families in the hills of Nepal: the community-based action research*. Paper presented in the XXI IUFRO World Congress, Kuala Lumpur, Malaysia.
- Singh, B.K., & Shrestha, B.B.** 2000. *Status of leasehold groups and leasehold sites*. Kathmandu, Nepal, FAO.
- Wyatt-Smith, J.** 1982. *The agricultural system in the hills of Nepal: the ratio of agricultural to forest land and the problem of animal fodder*. APROSC Occasional Paper 1. Kathmandu, Agricultural Projects Service Centre.
- Yadav, R.P., & Dhakal, A.** 2000. *Policy outlook: leasehold forestry for the poor, an innovative pro-poor programme in the hills*. Kathmandu, Nepal, HMG Ministry of Agriculture/Winrock International.