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ECO-RESTORATION OF MICRO WATERSHEDS FOR ENSURING SUSTAINABILITY – A CASE STUDY OF CHITTAR IN THE UPPER CATCHMENT OF VAMANAPURAM RIVER, THIRUVANANTHAPURAM, KERALA

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Abstract: The common approach towards the management of natural resources emphasizes maximization of production rather than ensuring sustainability of the ecosystem. This has resulted in the ever increasing demand for potential resources and their depletion at an alarming rate. Degradation of the natural environment, augmented by population pressure coupled with unscientific management strategies pose serious threat to the fragile ecosystem. In this context, eco-restoration measures at micro watershed level deserve special recognition by policy and decision makers. Eco-restoration refers to the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (Foundation for Ecological Security, 2008). It envisages the revitalization and rejuvenation of potential landscapes in the verge of degradation. The primary objective of eco-restoration is to ensure sustainable as well as productive ecological units to human beneficiaries. This could be effectively achieved only by considering micro watersheds at regional levels. Watersheds are hydrologic units that are considered to be efficient and appropriate for assessment of available resources and subsequent planning and implementation of various development programmes (Rao, 2000). Eco-restoration of micro watersheds is a highly complex process that could be initiated with the proper identification of priority watersheds faced with specific ecological problems which accelerate the depletion of bio-physical resources. This should be followed by site and need specific restoration measures which ensure sustainability as well as maximization of production. The role of beneficiaries should also be properly appreciated in this endeavour. The present study focuses on the extent of degradation of Chittar, a highland, forested micro watershed in the upper catchment of Vamanapuram River in Thiruvananthapuram District, Kerala and the possible restoration measures to be adopted for regaining the sustainability of the region. The thickly forested upper reaches of the micro watershed is species rich and forms part of the Agasthyamalai Biosphere Reserve, the store house of rare and endemic plant species, and hence require utmost attention. Chittar micro watershed has been prioritized for the study after assessing the existing bio-physical status such as soil erosion, forest degradation, unsustainable land use, etc. Site specific eco-restoration measures, both vegetative as well as mechanical have been recommended for ensuring the sustainability of the land, with the aid of community based management strategies.

Key words: Hydrologic units, Endemic species, Rejuvenation, Fragile ecosystem, Community based management

INTRODUCTION

The common approach towards the management of natural resources emphasizes maximization of production rather than ensuring sustainability of the ecosystem. This has resulted in the ever increasing demand for potential resources and their depletion at an alarming rate. Degradation of the natural environment, augmented by population pressure coupled with unscientific management strategies pose serious threat to the fragile ecosystem. In this context, eco-restoration measures at micro watershed level deserve special recognition by policy and decision makers. Eco-restoration refers to the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (Foundation for Ecological Security, 2008). It envisages the revitalization and rejuvenation of potential landscapes in the verge of degradation. The primary objective of eco-restoration is to ensure sustainable as well as productive ecological units to human beneficiaries. Natural units outweigh human boundaries in this regard. This could be effectively achieved only by considering micro watersheds at regional levels. Watersheds are hydrologic units that are considered to be efficient and appropriate for assessment of available resources and subsequent planning and implementation of various development programmes (Rao, 2000).

Adoption of watershed as a basic unit for restoration programmes enables the planners and researchers to suggest and execute various conservation measures based on sustainability. It essentially relates to the conservation of bio-physical resources in the watershed which includes proper land utilization, protection from all forms of land degradation, replenishing soil fertility, checking soil erosion, water conservation and harvesting, ensuring sustainable productivity from all land uses, etc.

Eco-restoration of micro watersheds is a highly complex process that could be initiated with the proper identification of priority watersheds faced with specific ecological problems which accelerate the depletion of bio-physical resources. This should be followed by site and need specific restoration measures which ensure sustainability as well as maximization of production. The role of beneficiaries should also be properly appreciated in this endeavour. The present study focuses on the extent of degradation of Chittar, a highland, forested micro watershed in the upper catchment of Vamanapuram River in Thiruvananthapuram District, Kerala and the possible restoration measures to be adopted for regaining the sustainability of the region. The thickly forested upper reaches of the micro watershed is species rich and forms part of the Agasthyamalai Biosphere Reserve, the store house of rare and endemic plant species, and hence require utmost attention. Chittar micro watershed has been prioritized for the study after assessing the existing bio-physical status such as soil erosion, forest degradation, unsustainable land use, etc. Site specific eco-restoration measures, both vegetative as well as mechanical have been recommended for ensuring the sustainability of the land, with the aid of community based management strategies.

Eco-restoration–The Concept and Approach

Eco-restoration is a broad perspective that ensures the restoration of ecosystem composition, structure and function. Restoration is defined as the return of an ecosystem to a close approximation of its conditions prior to its disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and functions of the ecosystems are recreated. Merely recreating the form without the functions of functions in an artificial configuration bearing little resemblance to a natural resource, does not constitute restoration. The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs (National Research Council, 1992). A systematic appraisal of ecological deficiencies and a well defined course of scientific management ensuring community participation are necessary for the success and sustainability of all restoration programmes. In fact, the prime concern of eco-restoration is the rejuvenation of sustainable ecosystems that benefit mankind.

The eco-restoration approach initially identifies the ecological crisis and then selects the rationale for restoration. It differs from other approaches in the fact that it tries to restore the original biodiversity and ecosystem processes that existed before the degradation or disturbance. Any ecosystem has an inherent capacity and potential to regenerate on its own (Foundation for Ecological Security, 2008). Therefore all restoration efforts should give prominence to natural regeneration while providing ecologically viable alternatives that will reduce the regeneration time. In this effort, human intervention could never be under-estimated. Community based restoration measures are helpful in augmenting the production potential as well as the natural regeneration capacity of degraded landscapes.

MATERIALS AND METHODS

The Survey of India topographic sheets of the scale 1:50,000 and the Watershed Atlas prepared by the Kerala State Land Use Board have been consulted for preparing the base map. For effective planning and management of watersheds an appraisal of biophysical resources of the region is necessary. Reconnaissance surveys were conducted to gather the general details regarding land and water resources, agro ecological problems, etc. Rational method of runoff estimation is the oldest, simplest and possibly the most consistent one in its ability to adjust with the new concepts and developments in evaluating a watershed condition. Universal

Soil Loss Equation (USLE) has been applied in the present study for estimating the extent of soil loss through erosion. The different land use categories identified in the basin have been obtained through SOI toposheets of 1:50,000 scale, IRS imageries and aerial photographs of the scale 1:20,000 and through intensive field checks. Land capability assessment has been done following ICAR's methodology. Spatial extent of each land use class has been computed and analysed in ARCGIS. The principal criteria selected for the demarcation of agro ecological zones were terrain units, climate, soil characteristics, water table level and ground water potentialities. Geographical analyses of the agro ecological problems in the watershed at micro level have also been attempted for the present study. Based on the problems analysed several eco-restoration measures were suggested and a spatial image of the recommended practices is prepared using ARCGIS.

Eco-restoration for ensuring sustainability – A case Study of Chittar microwatershed

Chittar is a typical forested microwatershed in the Vamanapuram River Basin, lying between 8°40' and 8°42' N latitudes and 77°5' and 77°10' E longitudes. The microwatershed covers a total area of about 2064 ha and forms part of Vithura Panchayat in Vellanad Block. Vithura-Kallar road connects the watershed with the major urban centres in the Vamanapuram River Basin. The watershed is selected for the present study since it represents one of the typical priority watersheds in the Western Ghats region confronted with the problems of accelerated runoff and soil erosion as well as forest degradation. The location of the micro-watershed in the transition zone of the Agasthyamalai Biosphere Reserve highlights the significance.

Physical aspects

The Chittar watershed is characterised by a highly undulating terrain varying in elevation between 200 m and 800 m above mean sea level. The eastern portion of the watershed is precipitous with slopes of >35%. Khondalites underlie the entire watershed area. Soils are mainly forest loams with moderate depth and are well drained. In moderate to steep slopes they are susceptible to severe erosion. The presence of organic carbon in the soil is more

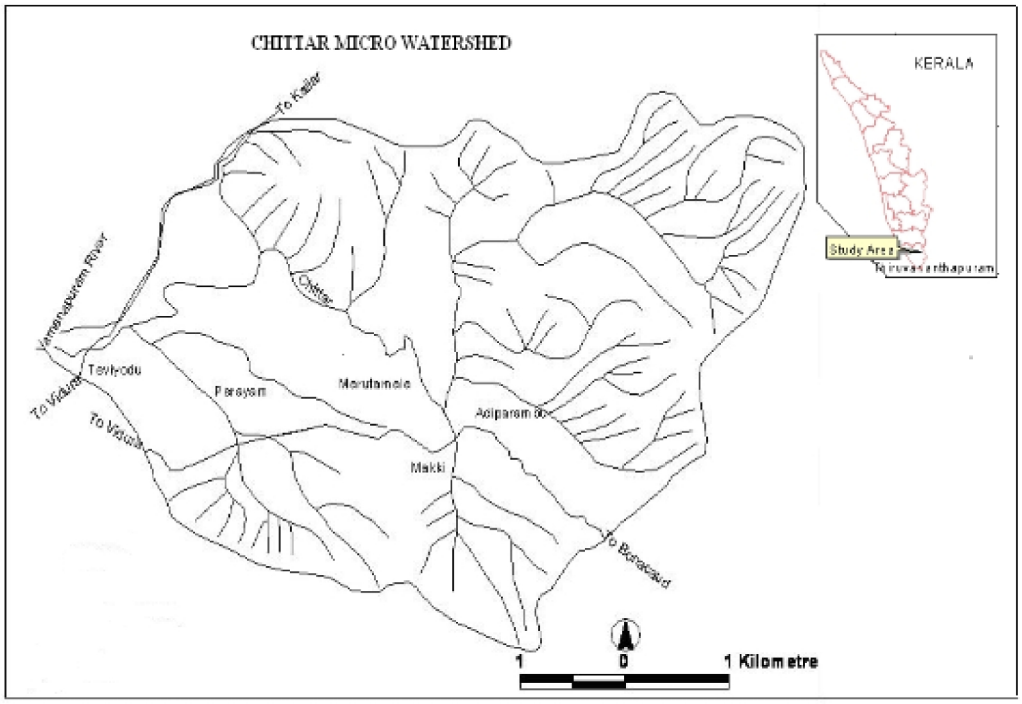

Fig. 1. Study area

(2.5 to 3.5%), but they are poor in sodium and potash (0.07 and 0.08 Cmol (+1)/kg respectively) and the average pH is 5.6 (Kerala State Land Use Board, 1995).

The Chittar stream and its tributaries form the major source of surface drainage. The Chittar empties into the Vamanapuram River near Chandani Kunnu. The watershed is entirely rainfed. This jointed and highly weathered zone holds rich ground water potential. The water table depth in this region varies between 10 and 15 m. Open or dug wells are the common ground water extraction structures. The watershed enjoys a warm and humid tropical climate. Both the South West and North East monsoons are well received in the region with an average annual rainfall of about 400 cm. The months of March and April record the average maximum temperature of 32°C.

Socio-economic aspects

Perayam, Maruthamala, Makki and Adiparambu regions are inhabited, while the thickly forested upper catchment of the Chittar, with an area of about 1400 ha is devoid of settlements. The settlements are mainly linear with houses clustering along the sides of roads. The watershed has a total population of about 420. There are altogether 75 families in the watershed, the average family size being 5 members. Majority of the watershed population depend on agriculture for their livelihood. A sizeable minority also earn their living by collection of minor forest produce. Among the total workers (164 nos.) 21 are cultivators and 64 are agricultural labourers. 10 persons are employed in the service sector. Others are mainly marginal workers engaged in the collection and local trade of minor forest produce, small-scale household industrial sector and construction activities. The socio-economic scene in the watershed is grim. As per the Panchayat records 39% of the workers are agricultural labourers. But most of them are rendered unemployed with agriculture losing its prominence over the decades.

Agro-ecological Conditions

The lower catchment of the Chittar watershed falls in Agro Ecological Zone (AEZ) IV comprising moderate to highly undulating terrain with moderate to steep slopes of gradient upto 35%. The zone lies at an elevation of 100 to 700 m above MSL. Soils are deep and well-drained clay loams. The comparatively limited wetland patches located in the interfluves between the foothills and the low-lying areas and larger areas of dry lands under rubber plantations together constitute this zone. This zone enjoys a humid tropical climate. Mean annual rainfall ranges from 2500-4000 mm. The high rainfall is conducive to the growth of luxuriant vegetation in this zone. The water table depth varies from 10 to 15 m from the ground surface. Paddy fields under wetland conditions are very rare and that too found distributed in small patches because of uneven terrain. The major type of farming activity noticed is the coconut-based homesteads where banana, minor tubers, perennial crops like Pepper, Arecanut, etc are cultivated as inter crops. Soil erosion is a major problem faced by the farmers.

The upper catchment of Chittar falls in AEZ VII, characterised by highly undulating terrain with gradual to very steep slopes. Tropical humid climate prevails in the region. Average annual rainfall is above 4000mm. Rainfall is at its peak during the southwest monsoon season. Very deep well drained clayey forest loams occur in the region. The average water table depth is between 5 and 10m. But in the highlands above 1000m the depth to water table is less than 3m.

The climatic, edaphic and physiographic characters in the watershed favour luxuriant natural vegetation, especially in the eastern portion. Rubber is the dominant crop and occupies an area of about 310 ha. Banana, minor tubers and perennial crops like pepper, arecanut, etc., are cultivated as intercrops in coconut-based homesteads. Further expansion of agriculture is not possible in the watershed, since its upper catchment is thickly forested and forms part of the Agasthyamalai Biosphere Reserve. The farmers in the watershed have not yet adopted any crop diversification strategies compatible to the land capability. The region is included in the Land Capability Class VI-es limited by severe erosion, shallow soils and steep slopes. The land is suitable for forestry with moderate restrictions. An area of about 560 ha in the foothill zone is covered by highly degraded forests, which requires immediate

attention. The destruction of the protective vegetation cover has aggravated the runoff and erosion problems in the upper catchment of the watershed. Lack of appropriate management measures coupled with absence of natural regeneration threatens the agro-ecological contiguity of the watershed.

Recommended eco-restoration strategies

Vegetative measures

The entire watershed is prone to very severe soil erosion (40-80 tons/ha/year). Vegetative measures are more effective and sustainable to mitigate soil erosion in degraded lands. Diversified cropping pattern should be adopted in the agricultural lands of the lower catchment.

Category	Area (ha.)
Rubber plantation	310
Mixed crops with settlements	187
Degraded forest	560
Dense mixed jungle	1007

High yielding banana varieties could be cultivated in the valley portions where irrigation is available. Other erosion resistant, perennial fruit crops like Sapota (*Manilkara zapota*) and West Indian Cherry *(Malphigia punicifolia*) could be cultivated in homesteads within the slope range of 10-15%. Medicinal and aromatic plants are recommended in the degraded lands bordering the foothill zone. Perennial grasses like Lemongrass (*Cymbopogon flexuosus*) and Vetiver (*Vetiveria zizanoides*), can be cultivated on hill slopes as a rainfed crop. The crop provides maximum yield from the second to the fourth year of planting and economic yield up to the sixth year. Vetiver has a deep, dense and strong fibrous root system. The perennial and sterile characteristics of the crop with its hardness and un-palatability to live stock make it an excellent soil-conserving crop. It may be planted as a contour hedge on slopes (KAU, 2002). Other medicinal herbs like Citraka (*Plumbago rosea*), Nili (*Indigofera tinctoria*), Kacholam (*Kaempferia galanga*), Kasthurimanjal (*Curcuma aromatica*), Chittaratha

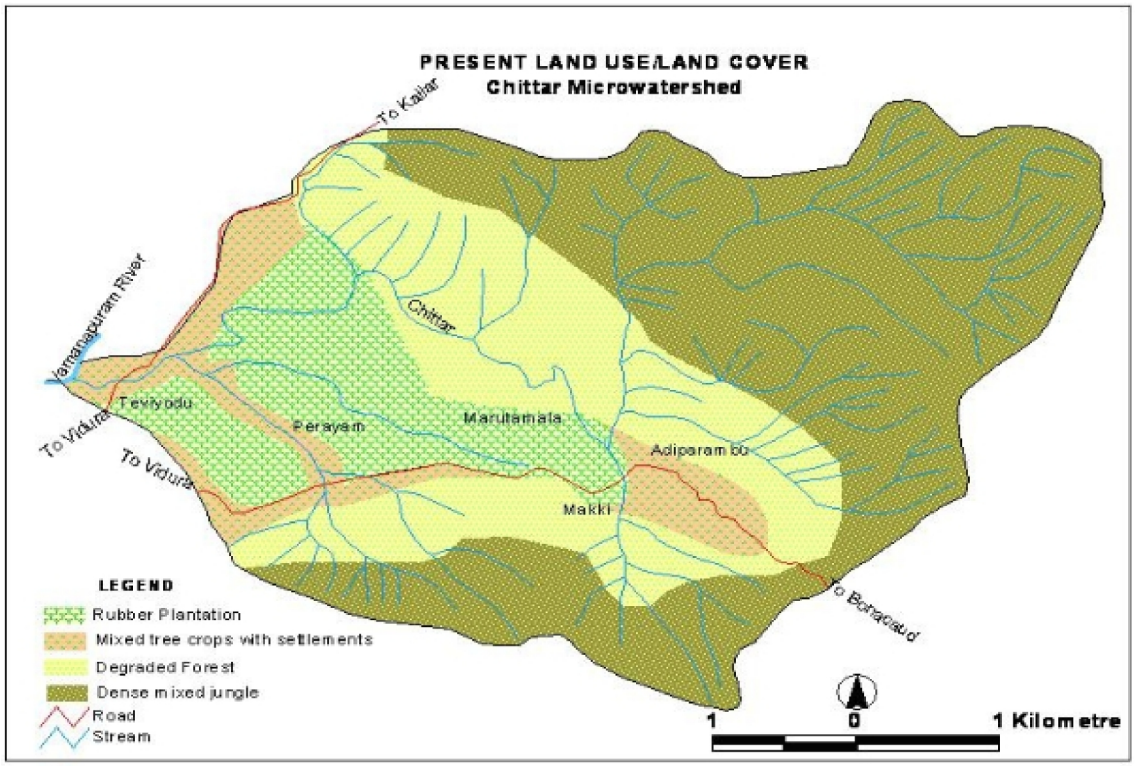

Fig. 2. Landuse/Landcover map of Chittar Microwatershed

(*Alpinia calcarata*), etc., may be raised in herbal nurseries in the foothill zone.

Agroforestry is also a sustainable management system that could be adopted in the forested degraded foothills. It refers to land management systems that integrate agricultural crops with forest crops (KAU, 2002). Tree species specific to the watershed conditions include Ailanthus (*Ailanthus triphysa*), Teak (*Tectona grandis*), Wild Jack (*Artocarpus hirsutus*), Mango (*Mangifera indica*), etc. Shade loving crops such as ginger and medicinal plants can be planted in the inter-spaces of these tree species. Above all natural regeneration processes should be allowed to take over in the degraded forests. The dense mixed jungle in the upper catchment of the Chittar should be maintained in its full serenity. Human intervention into this zone should be strictly prohibited for protecting the natural cover from destruction.

Mechanical measures

Construction of suitable engineering structures also can reduce soil erosion in degraded watersheds. Mechanical measures are the basic and fundamental interventions, which may be compared to foundation of a building and concurrent vegetative measures act as super structure. It is found that vegetative measures developed on treated degraded slopes are more sustainable and effective (Rajora, 1998). Hence both the measures should be integrated.

Contour trenches are recommended in the upper watershed under land capability class VII characterised by extreme limitations of slope and erosion. These trenches retard the rate of runoff and soil erosion and protect the agricultural lands from runoff, especially from the upper portion of the catchment. Contour trenching is the excavation of trenches along a uniform level in upper reaches of the watershed (Rajora, 1998). The number and density of the trenches should be high in areas with steep slope, high rainfall intensity and shallow soils.

Bench terracing could be adopted in class IV lands with 16-35% slope. In addition to soil and water conservation, it helps in the cultivation of fruit crops and green manure crops on a sustainable basis. Temporary gully control structures like checkdams increase the time of concentration of runoff leading to moisture retention, ground water recharge and reduction

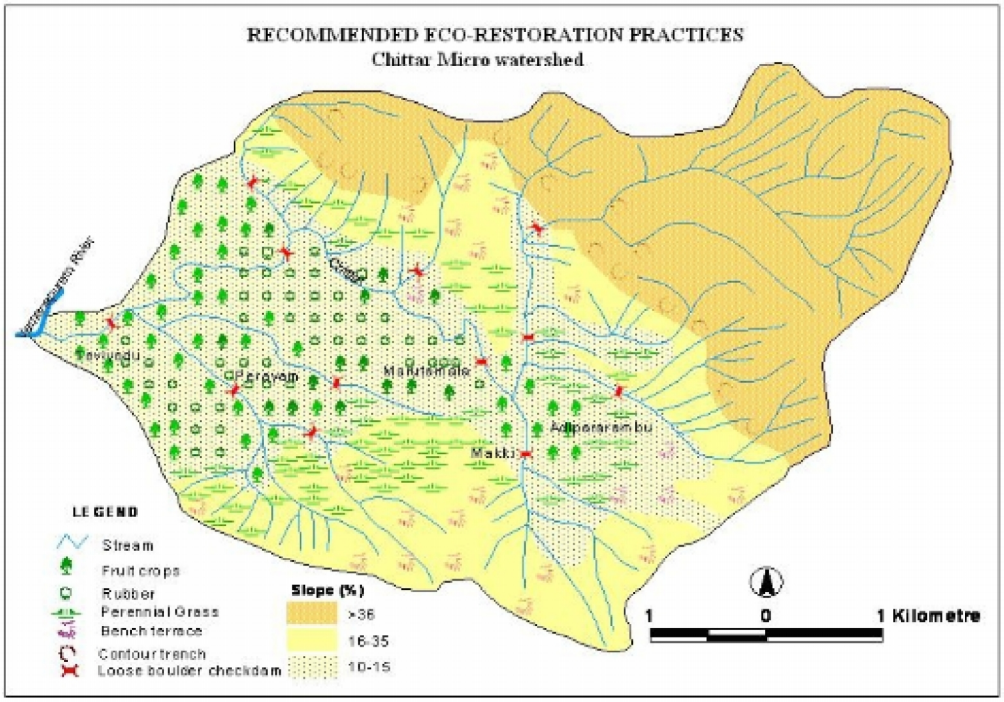

Fig. 3. Recommended Eco-restoration practivces in Chittar watershed

in channel erosion. The checkdams could be made cost effective by utilising the locally available materials for construction. Loose boulder checkdams are recommended in the Chittar watershed. To ensure longer survival it should be strengthened by vegetative cover.

Participatory management

Community based management of natural resource is more effective for maintaining the sustainability of restoration programmes. Participatory Forest Management introduced in the new Indian Forest Policy of 1988 envisages active association of rural communities in planning, management and rejuvenation of degraded forests in their proximity (Rajora, 1998). The degraded forests in the foothills of Chittar watershed could be regenerated with the help of local communities. Forest Protection Committees (FPC) is to be organised involving the members of the Self Help Groups and User Groups. At least one member from every family should be nominated in the FPC and 50% of the members should be women. The FPC should also ensure the involvement of forest officials. Micro-plan should be prepared for eco-restoration oriented watershed development. The micro-plan for watershed development should consist of low input management measures for assisted regeneration and rejuvenation of degraded forests. The committee should also conduct timely monitoring and evaluation of the parameters like people's participation in planning and implementation, control of human intervention, local ecology, benefit sharing, etc. The active participation of women in the restoration programmes helps to reduce gender disparity to a great extent. Empowerment of women in the watershed can be ascertained by credit group formation. The successful functioning of women oriented self-help groups, locally known as "Kudumbashree" in the neighbouring midland watersheds could be sited as an excellent example. Women oriented self-help groups can undertake income-generating activities conducive to the management of forested watersheds. Such activities include apiculture, processing of tropical fruits cultivated in the watershed, raising medicinal herbs and their marketing, etc. The additional savings generated by the credit groups can be utilised as revolving fund for the developmental activities.

CONCLUSIONS

Over the past few decades, there occurred several modifications in conceptual models, objectives and implementation of programmes aiming at sustainable maintenance of ecosystems.In due course the protection oriented approach gave way to the restoration of degraded natural units. Thus watersheds have become the single and most effective units for the planning and implementation of eco-restoration programmes. The eco-restoration approach helps in the integrated development of forested ecosystems and is considered ideal for managing the vital resources of land, water and biomass, especially in the upper catchment of the watersheds. In this context, the identification and prioritisation of degraded watersheds, specifically in the transition zones of protected forest ecosystems project the urgency of concerted efforts to restore their pristine environment through site and need specific interventions in participatory mode.

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