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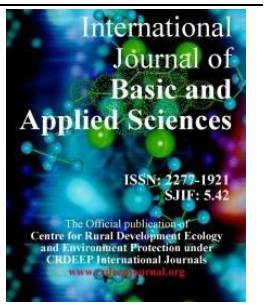

Review Paper

Watershed Management in the Headwater Catchments of Kiliki River, Nagaland, India: A Review

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ABSTRACT

This paper is an attempt to propose planning for watershed management in the selected headwater catchments of the Kiliki River, Nagaland in the Brahmaputra basin of the North East India. These headwater catchments are representative areas of this region in terms of providing ecosystem and environmental services. The natural resources are being over exploited resulting in widespread ecosystem and natural resources degradation in the region. At present, watershed management, conservation and wise utilization of natural resources like land, water and forests in the study area are important issues of concern for sustainable development in and around the study area. It has been realised that there is an urgency to integrate the environment in decision making and planning to maintain quality environment and to achieve sustainable development. Data collection was supported by regularly organized field surveys to assess the physical environment and natural resources. The present work has adopted the most suitable approach with proper planning exercises in the six headwater catchments having different land uses and geo-environmental characteristics for the detailed study of environment and natural resources management to propose planning for watershed management and sustainable development. This study illustrates some practice-oriented examples of effective planning in the headwater catchments. The paper also discusses the current environment and development issues of the North East Hill region of India and suggests some remedial measures for achieving sustainable development.

Introduction

Watershed is the area which contributes water to a particular stream or set of streams (Leopoled et al, 1964). Watershed management may be defined as the development and management of watershed resources in such a manner as to achieve optimum production, which can be sustained without causing deterioration in the resource base or disturbing the ecological balance (Das, 1998). It aims at optimising the use of land, water, vegetation, man, animal and environment to prevent soil erosion, moderate floods, improve water availability, increase food, fuel, fodder, fibre and timber production on a sustained basis (Bhardwaj and Dhyani, 1994). The Brahmaputra is one of the world's largest rivers with a drainage area of 580000 km² (50.2% in China, 33.6% in India, 8.1% in Bangladesh and 7.8% in Bhutan). The environment in the region has been degraded by the land use change, mainly due to shifting cultivation, deforestation, road construction slash and burn on hill slopes, accelerated soil erosion, landslides, flood hazard and the dwindling natural resources. Watershed management is inherent in the concept of sustainable development. Efficient watershed management is prerequisite for sustained economic and other components of local and regional level planning in the North East Hill region in general and Nagaland in particular (Rawat, 2004). Critical gaps exist between planning for economic development and environmental management to achieve watershed development. Watershed management needs for a holistic approach to integrate on single problem (process) to all other problems (processes) to identify a unit (sub-system) in the landscape (drainage basin system/headwater catchments) for operation of management activities and to monitor the quantity of inputs and their outputs and to analyse the state of the system (Rawat, 2011). Sustainable development assures that the development activities remain firmly attached to their ecological roots and that these roots are protected and nurtured so that they may support economic growth as well as environmental conservation over the long time. Ecology and economy are becoming ever more interwoven locally, regionally and globally into a net of cause and effect. An awareness of the role of scientific works in watershed management is going rapidly after a very

slow start. In the list of such works which have a potentially fruitful basis for landscape studies in environmental management, the works of Cook and Doornkamp (1974); Tiwari and Singh (1982); Rawat (2008); Rawat and Furkumzuk (2010) and Singh (2002). A large amount of literature exists on other parts of the North East Hill region which unequivocally points to the facts that human activities have led to increasing environmental and ecological degradation, and therefore the development achieved is far from sustainable. Reduced forest cover (Singh, Tiwari and Saxena, 1985), accelerated soil erosion and increased silting of water bodies (Valdiya, 1985; 1987 & Rawat and Rawat, 1994 a), drying up of springs (Valdiya and Bartarya, 1991, Rawat and Rawat, 1994 b), replacement and disappearance of species (Saxena et al, 1994 and Singh et al, 1984), increased ratio of energy expanded in fodder and fuel collection to energy expended in direct agricultural activity and consequent high level of drudgery of womenfolk (Pandey and Singh, 1984).

Degradation of ecology, environment and natural resources in the river catchments of North East Hill (NEH) region is often associated with shifting cultivation which is the most prominent farming system providing a way of life for a large number of ethnic communities. This is common across Bangladesh, Bhutan, Northeast India, Nepal and Myanmar (ICIMOD, 2006). In the recent past, Nagaland has received growing attention due to environmental and ecological degradation caused in the process of short-term developmental motives and basic life survival activities (Rawat, 2008). About 64 % of its total geographical area is under shifting cultivation in the state (Keitzar, 2009). This cultivation system is not only inefficient in terms of the productivity of the labour and land but also causes degradation of the catchment ecosystems resulting environmental degradation and ecological crisis (Rawat, 2013). The environmental, ecological and economic considerations are therefore to be combined for attaining sustainable development. Strategies for sustainable development must be based on reliable and comprehensive data on natural – cultural environments and socio- economic resources (Singh, 1998). Recent watershed management works are specific problem oriented rather than generalized. So far watershed management has not been taken seriously as the social, economic and other components in development planning. Actions at all levels are required to develop and promote programs, policies and approaches that integrate environment, ecology, economics and social components of the region in general and Nagaland in particular for its overall sustainable development. Over the years several factors have caused progressively increasing strains and stress on the society and on the efficiency of the jhum practice so that in majority of cases the practice has become highly resource depleting and severely environment degrading (Rawat, 2010). The major challenges are how to adopt its land use pattern and production system to the increasing population and changing life style, making them environmentally and economically sustainable. The paper explores the planning strategy for watershed management in six selected micro watersheds / headwater catchments having different land uses encompasses a total area of 80 km² to propose micro level / grass root level planning for watershed management and sustainable development.

Materials and methods

Watershed has been widely recognised as a natural unit for environmental, socio-economic, natural resources use and management planning and sustainable development studies in the mountain (Curry, 1976; Gregory and Walling, 1979). The watershed and its headwater catchments have been selected for this investigation which provides the best way of managing the environment and natural resources so as to meet the present and future needs of the concerned community without jeopardizing or destroying the environment and ecology. Integrated and basic resource surveys were conducted for assessing physical environment and natural resources-covering geomorphology, surface hydrology, climate, soil, vegetation etc and socio-economic surveys were also conducted for the study of the present socio-economic (cultural) environment like population, land use, and socio-economic status etc. The materials and instruments were used-Survey of India Topographical Maps, IRSP6LISS-III & IRS p6 PAN imagery, Arc-Info GIS software, Altimeter, Pedometer, Brunton Compass, Geology Hammer, Measuring Tape, Abney level and Questionnaire etc. Data on forest cover, land use, general geology and geomorphology, surface hydrology were also collected during the field work.

The study area

The study area falls under the Brahmaputra river basin of the North East India located in the central part of Nagaland covering the urban and rural landscapes with different land uses. The Kiliki river basin, viz. the study area lies between latitudes 25° 59′ 33″ N & 26° 06′ 43″ N and longitudes 94° 25′ 55″ E and 94° 32′ 52″ E in the Zunheboto district of Nagaland (Fig.1) and encompasses a total area of about 80 km². About 32 percent of total area is covered by dense natural forest. The land is being utilized as 55 per cent under shifting cultivation and fallow land, 2 per cent under terrace cultivation, and remaining 11 per cent area is under plantation and settlements. The elevation ranges between 510 m above msl at the outlet of the watershed and 2066 m above msl near Atoizu- the highest elevated ridge on the watershed divide. Most of the villages, sub towns and the main town namely Zunheboto- the district headquarters are situated on the top of the hills in the headwater areas (Rawat and Furkumzuk, 2007). The important villages of the watershed are Sukomi, Litsami, Emilomi, Yeshulumi, Asukhuto, Vekuho Phuyeu, Vekuho Phutheu, Atoizu, Kisakita, Asukhomi, Lizu Naghuto, Lizu Phuyeu, Lizu Phutheu, Lizu Avikuqato, Natha Yeptho-u, Natha Zhimo-u, Xukhepu, Nikuto, Ghukiye, Kulhopu and others (Fig.1). The total length of Kiliki river is about 17.94 km, a tributary of the Doyang river which has its confluence with Langki river first then contributing to the Doyang river a tributary of the Brahmaputra river. The river basin is totally under hilly terrain of rather immature topography having rugged and rough hills with narrow alternating inter- montane valleys. About six micro watersheds with different headwater catchments have been identified for the detailed studies on environment and development to propose micro level land use planning and natural resources conservation for watershed management. The ultimate aim of this research is to study the environment and development problems in the headwater catchments of the study area in particular and North East Hill region in general to formulate a proper planning strategy for integrated watershed management,

natural resources conservation and economic development of the headwater areas in terms of providing ecosystem services.

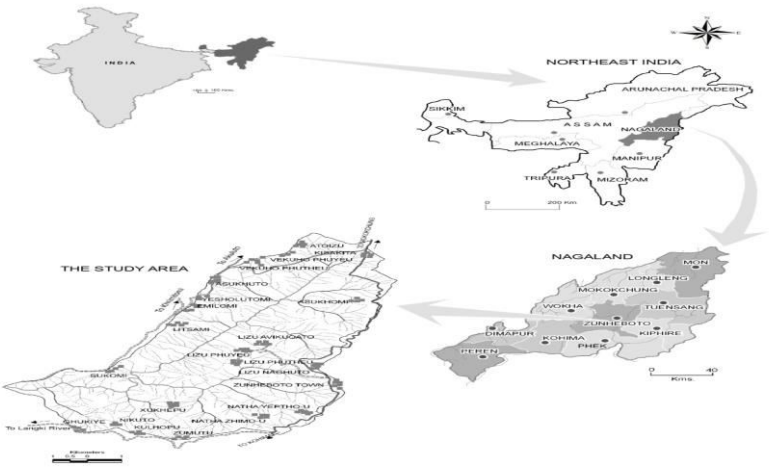


Figure 1: Location map of the Kiliki River Basin of Nagaland, North East Hill region of India.

Results and Discussion

Impacts of shifting cultivation

The hill ecosystems of the Himalaya are critical for ensuring food, water and energy security not only in the upstream areas but also in downstream river basins. As water, nutrients and other ecosystem services flow downstream, the land use and management practices at the headwaters in upstream watersheds affect the availability of natural resources and therefore, critical for sustaining environment and ecology. Mountain communities are the custodians of vital resources and their actions have important implications for the condition of the headwaters and watersheds. With limited land resources, growing water stress, increasing energy demand and poor socio-economic conditions, the North East Hill region of India face serious challenges as to how to provide adequate food and nutrition access to modern energy, and safe water to a burgeoning population without degrading the ecology and environment. Nagaland - an extreme north eastern hill state of India is receiving growing attention in recent years due to the environmental changes and ecological degradation caused in the process of shifting cultivation activities. One of the issues of ecology and environment is the role of shifting cultivation activities and the threat they pose to environmental sustainability. Shifting cultivation is a traditional practice and still predominant in the region. As a result of population explosion, demand for food and fuel increased and land availability for agriculture has reduced. As a result, the jhum cycle of 10-15 years is reduced to 3-5 years. Earlier when jhum cycle was long, the abandoned land got time for regeneration of vegetation. Indiscriminate felling of trees on the hill slopes brought an undesirable eco-imbalance. Erosion of soil in the hill slopes resulted in silting of the reservoirs and streams leading to unprecedented floods. Hence, this situation needs to be tackled on top priority to keep the ecological imbalance in tact as well as to meet the fodder, food, fuel requirements, etc., in the region. The calendar of shifting cultivation system and soil erosion is given in Table1. The cultivation is highly uneconomical and has caused extensive resource depletion and widespread land and environmental degradation in the region (Ramakrishnan, 1990).

Table 1: Soil erosion calendar of shifting cultivation system in the North East Hill region of India (after Yadav *et al,* 2001).

Month	Agricultural operation	Erosion problem	Soil erosion (t/ha)	
			Minimum	Maximum
January to April	Selection of plot, forest cutting, burning and cleaning of hill slopes and sowing begins	Displacement of loose soil materials to down hills and rolling down of earthworm casting, soil erosion as above and wash due to rains	0.0	22.4
May	Sowing / weeding	Heavy soil wash, faint drilling at foot hills on silt deposits	0.2	61.9
June	Weeding	Heavy wash of soil aggregates	0.2	45.4
July	Weeding/harvesting begins	Heavy wash of soil aggregates, crop root exposed, farm soil visible	1.8	21.9
August	Harvesting and occasional weeding	Soil wash continues	1.0	29.6
September	Harvesting	Moss appears, soil erosion slows down	0.1	13.8
October	Harvesting	Soil erosion appreciably reduced	0.0	2.7
November	Harvesting	No erosion, moss turns blackish	0.0	0.0
December	Harvesting/threshing/carry harvest back to home	No erosion	0.0	0.0

Year	Cropping with zero tillage on steep slope	Heavy soil wash	3.3	201.4

Table 2: Land use classification in states of North East region of India (area in '000 ha). Source: Anonymous (1995).

State	Geographical area	Forest area	Area not available for cultivation	Other unscientific land	Waste land (Km^2)	Percent of geographical area	Net sown area
Arunachal Pradesh	8174	5154	77	41	8934	16.1	149
Assam	7844	3071	2455	535	2439	25.3	140
Manipur	2233	1515	1445	24	5594	25.3	140
Meghalaya	2243	851	226	646	4745	21.1	202
Mizoram	2108	1593	211	81	4456	21.2	65
Nagaland	1658	862	28	224	2053	19.7	190
Tripura	1049	631	131	40	3224	31.1	270

The region is severe threat of soil erosion mainly due to the shifting cultivation (Singh and Singh 1981, Toky and Ramakrishnan, 1981). Estimates have revealed that nearly 88.3 million tonnes of soil is lost annually as a result of shifting cultivation in North East Hill region. The degraded land as can't be put to any productive use. The faulty land use pattern (Table 2), population pressure on resources, unscientific developmental activities, large scale deforestation, mining activities, landslides, agriculture on steep slopes are major causes of soil erosion and land degradation (Mishra, 1998). The North East Hill region is considered as mega-biodiversity area. However, due to indiscriminate deforestation the forest of the region has started dwindling at an annual rate of 0.7 per cent. The dwindling forest cover has resulted in the changed rainfall pattern. A sizeable amount of biomass including wet/dry leaves, forest litter and wooden material is burnt in uncontrolled conditions in this system (slash and burn) of agriculture. The estimated amounts of dry/wet leaves, wooden material, and forest litter burnt in shifting cultivation comes to around 25.61 million tones, resulting into adding up of approximately 10.88 million tonnes of pollutants in the environment every year. Apart from this, about 15000 MW equivalent amount of energy, in terms of heat units is also added to the environment (Table3).

Table 3: Annual energy wastage in burning biomass in shifting cultivation in the North East Hill Region of India (after Mishra 1998).

Source	Amount burnt in shifting cultivation		Calorific Value of the Biomass	Total wastage of Energy	Equivalent Power
	Million Tones	Kg	GJ/Kg	GJ	MW
Wooden material	21.511	$21.511x10^9$	0.01901	$40.89x10^7$	12966.0
Leaves	1.868	$1.868x10^9$	0.01521	$2.84x10^7$	900.56
Forest Litter	2.228	$2.228x10^7$	0.01877	$4.18x10^7$	1325.47
Total	25.607	$25.607x10^9$	-	$47.91x10^7$	15192.03

Table 4: Nutrient released through ash and blow-off under jhum cycles at lower elevations in the North East Hill region of India (after Toky and Ramakrishnan 1981).

Nutrients (kg/ha/yr)	Jhum Cycle					
	30 years		10 years		5 years	
	Release	Blow off	Release	Blow off	Release	Blow off
P	313	147	262	156	151	43
K	1739	817	2070	1229	262	156
Ca	956	449	193	115	116	33
Mg	209	98	152	90	114	32

Table 5: Hydrological responses to different jhum systems and jhum cycles in the North East Hill region of India (after Toky and Ramakrishnan 1981).

Site of Agro-ecosystem	Runoff (cm)	Percolation(cm)	Sediment (t/ha/yr)
5 Years Jhum Cycle	37	23	30
10 Years Jhum Cycle	34	19	23
30 Years Jhum Cycle	29	14	23
Site of Fallow Land			
5 Years Jhum Cycle	27	21	1.1
10 Years Jhum Cycle	19	14	0.8

Table 6: Soil erosion in the headwater areas under different land use practices in the North East Hill region (after Yadav et al, 2006).

Sl. No.	Land use practices	Soil loss (t/ha/yr0	Author
1	'Bun' System for raising tubes crops	40-50	Singh and Singh (19810
2	Pineapple along the hill slope	24-62,6	Ghosh (1976)

Table 6 reveals the soil erosion in headwater areas under different land use practices in the North East Hill region of India. A multidisciplinary long-term study showed that 92.9 to 99.1% of rainwater can be retained in-situ, compared to 66.3% in shifting cultivation areas. Mean annual soil loss varied from 11.2 to 97.2 t km² in new land use system as against 3621.3 tkm² in shifting cultivation system. The sediment load per litre of runoff from watersheds varied from 1250-20300 mg suspended sediment in the shifting cultivation areas. The environment of the study area has also been greatly affected by changes in land use, shifting cultivation, deforestation, accelerated soil erosion and landslides etc. The Kiliki river basin is characterized by different sizes of headwater catchments with geologically sensitive and unstable soil profiles. Rapid geomorphologic changes due to active tectonics are evident. During monsoon months landslides become acute problem. The conservation and management of natural resources like land, water and forests in the study area is an issue of concern for sustainable development and improving the livelihood of local inhabitants. To manage the watersheds means to provide an ecologically sound economic base for the inhabitants and to maximize the long-term productivity and optimize social and economic well being of the people; and scientifically, a combination of environmental repair and economic development. Environment and resource degradation in and around the study area in the North East Hill region threatens the livelihood of the people and constraints the ability of governments to develop a healthy agricultural and natural resources base. The effective environmental management is not found in the region. Due to time factor and the systems responsiveness to changing requirement of high population pressure, jhum cultivation has caused drastic decline in crop yield, loss of forest wealth, soil fertility, biodiversity and environmental degradation. So far, environment has not been taken as seriously as the social, economic and other components of local and state level planning

The strategy for watershed management

The study area viz., the Kiliki river basin has been broadly divided into six micro watersheds with different headwater catchments as planning units based on different land uses, environmental characteristics and development problems to achieve watershed management and sustainable development. These identified micro watersheds and headwater catchments are as follows- (1) Shichi Micro Watershed (2) Azukikihi-Lomopula Micro Watershed (3) Asukhomi Micro Watershed (4) Kiliki Hu- Lokobo Micro Watershed (5) Upper Shepoki Micro Watershed (6) the Miscellaneous Land and its Headwater Catchments. The general geographical characteristics of these watersheds have been presented in the figures 2, 3, 4, 5, 6 and 7. The proposed land use planning strategy for environmental management of these headwater catchments has been discussed as follows.

Management in the Shichi Micro Watershed

The Shichi micro watershed and its headwater catchments are situated in the east direction at the middle part of Kiliki river basin and extents between latitude 20° 02′ 23″ N & 26° 03′ 53″ N and longitude 94° 30′ 10″ E & 94° 32′ 04″ E. This micro watershed and headwater catchments encompasses an area of about 5.02 km^2. The Shichi stream has its confluence with Kiliki river at an altitude of 800 m above msl. The main village comprising about 10 households is located at the south western boundary of this headwater at an altitude of about 1500 m above msl. Figure 2 is showing the proposed planning strategy for watershed management, environment and development. The existing land use is as the current jhum area is 55 ha, the forested land is about 147 ha, plantation covered 3.0 ha, scrubs and fallow 336 ha, settlement 0.2 ha and area under terrace cultivation is 9 ha. There are many springs which are drying up and some have been already dried up. During the driest month one of its springs was having water discharge capacity of 0.12113 l/sec in the month of April-the lean period of the year. To make all the springs functional or perennial, spring sanctuaries may be developed and rain and surface water harvesting practices may be started in and around the water scarcity areas. The Shichi stream water may be utilized for surface/stream water harvesting and then utilized for minor irrigation for agriculture and horticultural development nearby areas of the village. The water from the streams can be taken from one place to another and may be utilized at many mid- point areas (Figure 2). At places of downstream of Shichi stream, check dams are being proposed to check the land degradation and control the overland flow. There is suitable land area around the outlet of this headwater catchment for further development of terrace cultivation. Below of the Zunheboto road side in the south east areas, massive afforestation is required and proposed. Afforestation is recommended in these headwater areas. A good network of roads is helpful to reach inaccessible areas for the development activities. The eastern side of the Lizu Avikuquato village is having land with gentle slope which may be utilized for terrace cultivation.. In an around the Lizu Avikuquato village, home gardening, horticulture and fruit growing areas may be developed (Figure 2).

Management in the Azukikihi-Lomupula Micro Watershed

The Azukikihi-Lomupula micro watershed and its headwater catchments are the drainage areas of two small rivers namely, Azukiki and Lomupula streams which are joining at 2 kms before confluence in the Kiliki river at an altitude of about 650 m above msl. These headwaters extent between latitude 25° 59′ 36″ N & 26° 01′ 20″ N and longitudes 94° 27′ 32″ E & 94° 28′ 57″ E. The altitude ranges between 650 m and 1800 m above msl. The total area of these headwater catchments is about 6.02 km^2 . Three villages namely, Kulhopu and Zumutu, are situated on the southern and south-western watershed divide and Lxukhepuis village is located on the western water divide of this micro watershed. The existing land use is as 403 ha area is under forest cover, scrubs and fallow land which spread about 156 ha area. Settlement covered 36 ha area. Terrace cultivation area is only 7.1 ha. The headwater areas of this micro watershed are an urgent need of forest conservation. On the gentle hill slopes, nurseries may be

developed for the massive afforestation. Figure 3 is showing the proposed strategy of planning for environmental management and development under two general categories as (A) an appropriate general land use planning and (B) the planning strategy for management of environment and development activities. A general awareness for the importance of people's participation may be started in the area for environmental conservation, management and sustainable economic development. An "Environment Management Committee" (EMC) may be constituted for the overall supervision of implementation and monitoring of the management plans. All the four villages are experiencing economic backwardness, resources scarcity and migration of people from villages to urban areas within and outside Nagaland. Surface water harvesting from the nearby streams and rooftop rain water harvesting systems are required for domestic and minor irrigation purposes. In and around of some selected villages *"spring sanctuaries*" may be introduced for the regular and proper functioning of water sources. Across the small rivers of Lomupula and azukiki, check dams are proposed to control the land degradation and overland flow. Terrace cultivation may be encouraged in the valley areas of both the small rivers with the introduction of minor irrigation facilities. Tree farming may also be developed in the steep hill slopes for the fuel, fodder and timber purposes. An urgent requirement was felt for the improvement of school education within the watershed.

Management in the Asukhomi Micro Watershed

Asukhomi micro watershed and headwater catchments extent between latitudes 20˚ 03′ 20″ N & 26˚ 05′ 42″ N and longitudes 94˚ 30′ 54″ E & 94˚ 32′ 58″ E and encompasses a total area of about 8.0 km^2. The elevation ranges between 800 m and 1900 m above msl. There is only one village (Asukhomi village) on the western part of the watershed. The area under current jhum is about 92 ha, forest 303 ha, plantation 48 ha, scrubs and fallow land 323 ha, settlement 12 ha and terrace cultivation is about 22 ha of area in this micro watershed. The Asuhkomi micro watershed is badly suffered by frequent landslide hazards. Many families have been already shifted to the safer sites and many are planning to shift from their own place to the safer place as early as possible. The landslide affected areas are urgently require landslide hazard management to check the further degradation of land. Large scale afforestation and construction of retaining walls are required at the earliest. The regular landslide activities, slope failures and land destabilization are due to because this area is under a major fault zone area. The continuous soil erosion and land degradation have been observed downstream due to the active mass movement processes in the upper part of this micro watershed. The rain splash erosion, sheetwash erosion, gully erosion and channel erosion have been identified. During monsoon months, enormous suspended sediment, dissolved sediment and bed load sediment flowed down. This micro watershed is also facing acute shortage of drinking water. Because majority of springs have been chocked up due to deposition of landslide materials. Therefore surface, stream and rain water harvesting system have been proposed (Fig. 4). The agricultural land is experiencing lower productivity due to the erosion of productive top soil of the area. The water flow of three springs (Headwater streams) located in the north of this micro watershed were recorded as 0.10309 l/sec¹, 0.19166 l/sec¹ and 0.12052 l/sec¹ during the driest month of the year. The areas where dense forest cover is in the upstream areas, many perennial springs were found down slope areas of the forest. The springs which are drying up or already dried up, may be again recharged and make them functional through the introduction of spring sanctuaries, massive plantation and large afforestation in the upstream areas of these springs. A systematic planning strategy has been presented in figure 4.

Management in the Kiliki Hu-Lokoba Micro Watershed

The Kiliki Hu- Lokobo micro watershed and its headwaters are located in the extreme north direction of the Kiliki river basin. This area is the most elevated part of the study area. These headwater catchments extent between latitude 26˚ 04′ 41″ N & 26˚ 07′ 05″ N and longitude 94˚ 30′ 28″ E & 94˚ 32′ 41″ E. The altitude varies from 800 m to 2000 m above msl.The total area of this micro watershed is about 10.02 km^2. Atoizu is the main sub-town of this micro watershed. The important villages are- Vekuho, Phuthen, Kisakita and Vekihou Phuye. The existing land use is as current jhum is being practiced fewer than 193 ha of area. The forested land, plantation and scrubs and fallow land are under 222 ha, 88 ha and 499 ha, respectively. The area of this micro watershed is characterized by steep slopes which are being denuded of its soil cover by sheet wash and gully erosion and also being deeply dissected as a result of quickened pace of erosion. Frequent land sliding and slope failures are also occurring in some areas of this experimental micro watershed. There is better scope for terrace cultivation development on both the hillsides of the main streams. Permanent terraces may be connected with small irrigation canals facility from harvested water from nearby streams or rain water harvesting structures. Rain water harvesting is very much possible on the gentle hill slopes above the terraces. Terrace cultivation may become an alternative of jhum cultivation through demonstration and action programmes. In and around the jhum land, tree farming and afforestation may be done for the requirement of wood (fire wood for fuel) for domestic as well as commercial purposes. The springs are in very less numbers in this micro watershed. There is a good scope for rainwater harvesting and development of "spring sanctuaries" in and around the villages for the regular supply of fresh water and ground water recharge. In each and every house of all the villages roof top rainwater harvesting system may be introduced with hygienic and quality structures to cope with the domestic water scarcity during dry months. Horticulture development is another sector of economic development of this area. It may be introduced and developed nearby villages to grow vegetables and fruits along with agricultural crops for commercial purposes too. Village community participation may also be encouraged for environmental awareness and optimal utilization of all the resources. The headwater areas of this experimental micro watershed are required large scale afforestation activities. For the restoration of optimal hydrological functions of catchment areas, conservation of water and prevention of erosion caused by runoff and overland flow may be introduced at the required sites/ location within the micro watershed. Judicious and equitable allocation of water is also required in all the villages. Figure 5 is presenting a systematic planning strategy for the environmental management and economic development of this micro watershed for their implementation.

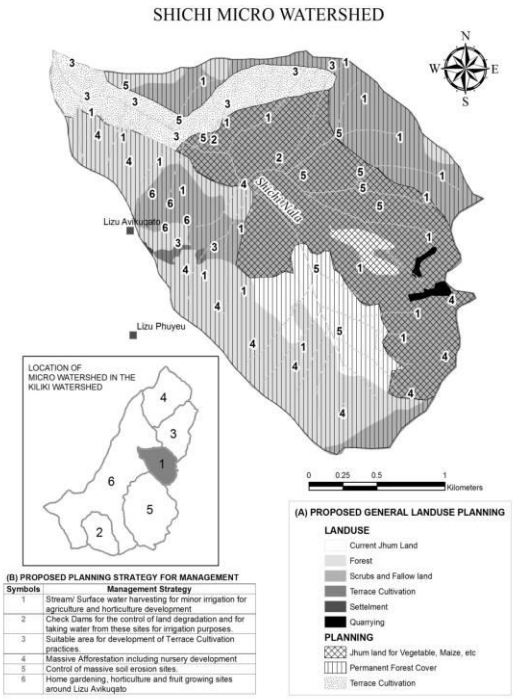


Figure 2: Map showing the proposed micro level planning strategy for general land use and environmental management in the Shichi Micro Watershed and its headwater catchments of Kiliki River Basin of Zunheboto district, Nagaland.

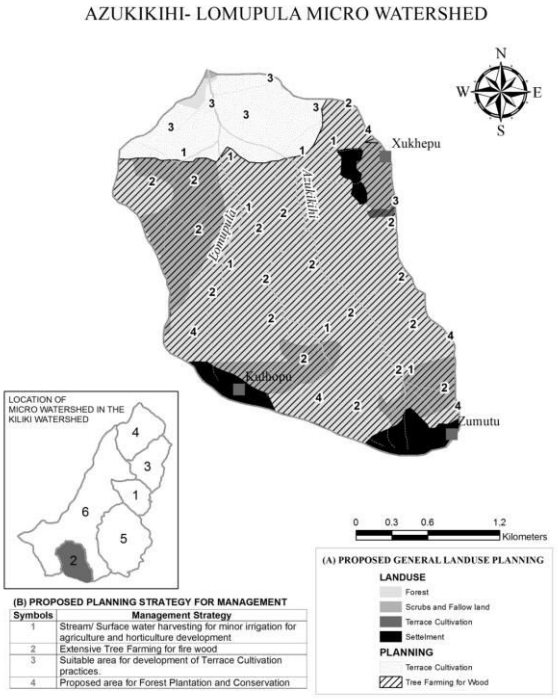


Figure 3: Map showing the proposed micro level planning strategy for general land use and environmental management in the Azukikihi-Lomupula Micro Watershed and its headwater catchments or headwater catchments of Kiliki River Basin of Zunheboto district, Nagaland.

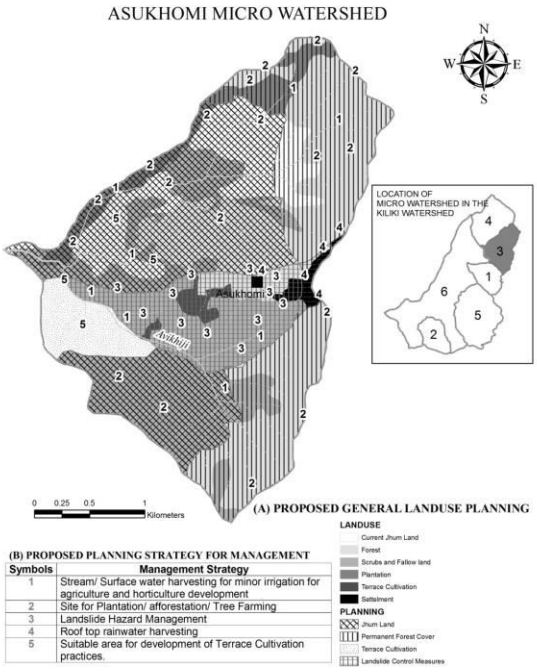


Figure 5: Map showing the proposed micro level planning strategy for general land use and environmental management in the Asukhomi Micro Watershed and its headwater catchments of Kiliki River Basin of Zunheboto district, Nagaland.

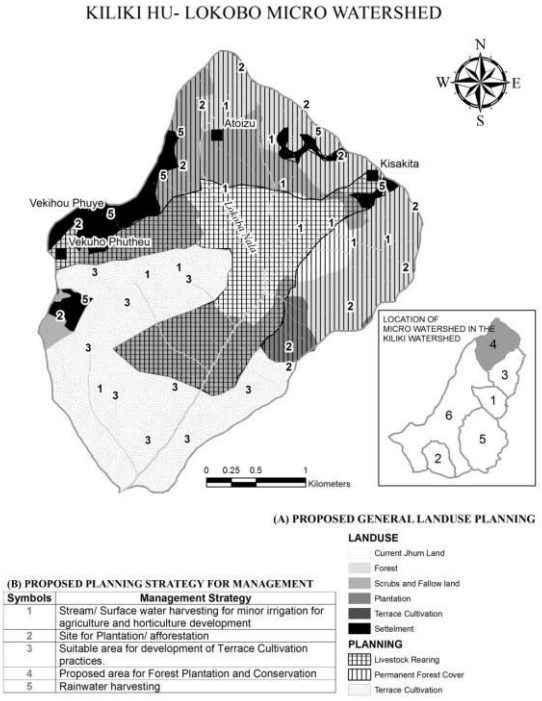


Figure 6: Map showing the proposed micro level planning strategy for general land use and environmental management in the Kiliki Hu-Lokobo Micro Watershed and its headwater catchments of Kiliki River Basin of Zunheboto district, Nagaland.

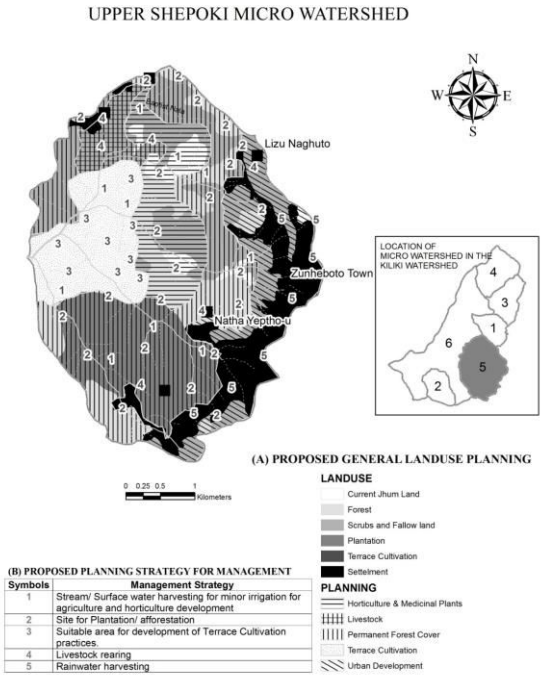


Figure 6: Map showing the proposed micro level planning strategy for general land use and environmental management in the Upper Shepoki Micro Watershed and its headwater catchments of Kiliki River Basin of Zunheboto district, Nagaland.

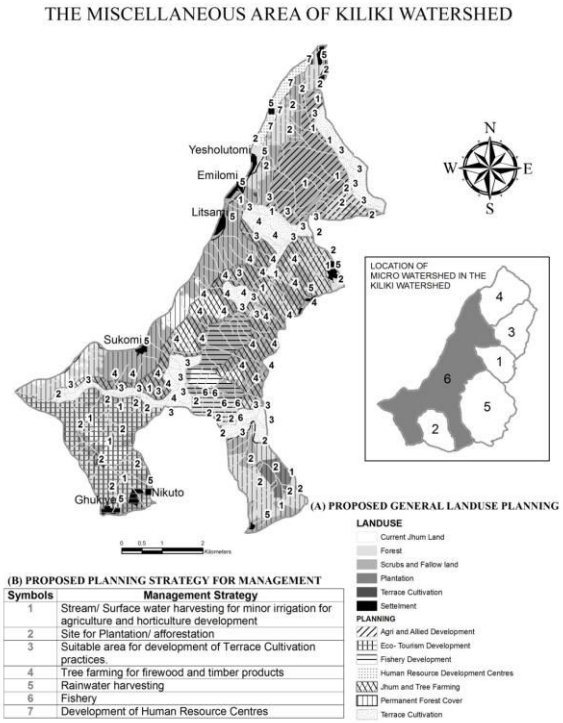
Management in the Upper Shepuki Micro Watershed

The upper Shepuki micro watershed and its headwater catchments are situated in the south eastern direction of the study area viz. the Kiliki river basin (Fig. 6). This micro watershed extent between latitudes 25° 59′ 48″ N & 26° 02′ 55″ N and longitudes 94° 29′ 28″ E & 94° 31′ 59″ E encompasses an area of 16 km^2 . The western part of the Zunheboto town is lying in this micro watershed. The main villages are situated on the watershed namely Natha zhimo-u, Natha Yeptho-u, Lizu Phuyeu. The altitude ranges between 800 m to 1900 m above msl. The existing land use is under current jhum practices 57 ha, forested land is 392 ha, plantation 302 ha, scrubs and fallow land 582 ha, settlement 252 ha and terrace cultivation is under 39 ha of land. Some parts of upper Shepuki micro watershed are under serious threat of land sliding, mass wasting processes and soil erosion caused by hill slope processes, deforestation, slash and burn practices and other human activities. Many buildings- houses are under risk of land sliding. Landslide control measures and landslide hazard management and mitigation are urgently required. In and around the landslide prone areas large scale afforestation will be a wise step towards minimize the land degradation. Land, water and forest resources conservation and management is the most important priority of this micro watershed. The expansion of urban settlements is recommended only through a planned urban development. In some areas ground water is being used for domestic purposes during the dry months of the year. Therefore, replenishment of ground water table is urgently required because the ground water table is going down fast. This may be done through the rainwater harvesting practices. There is another urgency to start work for diversion of over land flows from eroding areas through drainage treatment and drainage construction. Contour benches, walling of terraces and planting of trees and grasses are required. There is a serious problem of irregular domestic water supply in most of the villages. To cope with this crisis rainwater harvesting is being suggested for each and every households of this watershed. Environment Management Committee may be constituted for the involvement of people from all villages in the programme planning, execution and monitoring of management works on the priority basis for resources management and environmental hazard mitigation. There is another need of the hour is to enhance local level self-reliance by the formation of a Environmental Conservation Fund (ECF) which will encourage environmental conservation and restoration of ecological balance and promotion of sustainable development.

Management in the Miscellaneous Micro Watersheds

The miscellaneous land of the study area comprises other micro watersheds / headwater catchments which are laying along with the boundary of Kiliki watershed in the western and south western direction sloping towards the Kiliki river. It extent between latitudes 25° 59′ 54″ N & 26° 06′ 08″ N and longitudes 94° 25′ 50″ E & 94° 31′ 19″ E. The total area is about 35 km^2 under this planning unit of management. The altitude varies from 500 m to 1800 m above msl. The present land use comprises as current jhum is under 66 ha of land, forest 1133 ha, plantations 51 ha, scrubs and fallow 1895 ha, settlement 86 ha and the area under terrace cultivation is about 75 ha. The villages of this area are Ghukiye, Nikuto Sukomi, Lizu Avikuqato, Litsami, Emilomi, Yesholutomi, Asukhuto sub town and the Asukhuto. All these villages require grass root level planning for agriculture, horticulture, water, animal husbandry etc. There are enough opportunities for the development of terrace cultivation in the valley side areas. The maximum area is under scrubs and fallow land. Therefore, management of this category of land is first priority area of planning for development and management activities. Water harvesting practices may be started in this area for minor irrigation and domestic purposes. The conservation, development and management of land, water, forest and other resources to improve ecological well-being

and life supporting systems for the betterment of the village people and their environment. Tree farming may also be developed in areas where jhum land is being utilized for wood production for domestic and commercial purposes of fire wood for fuel. Employment generation through the establishment of cottage industries based on the local resources and development of the human and natural resources of the villages in order to promote income generation activities may be encouraged through appropriate integrated planning through Participatory Rural Appraisal (PRA) techniques. Concern over the depleting water resources of this area, the agriculture sector is the most affected while deforestation is one of the main causes for depleting water resources. PHE department is taking up a lot of water resource related projects to supply adequate water supply. Actual implementation on ground is not so encouraging in this area due to lack of co- ordination among various departments. Figure 7 is showing the proposed strategy of planning for the environmental management and sustainable development. The analysis reveals that the issues of the jhum cultivation activities have caused drastic decline in crop yield, loss of forest wealth, soil fertility, biodiversity and environmental degradation in all the above experimental micro watersheds and headwater catchments. Actions are urgently needed to be taken to halt and reverse environmental degradation. The healthy agricultural and natural resource base is must for the secured future of the people. For this, we have to promote sustainable use of the natural resources build on the combination of traditional knowledge and the modern science and technology skills. People's participation, technical and traditional knowledge are the benchmark pillars of watershed management and sustainable development in the area. So far environmental management has not been taken seriously as the social, economic and other components in development planning. Actions at all levels are required to develop and promote programs, policies and approaches that integrate environment, ecology, economy and social components of Nagaland for its overall sustainable development.



Symbols	Management Strategy
1	Stream/ Surface water harvesting for minor irrigation for agriculture and horticulture development
2	Site for Plantation/ afforestation
3	Suitable area for development of Terrace Cultivation practices.
4	Tree farming for firewood and timber products
5	Rainwater harvesting
6	Fishery
7	Development of Human Resource Centres

Figure 7: Map showing the proposed micro level planning strategy for general land use and environmental management in the Miscellaneous land / headwater catchments of Kiliki River Basin of Zunheboto district, Nagaland.

Conclusion

The study shows how human activities particularly shifting cultivation, which have caused drastic decline in both the crop yield and the environment of Nagaland, may be tackled. The problem is that the environment has been degraded by shifting cultivation, the slash and burn system on steep slopes, deforestation, and also by road construction. These phenomena have accelerated soil erosion, landslides, the deterioration of natural resources and the consequent loss of the well being of inhabitants. Action is urgently needed to halt the further environmental degradation and the micro watershed planning approach described here, which is based on ecosystem services considerations, seems to be a good way to secure a better future for the citizens of these isolated mountain headwaters. The proposed concept of micro watershed planning includes combination of the traditional local knowledge applied through citizen participation with modern technology skills. Of course, actions at all levels are required to develop and promote the programmes, policies and approaches that integrate environment, ecology, economy and social components of Nagaland for its overall sustainable development.

Participatory micro-watershed planning, which is guided by the involvement of rural people, illustrates how small-scale changes, locally agreed, can help restore and sustain the ecosystem services and the environmental services of hilly headwater catchments and might become an integral part of the food, water and energy nexus. This study illustrates some practice-oriented examples of such effective planning in small headwater catchments. It shows how decision making and planning procedures have to integrate and unite

environmental and socio-economic approaches with the local stakeholder wishes and control.

Recommendations

1. There is an urgency to integrate the environment and economics in the decision making and planning in the North-East hill region in general and Nagaland in particular.
2. Urgent extensive measures be taken to arrest the ongoing eco-degradation in the Zunheboto hills, so that not only the environment improves but also get high yielding sustainable ecosystem to develop the local economy.
3. An action programme should be initiated for the collection of reliable geomorphological and hydrometeorological data in different major and micro watersheds of Nagaland to understand the geohydrometeorological problems for the effective solutions for watershed management and sustainable development.
4. The study recommends that there is a need of review and re-orientation of the planning process and programmes particularly for conservation and maintenance of natural resources for the environmental sustainability. Therefore, it is suggested that the watershed farming systems with components such as agriculture, horticulture, agri-horti-silvi-pastoral livestock based etc which are required to be disseminated to the hill farmers and popularised. The watershed based farming system help in conservation of soil and water are more remunerative. The mixed farming component of shifting cultivation should be incorporated in the watershed systems.

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