Combining Innovative indigenous knowledge and frontier techniques of blue and green water management for improved water use efficiency in the north-eastern region of India

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ABSTRACT
Because of the significance of water for human and animal life, ecological balance, economic and development activities, and considering its increasing scarcity; planning and management of this resource as well as its optimal, economic and equitable use is of utmost importance. Two national water policies of 1987 and 2002 of the Government of India attach great significance to the role of hydrology for water resources management. The environment of a place determines the habitat, the mode of life and the progress of civilization up to a large extent. In northeastern region of India, the social sanctions and belief system maintained a balance between resource potential and their utilization for a long time but due to the increase in the demographic pressure and indiscriminate use of natural resources, imbalance has been created. The fast growing population in the region has pressurized the food production base and to satisfy their needs, the people have mismanaged and misused water resources. The region receives about 510 km^3 of water as rainfall, at an annual average of 2474 mm. However, gross misuse and mismanagement of rainwater has resulted in soil erosion and land degradation in the hills and silting of river beds and frequent floods in the plains. The problem has further been aggravated by the prevalence of shifting cultivation in 3869 km^2, annually. Estimated soil loss from the region is 601.2 million tonnes while N, P and K lost annually through erosion are 686, 99.2 and 511 thousand tonnes, respectively. Sustainable solutions to water problems would require a radical policy and institutional reforms for better management and utilization of water resources. Studies were undertaken to document potential indigenous as well as experiments were conducted to evolve new location specific techniques of water resources management, considering that a combination of indigenous knowledge and frontier technologies in water resources management, would have more social acceptability, environmental compatibility and sustainability. Shifting cultivation is the major form of land use of the people of the northeastern region of India, which has resulted in huge soil erosion through runoff from hill slopes and silting of river beds and floods in the plains, causing land and environmental degradation. Due to their ingenuity and skill, the tribal farmers of the region, have developed excellent water management systems in isolated pockets, which have remained sustainable for centuries. The 'Zabo' system of water management is practiced by the *Chakhesang* tribe in Phek district of Nagaland state. It is a combination of soil and water conservation, forestry and livestock. To maintain soil fertility, use of the leaves and succulent branches of *Alnus nepalensis, Albizia lebbeck* etc., is also done in the fields. Another system of water management is followed in Apatani plateau of Arunachal Pradesh state. The streams emerging from the hills are tapped and the water is diverted by a network of primary, secondary and tertiary channels to the fields. This is a community operation.

1. INTRODUCTION

The environment of a place shapes and determines the habits, the mode of life and progress of civilization. The region receives about 510 km^3 of water as rainfall, at an annual average of 2474 mm. However, gross misuse and mismanagement of rainwater has resulted in soil erosion and land degradation in the hills and silting of river beds and frequent floods in the plains (Sharma, 1997a, 1998). The problem has further been aggravated by the prevalence of shifting cultivation in 3869 km^2, annually (Table 1). The practice of shifting cultivation is prevalent in north eastern region of India, which results in an annual loss of 88.3 million tonnes of soil and 10.51, 0.37 and 6.05 thousand tonnes of nitrogen, phosphorus and potassium (Sharma and Prasad, 1995). Every year about 386.9 thousand ha area is deforested, the crops are grown for 2 to 3 years and then the place is abandoned. This has led to soil and environmental degradation and depletion of water resources. The practice was evolved during Neolithic age and tribal people are involved with this socio-culturally (Sharma, 1976). Shifting cultivation is not only a set of agricultural practices but implies the whole nexus of people's belief, attitude, self-image and tribal identity. The fast growing population in the region has pressurized the food production base and to satisfy their needs, the people have mismanaged and misused water resources (Sharma, 2003). The region, though having sufficient water in aggregate, cannot boast of adequate quantities of water at all the places and during all the times.

Under such restrictions, the *Chakhesang* tribe realized the significance of water and developed a remarkable system of water harvesting, management and resource conservation known as 'Zabo' system. This system, not only enhanced the crop productivity but helped in water resources development and sound resource base, improved the quality of life of the people and environment around as the deforestation was totally checked and soil erosion is negligible. The Apatani tribe of Arunachal Pradesh has also developed an excellent system of water management. The Apatani plateau is called the 'rice bowl' of Arunachal Pradesh. Field studies were also conducted to evolve new sustainable and eco-friendly land use system to replace shifting cultivation by efficient management of rainwater. Combining indigenous knowledge of water management and newly developed techniques of hydrology would go a long way in enhancing crop productivity and resource conservation for enduring food security. There is urgent need to develop, manage and judiciously use the water resources for enduring and sustainable resource base, environmental compatibility as well as food security.

Table 1. Shifting cultivation, forest depletion and soil and nutrient loss in northeastern region.

State	Shifting cultivation		Soil loss	Nutrient loss (000' t)		
	Annual Area (km^2)	Fallow (years)	(Million tonnes)	N	P	K
Arunachal	700	3-10	178	217	37	153
Assam	696	2-10	177	201	33	155
Manipur	900	4-7	64	76	7	63
Meghalaya	530	5-7	67	62	7	48
Mizoram	630	3-4	49	60	7	40
Nagaland	190	5-8	52	44	5	34
Tripura	223	4-9	15	26	3	18
Total	3869	2-10	602	686	99	511

2. THE PLACE OF STUDY

The place of study is the northeastern region of India, comprising seven states and having an area of 255 090 km^2 (fig 1). The region is predominantly hilly, with elevation above mean sea level varying

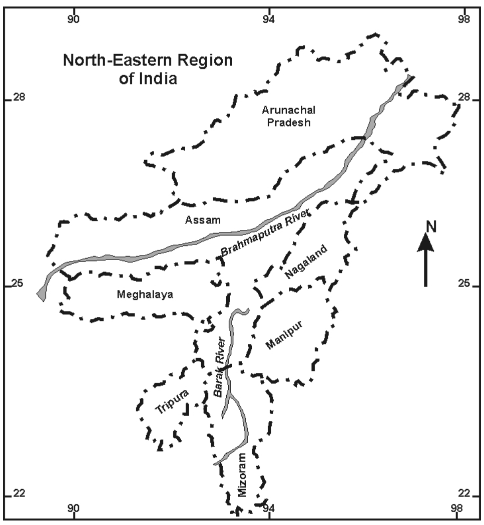


Fig.1 Northeastern region of India

varying from 73m to more than 15000m. The agriculture is mostly done on hill slopes. Shifting cultivation is the predominant mode of cultivation. The practice was acceptable when the population was low and the shifting cycle was 25 to 30 years. The period was sufficient for the rejuvenation of vegetation but, with increase in demographic pressure, the shifting cycle has come down to 2 to 5 years, rendering the practice as most uneconomical and resource eroding. However, there exist some sustainable, eco-friendly and economically viable land use systems, followed in isolated pockets of the region. These systems, devised due to ingenuity and skill of the tribal people, are unique in water resources development and management, particularly rainwater.

3. DISCUSSION

3.1. Water Resources Development in Northeastern Region

The northeastern region of India has surface water and replenishable ground water resources of 1064.7 km^3 and 16.63 km^3, respectively (Table 2). The ultimate irrigation potential in the region is 1606 thousand and 840 thousand ha from surface and groundwater, respectively. Most of the surface water in the region is confined to river systems which are in highly dynamic state due to high gradient and thus retain a very small quantity of fresh water for human use. Two major river basins in the northeastern region are Brahmaputra and Barak which drain 194.4 thousand and 78.1 thousand km^2 area, respectively (Table 3). The average annual flow from Brahmaputra river is 537.2 km^3 while it is only 59.8 km^3 from the Barak river. The water needs of the region are increasing with. The water needs of the region are increasing with increase in

Table 2. Water resources of northeastern states of India.

State	Surface water potential (km^3)	Ground water potential (km^3)	Irrigation potential (000' ha)	
			Surface water	Ground water
Arunachal Pradesh	366.0	0.79	166	100
Assam	558.7	14.82	1000	700
Manipur	19.8	0.04	100	5
Meghalaya	67.2	0.36	85	15
Mizoram	31.3	0.01	75	5
Nagaland	14.1	0.02	80	NE
Tripura	7.6	0.59	100	15
Total	1064.7	16.63	1606	840

NE – Not estimated

the demographic pressure. The sudden spurt in population growth has put tremendous pressure on land and water resources, while development has not kept pace to accommodate increased growth rate. The pressure on the fresh water system continues to grow for domestic use, agriculture, industry, energy and disposal of effluents, not only due to population increase but also due to a change in life style of the people (Sharma, 2003). The present fresh water demand is 27.4 km^3, which will grow to 43.0 km^3 by the year 2025. Since food productivity is highly dependent on spatial and temporal changes in water availability, the future needs for water have

Table 3. Water availability in major rivers of northeastern states

River	Drainage area (1x10^5 km^2)	Average annual runoff (km^3)	Average runoff per km^2 (m^3)
Brahmaputra	1.94	537.2	2763395
Barak	0.78	59.8	765195

to be met from water resources similar to those existing at present. Pollution threats from solid and liquid wastes in the region are alarming. Adequate plans need to be developed to accommodate the needs of growing population without jeopardizing the natural balance and the ability of the ecosystem to cope with the requirements. The government of India introduced two major water policies of 1987 and 2002 to stream-line the development, management and utilization of water resources. The former recognized the drainage basin as the basic unit of planning water resources and to optimize their utilization. The national water policy of 2002 stressed for rain water harvesting, ground water recharge and prevention of over-exploitation of water resources, water allocation priorities, flood control management and involvement of beneficiaries and stake-holders in the developmental works undertaken. Monitoring and evaluation of the performance and socio-economic impact of the hydrological projects undertaken, has been emphasized. Drainage basin management through extensive soil conservation, preservation of forests and construction of check dams are included as part of water management.

3.2. Socio-economic Aspect of Water Management

The main problem of facing the harmonious development and management of water resources in the northeastern region of India, apart from social and economic constraints, is the paucity of reliable data and lack of human and institutional capacity necessary for confronting the complex interactions of the hydrological cycle with societal needs and the environment. The shifting cultivation prevailing in the region was a good land use system when the population was less and the shifting cycle used to be 25 to 30 years but, with increase in demographic pressure this cycle has come down to 2 to 10 years and the land does not get enough time for vegetation rejuvenation (Table 1). Since, the vegetation is the main component for *in-situ* burning to add nutrients for higher crop productivity, the production is now declining. There is huge soil erosion from hill slopes and silting of river beds and floods in the plains. This has caused land and environmental degradation in the region. The other constraints in water management are; land tenure system, small size of land holdings, high rainfall, deforestation, free range grazing, lack of finance and infrastructure, absence of suitable resource conserving land use systems, ignorance and lack of will. Most of the land either belongs to the village chief or community as a whole and the tribal farmers have only usufructuary right over land. They do not have a sense of belonging and, so, least interested in adopting soil and water conservation measures. Due to small size of land holding (more than 80% less than 2 ha), no water conservation measure can be taken-up properly. Free range grazing by the livestock make the hill slopes and other areas vulnerable to soil erosion, landslides and subsidence.

3.3. The ‘Zabo’ System

3.3.1.Historical

The tribal population in northeastern India remained more or less static for a very long period until inter-tribal warfare, head hunting, and pestilence and epidemics got effectively controlled. Gowswami (1981) mentioned that one Mr. Peal, who was sent on exploratory expedition in early nineteenth century by the British Government observed in his notes “from internal evidence, the tribal population seems to have been stable for a very long period, perhaps centuries. The checks are all positive, such as constant warfare, want of food, inducing diseases etc. Perhaps in no other part of the world can so complete a tribal isolation seen. The every 40 or 50 square miles, there are about 4 villages of, perhaps, one hundred families each, yet no more than an eighth or tenth of the land available can be cultivated at a time, and the population would seems to have reached it maximum”. Thus an equilibrium was maintained for centuries between the population and available land on long cycles of 30 to 35 years for shifting cultivation. The equilibrium, however, got upset when the population started increasing paradoxically because of stopping of warfare amongst the tribes, health care and general awareness. Shortening of shifting cultivation cycle became inevitable as no migration could be contemplated till it had come to so short a period as 3 to 5 years. The factor that sustained crop yields in shifting cultivation of 30 to 35 years cycle disappeared when it came down to 3 to 5 years. Poor crop yields in shifting cultivation, the higher population and economic and social goals were no longer compatible with shifting cultivation as a way of life. The practice of shifting cultivation, which was prevalent in northeastern region of India since 7000 B.C. (Sharma, 1976) did not keep pace with the food, fodder, fuel and fibre needs of growing tribal population. The Zabo system is the soil and water management system developed by the tribal farmers due to their ingenuity and skill to cope with increase in population.

The homosapiens were under the awe of natural objects such as oceans, rivers, forest, springs etc. from the pre-historic age. Population was small in number, primitive in technology and their needs were extremely limited. With decrease in shifting cultivation cycle as a result of increase in population, the crop productivity decreased considerably, thereby necessitating the tribal people to migrate from one place to another for an easy access to food and water. The tribal people of northeastern region of India have some social taboos and superstitions, which are to be followed religiously. One such tribe, known as *Chakhesang*, also migrated from the areas bordering Burma (now Myanmar) and settled in an area, now called Kikruma village in Phek district of Nagaland State of India. The village is located at an altitude of 1270m above mean sea level. There is a legendary story attached with the migration of the tribe. According to the village elders, the inhabitants of kikruma village have possibly migrated during nomadic period. During migration, the people were accompanying their leader, the chief of the tribe, for settlement at some suitable place, which should have fertile land for crop production and pastures for grazing of the domestic animals. The leader was carrying a big stone on his head and a cock in his hands. The belief of the tribe was that they would settle at a place where the stone must fall from the leader's head and the cock must crow. Only then that place will be free from diseases, good from crop production and overall welfare of the tribe. During the movement, the tribe moved through many fertile lands, but neither stone fell down from leader's head and not the cock crowed. This was not a good omen, the leader thought. The tribe kept on moving and reached a place where the stone fell down from the leaders head and the cock also crowed. This was thought to be God's will for settling down of the tribe (Sharma, 1997a). The place was, however, was not good for crop production and devoid of water source nearby. This is the place where now kikruma, village is situated (Sonowal et al., 1991; Sharma, 1998) the village is sorrounded by two streams, 'Seidzu' and Khuzha, a few hundred meters down the settlement of the tribe on the hill. The tribe grew crops but the yields were poor in absence of irrigation. These was no drinking water around except to bring it from the streams after walking a couple of miles. This was the time when the people of *Chakhesang* tribe realized the importance of water for crop production, and for human and animal needs. The situation might have compelled the people to develop their own water resources due to their ingenuity and skill. The realization of importance of water and development of water resources transformed the life of the people of this tribe to a much better quality compared to others. This system of water harvesting and management is called 'Zabo' system. 'Zabo' means impounding of water in local language. The system has forest land on the top of the hill, water harvesting tanks (silt retention ponds and water storage tank) next down the hill slope, livestock enclosures and then terraced rice fields at the foot hills (fig.1). The system is a unique combination of forest, agriculture, livestock and fisheries with a water and soil conservation base, which encourages purification of environment, besides increasing crop productivity (Sharma, 1997b, Sonowal et al., 1989; Sharma and Sonowal, 1991).The system is followed on the land belonging to the farmers individually, but a group of 10 to 15 farmers join together to practice 'zabo' system.

3.3.2. Forest land

The area on the hill-top serves as catchment for rain water and is kept under natural vegetation. This area is normally not disturbed by cutting forest trees. The slope of this area is up to 100% or even more. Being permanent under vegetation, there is hardly any loss of soil through erosion.

3.3.3. Water harvesting

Water harvesting ponds are dug-out with formation of earthen embankment below the catchment area on the hill slope. First two small ponds serve as silt retention tanks followed by a big tank down the slope. The size of these tanks depends on the catchment area but usual capacity is 300 to 600 m^3 with a depth varying from 1.5 to 2.5m. Silt retention tanks are constructed in between forest land and the main water storage tank to store run-off water from the catchment area for few days in these tanks so that soil, humus and organic matter is retained here before passing on the water to the main tank. Soil retention tanks are desilted annually and the soil containing organic matter is put in the rice fields for enhancing fertility. The ponds are rammed and compacted from inner sides so as to avoid water loss through seepage. The main water-harvesting tank is plastered on inner surface with mud mixed with chopped paddy straw to minimize water losses due to seepage. The bottom of the tank is rammed and animals are let loose in the beginning to make the bottom surface hard to reduce water losses.

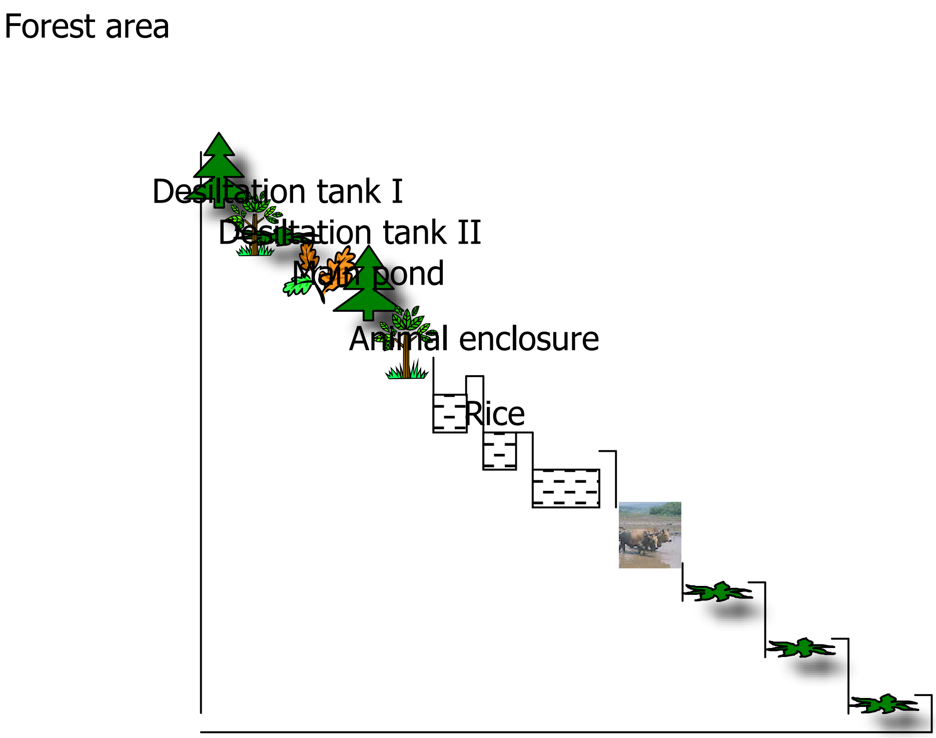


Fig. 2. Outline of *zabo* system on the hill

3.3.4. Cattle Enclosure

Enclosures are made with wood and bamboo for cattle and are managed by a group of farmers by stocking cattle on rotation basis. The enclosure is constructed on lower side of the pond. Buffaloes, cows, and pigs are the common animals with the farmers and about 30 to 50 of them are kept in one enclosure for a period of 10-15 days. During irrigation the water from the main tank is taken to the paddy fields by passing through the cattle enclosure and it carries dung and urine of the animals making the fields highly fertile.

3.3.5. Agricultural Land

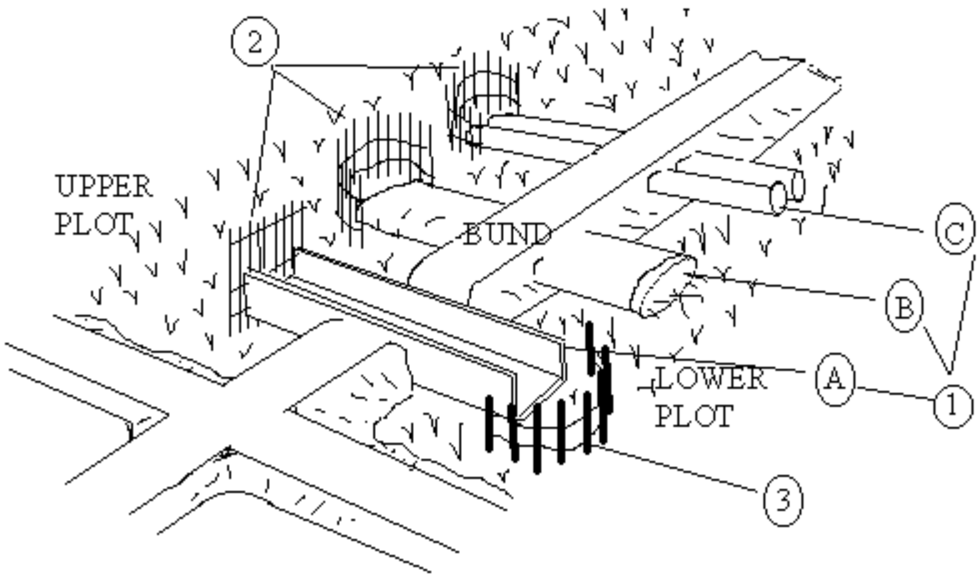
Paddy and other crop fields are located at lower elevation. Application of cow dung and run-off through open cattle yard are the common methods of manuring. Besides, leaves and succulent branches of *Alnus nepalensis* and *Albizia lebbeck* are also added to the fields and decomposed for soil fertility. No inorganic source of nutrients is added, making the whole system as organic farming. There is no pollution of water and environment due to fertilizer use. Some farmers practise paddy-cum-fish culture and about 50 to 60 kg of fish is obtained per ha which is an additional source of income to the farmers.

3.4. Water management by Apatani tribe

The *Apatani* tribe has developed a remarkable system of water management and irrigation. Every stream rising from the surrounding hills is tapped soon after it emerges from the forest, channelized at the rim of the valley and diverted by a network of primary, secondary and tertiary channels (Chaudhar et al., 1994). At a short distance above the terraces, occurs the first diversion from the stream. Usually only a little water is allowed to flow in the first feeder channel while the stream continues its course. The feeder channel branches off at angles which lead water through the series of terraces, so that by blocking or opening the connecting ducts (Huburs), any field can be flooded or drained, as required (Fig. 3). The cross section of main channels ranges from 1.0-1.7 m in width and 0.45-0.65m in depth, while that of sub-channels from 0.75-0.96 m in width and 0.38-0.65 m in depth. These channels are generally pitched with boulders at the entry, which checks erosion of channels due to high flow of water. The most important aspect of right water management in low land rice fields is to keep water layer on the soil surface at the permissible depth. The *Apatani* farmers drain off the water from the rice fields twice during tillering, once during flowering and finally at maturity. A 10cm water table is maintained in the plots by adjusting the height of outlet pipes. The water from the terraces is finally drained into the "Kale" river which flows through the middle of the valley. The discharge of this river recorded during rainy season was 4.8, 13.9 and 32.2 m^3 sec^{-1}, at the entrance, middle and end of the plateau, respectively.

3.4.1. Nutrient management

Nutrient and fertility management of the terraces is done mainly through the recycling of agricultural wastes. Paddy straw, approximately 10.0 t ha^{-1}, is allowed to decompose in the wet terraces and finally incorporated at the time of land preparation. Burning of undecomposed straw during January - February is also in practice especially on dry terraces. Pig and poultry droppings, rice husk, kitchen wastes, ash (approx. 4 truck loads of wood is used for kitchen purpose per family per year) and weeds removed during weeding are also recycled in the terraces every year for improving the soil fertility. After the rice crop is harvested, cattle are allowed free grazing in the fields from December to February and thus the cow dung is also recycled. Approximately, 20,000 cattle graze in the surrounding upper ridges of the plateau and discharge around 26,600 tonnes of dung every year. Since entire rain water of the surrounding hills is tapped for irrigation, nutrients from dung and even forest humus is also partly utilized through irrigation water.



1. Hubur
   A. Made of plank
   B. Made of pine tree trunk
   C. Made of bamboo stem
2. Obstruction for fish- Bamboo net
3. Erosion control at water outlets – wood sticks

Fig. 3. Structures used for inter-plot irrigation cum drainage system in Apatani plateau

3.4.2. paddy-cum-fish culture

Fish channels of about 30 cm x 150 cm with 30 cm depth are dug at various locations in the rice fields. Fish fingerlings are put in these channels at the start of the cropping season and the fields are flooded. When the rice fields are drained before the harvest of the crop, the water remains in the fish channels. Average weight attained by the fish in four months varies between 130 and 400g. Normally, a loss of 50% fingerlings, either due to escape or mortality, is observed. In general, 180-185 kg fish is harvested per ha. Even after the family consumption, some fish is left for disposal. It is a subsidiary source of income for the farmers.

3.4.3. Labour management and community cooperation

A well marked division of labour is generally followed for various operations in the farming. Men folk generally take care of hard works such as building terraces, irrigation channels, fencing, removing earth and planting trees while women folk look after nurseries, transplanting seedlings, weedings, fish management, harvesting, threshing, drying and storage. The periods of different operations and manpower requirement are given in Table 4. In *Apatani* society, many big operations are performed by the community. Some of the operations like fencing and maintenance of main irrigation channels are done on community basis. A proper code for erection of risers as well as maintenance and release of water for irrigation is followed. Community labour, gangs of boys and girls called “Patang” are always ready to help each other in various farming operations on mutual basis. Besides, there are landless people in the plateau whose services are always available on payment of wages.

Table 4. Period and manpower requirement of different operations

Operations	Period	Mandays required	Remarks
Fencing	February - March	4	Community operation
Maintenance of channels	January - April, July	3	- do -
Maintenance of risers	January - February	31	Individual operation
Nursery raising	February - March	18	-do-
Manuring	February - April	15	- do -
Land preparation	April - May	28	- do -
Transplanting	April - May	40	- do -
Weeding	Transplanting to harvest	41	- do -
Fish culture	May - September	7	- do -
Bird scaring and supervision	September - October	15	- do -
Harvesting, threshing and transporting	October - November	115	- do -
Drying and storage	October - November	11	- do -
Total		328	

3.4.4. Environmental preservation

Apatani farmers are well aware and extremely cautious of their environment and ecology. Apart from conserving the soil from erosion, farmers have taken up the plantation of *Terminalis myrinalia, Altingia excelsa*, *Michelia* sp., *Magnolia* sp., Pines and bamboos. Thus, the entire hills surrounding the valley and uplands surrounding the villages are fully kept conserved as forest. This helps in conserving of natural resources, maintenance of ecological balance and flow of streams. Thus, soil erosion, silting in rivers, drying of water sources, loss of nutrients, loss of flora, fauna and forest resources are negligible in this plateau. Apart from the utilization of rain water for irrigation and recycling of household wastes and by-products for fertility management, most of the important tools used in the *Apartani* farming are made of wood. The plot to plot outlets in rice fields are made with wood or bamboos. Fishing nets and fish catching baskets are also made of bamboos. Local baskets and containers called *yagli, Yopho and Rajhu* are made of bamboos too. Cattle and other animal thrive on forest resources while pigs are partly fed from the forest flora and partly from cultivated crops. Use of modern tools, implements and fertilizers is still not known to the *Apatani* farmers. However, the Department of Agriculture, Arunachal Pradesh is making all out efforts to make the system more productive and remunerative by introducing new techniques and improving the rice cultivation system of *Apatanis.*

3.5. **Combining indigenous with modern techniques**

A multi-disciplinary study was undertaken on watersheds with different slopes and with different land uses, based on indigenous knowledge improved with modern techniques; to monitor runoff, surface and base flows, soil and nutrient losses through monitoring gauges installed at the exit of each watershed. The land uses were; livestock based (grasses and fodders), forestry, agro-forestry. agriculture, agri-horti-silvi-pastoral (agriculture crops at the base of watershed, horticultural plantation in the middle and forest trees and pasture grasses at the top), horticulture and shifting cultivation for comparison. The soil and water conservation measures were; contour bunds, bench terraces, half-moon terraces and grassed water-ways, undertaken as per the requirement of the land use. The runoff was collected in water-harvesting tanks down the slope. This water was used for fish rearing as well as for irrigation at critical stages of crop growth. The data obtained clearly demonstrated the efficiency of various new land use systems over shifting cultivation in controlling the sediment load in runoff, resulting in significant reduction in the soil and nutrient erosion. The average sediment yield was only 0.44%, 2.68%, 1.47%, 0.31%, 0.73% and 2.27% in fodder, forestry, agro-forestry, agriculture, agri-horti-silvi-pastoral and and horticulture land use systems of that of shifting cultivation. The average sediment yield varied between 0.11 t ha^{-2} in agriculture land use and 36.2 t ha^{-2} in the shifting cultivation. Highest average sediment yield was 7.04 t ha^{-2} when the annual rainfall was 2770 mm and minimum 0.41 t ha^{-2} when the annual rainfall was 1992 mm. More than 90% of rainwater was retained *in-situ* in new land use systems compared to below 60% in the shifting cultivation. More *in-situ* retention of rainwater helped in the availability of adequate moisture from the soil to the succeeding crops when the rainy season receded. The sediment yield varied according to the rainfall received during a particular year and the nature of vegetation in a particular land use.

4. CONCLUSIONS

The practice of shifting cultivation in northeastern region of India has become uneconomical with increase in demographic pressure and reduction in the shifting cycle period. The practice needs to be replaced with sustainable, socially acceptable and eco-friendly land use systems or improve the practice over its present form. There are some unique indigenous systems of integrated water resources management, prevailing in isolated pockets of the region. Theses system have remained sustainable for centuries because of their sound scientific base and dependence only on locally available resources. Since no inorganic fertilizer are used, there is no pollution of surface and ground water regimes in the area. Improving these land use systems with state-of-the-art technologies in water and soil conservation would ensure judicious rainwater management, reduction in runoff and soil erosion, and environmental compatibility. Proper policy framework for planning, development and management of water resources in the region can be devised, taking advantage of the advances made in water science and technology as well as from positive and negative experiences of the developed countries.

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