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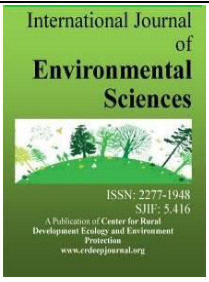

Review Paper

Water Resources Management for Sustainable Development in Nagaland, North East India: A Review

Vika V. Zhimo, Nukshienla Imchen and M. S. Rawat*

Department of Geography, School of Sciences, Nagaland University, Lumami- 798 627, India.

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Corresponding Author:
M. S Rawat

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ABSTRACT

Land and water are most important natural resources. The careful management of these resources is essential to food security and environmental protection. When use in sustainable ways, land and water produce the food, forestry and other products that we all depend upon. The study of water provides a logical link between an understanding of physical and social environments. Water is a biological necessity and also of great economic significance. Water resources are at the heart of sustainable development. There is no detailed scientific evaluation available for the water resources of Nagaland. Proper planning for development, management and optimal utilization of water resources is having paramount importance for socio-ecological development which can provide a basis for dynamic sustainable economic growth. Water is a vital part of socio-ecological system and rainfall is the only source of water resources in the study area where there are many hydro-meteorological implications of environmental change in the recent past. Therefore, water resources management particularly water harvesting/rainwater harvesting are the important options for the environment and development to achieve sustainable development. The present paper is based on the primary and secondary sources of data which concerns with an assessment of the water resources and their management and proposes water harvesting for the sustainable development of Nagaland.

Introduction

Water is a prime natural resource, a basic human need and a precious national asset. Water not only serves as a vital substance for human existence but also plays an important role in advancing civilization because water is also a vital part of socio- ecological system. Water resources are at the heart of sustainable development. Increasing water requirement due to rapidly growing population is increasing pressure on the available water resources. Leading experts of water resources are warning that the world is fast heading towards "a water shock" which may even dwarf the oil crisis. The worlds thirst for water is likely to become one of the most pressing resources issues of this century. This situation will worsen in the future unless water supplies are augmented based on an integrated long-term water resources development and management plan (Rawat, 2011). Sustainable development implies the use of ecological system in a manner that satisfies current needs without compromising the needs or options of future generations. Planning strategy for sustainable development needs reliable and comprehensive data on natural-cultural environment and socio-economic resources. In view of the ever-growing demand, water will become a major limiting factor in socio-economic development, unless early action is taken. The seriousness of the situation calls for the highest priority to be given to the development and management of water resources at all levels. National priority of water resources development in many regions is increasingly addressed to harness water resources. India possesses about 4 % of world's total water resources to support about 15 % of the world's population. It receives an average annual precipitation of about 4000 cubic kilometers and has sizable resources of water with a network of rivers and vast alluvial basins to hold groundwater (Sharma & Kumar, 2004). The North-East region of India is a land of rivers. The river systems are significant in almost every sphere of life whether physical, economic or socio-cultural (Sengupta et al., 2006). Proper planning for development, management and optimal utilization of water resources in the region is a paramount importance of socio-ecological development which can provide a basis for dynamic sustainable economic growth (Rawat et al., 2009). Generally, this region is drained by the Brahmaputra, Barak- Surma, Chindwin, Chimtuipui, Karnaphuli, Gumti and Feni river systems. All these river systems cut across the international boundaries, thus assuming environmental, developmental and strategic importance (Rawat, 2008). The Brahmaputra System is the major drainage system of rivers possesses about 34 % of the country's water resources, although the region represents about 8% of total geographical area. This river system carries about 44 % of the country's total hydropower potential of which about 3 % has so far been tapped for human use. The annual rainfall varies from 1300 mm to as high as 12000 mm with an average value of 2800 mm. About 70-75 % of the rainfall occurs within 4-5 months, leaving the remaining months almost dry. Capturing and storing this abundant rainwater for beneficial utilization in dry months is a challenging task. This is especially true when the spatial distribution of monsoon rain varies from normal to extreme maximum near Cherrapunji in Meghalaya. These spatial and temporal variations in water resources availability pose great challenges for storing and regulating the use of the water resources in the region. There is no detailed scientific evaluation available yet for Nagaland's water resources. The present paper discuses briefly the water resources of the study area supported with the challenges and opportunities for water harvesting to achieve sustainable development. There is no scientific evaluation yet for water resources of Nagaland. The present work will fill the gap of the water resources assessment. This work will also facilitate the efficient protection, development, planning, management and wise use of water on an environmentally sustainable basis for the benefit of all people of North East India in general and Nagaland in particular. The topic has been the subject of scientific interest in recent years is also a subject which has important ramifications for the future of sustainable development.

Materials and Methods

The study was based on the primary and secondary sources of data. The database was developed from the detailed analysis and study of Survey of India topographical maps, satellite imagery, and annual reports/monographs of different sources. For creation of detailed geospatial data base Arc-GIS was used. The other instruments like altimeter, GPS handset, pedometer, brunton compass, measuring tape and hydrometeorological equipment were also used.

Study Area

Nagaland- the study area is the 16th State of the Union of India and one of the extreme north eastern states which lies between latitudes 25º 20' N to 27º 04' N and longitudes 93º 20' E to 95º 15' E with Myanmar in the east, Manipur in the south, Assam in the north and west and Arunachal Pradesh in the north (Fig. 1). Nagaland has a total geographical area of 16579 km² divided into 11 administrative districts namely, Kohima, Mokokchung, Zunheboto, Tuensang, Phek, Mon, Wokha, Dimapur, Longleng, Kiphire and Peren (Fig. 1). These districts are further divided in Development Blocks and Circles for administrative conveniences. Physiographically, Nagaland can be divided into three NE-SW trending mountain ranges. These are (1) Eastern mountain ranges or High hill ranges in the east. (2) Middle hilly ranges or Medium high hill ranges in the intermediate zone and (3) Western low ranges. Nagaland is situated almost at the tri-junction of the three major river systems of the region viz., Brahmaputra River System in the west and north, Meghna River System in the south and Chindwin River System in the east. The altitudes ranging from 100 m to 3840 m above msl and climatic conditions that varies from sub-temperate to sub-tropical. The geographical location and varied climatic conditions have contributed to the State's unique environment and ecosystems that are home to numerous endemic and endangered species of flora and fauna. The agro-biodiversity consisting of both wild and domesticated varieties of plants and fruits- is amongst one of the most diverse in the region. The State has an interesting land use as 20.4% primary forest, 55.3% jhum, 8.2% current jhum, 4.6% terraced rice cultivation and wet rice cultivation, 0.9% horticulture and cash crop and about 10.6% area is under other land uses (Keitzar, 2009). Nagaland has a total population of 1980602 out of which 1025707 (52%) are male and 954895 (48%) are female according to the provisional Census of 2011. Due to the unique land ownership and management system of the Nagas there is little or no alienation of the people from their land and resources and therefore, even farmers, despite their poor economic condition can be considered resource-rich. A comparatively low population pressure, high regeneration rate of plant resources community- based natural resources management initiatives and most importantly shifting cultivation activities are the major controlling factors of ecological and environmental health of Nagaland. The hilly nature, rugged terrain and lofty ranges have a great bearing on the population distribution and the cultural landscape of Nagaland. It is the extreme eastern part adjoining Myanmar, which is less developed and inaccessible mainly because of the constraints imposed by the comparatively formidable physical terrain.

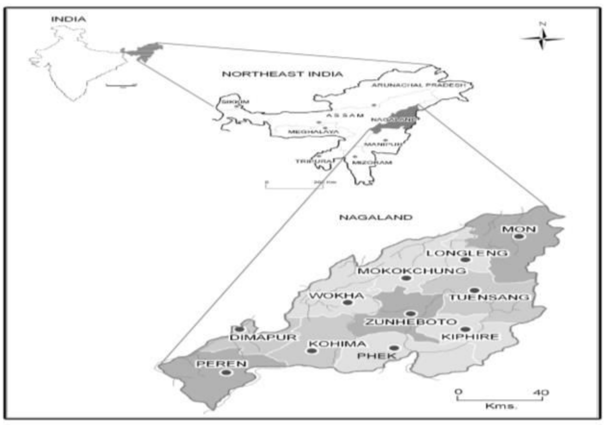

Fig. -1 : Location map of Nagaland, India.

Figure 1. Study area

Water Resources of Nagaland-An Overview

The water resources of Nagaland comprise mainly three hydro-meteorological regimes such as (1) Surface Water Regime. (2) Groundwater Regime and (3) Rain Water Regime.

The Surface Water Regime

The main surface water resources are rivers, lakes, ponds, tanks, springs. Nagaland is dissected by a number of seasonal and perennial streams and rivers with U shaped tinny valleys in between. There are five major rivers that run through Nagaland. Therefore, there are five major drainage basins in the State. The major drainage basins (watersheds) of Doyang, Dhansiri and Dikhu rivers are parts of Brahamaputra River System. The major watershed of Tizu river is a part of Chindwin river system and finally link with Irrawadi River of Myanmar. The watershed areas of rivers in Nagaland that drain into Brahamaputra and the catchment areas of rivers that drains into Chindwin are roughly equal but differences between the two catchments is that in the case of Brahmaputra drainage system a couple of rivers drain the area and they join the Brahamaputra in Assam separately whereas in the case of Chindwin drainage system all the tributaries join and run into the Chindwin. The Barak watershed area is a part of Meghana River System.

Rivers of the Brahmaputra River System in Nagaland

The Doyang is the longest river in the State and is formed by two rivers that run parallel in the upper part of Doyang- the Dzuu and the Sidzu rivers. The Dzuu river has its source from Japfu peak and flows towards the north where it is joined by many tributaries before it joins the Sidzu river below Kijumetouma. The Sidzu river originates from Mao Gap and flows in a north-west direction towards Chakkbama, later it joins the Dzuu river and then becomes and known as the Doyang river which flows in a northerly direction and receives tributaries from Zunheboto and Mokokchung districts. The Doyang river makes a 90º turn to the west at Doyang bridge on the Wokha-Mokokchung road. Before it emerges out of Nagaland the Doyang is joined by two tributaries- the Chubi and Chudi rivers. The Chubi river drains the south-west area of Mokokchung district and flows in a southerly direction to the Doyang. The Chudi river drains almost the whole of the Rengma area and flows northwards into the Doyang. The Chudi river drains almost the whole of the Rengma area and flows northwards into the Doyang. In other words the Doyang flows along a north easterly course for about 74 km and thereafter suddenly turns at right angle to the northwest and traverses in a southwest direction.The river drains the inhabited areas of various Naga groups, through Angami territory and flows towards the eastern edge of the Rengma area. Moving northwards it enters the Sema area and then flows through Lotha territory. It passes through a great part of Lotha territory. After flowing towards the southwest for a few kilometres it finally drains into the Dhansiri in Golaghat district of Assam.

The Dhansiri river system forms part of the south western boundary between Assam and Nagaland and flows south to north. This river rises in the southwest of Kohima district flows in the south western part of the State. It runs a westward course forming a natural boundary with North Cachhar Hills of Assam at the extreme south west of the State. The rivers Intangki, Monglumak and the Amaluma drain the greater part of the Zeliang area all flow into the river Dhansiri at different points. The Diphu and Dzudza rivers have their source at the Japfu mountain range and separately flow into the Dhansiri. Having debauched from North Cachhar it takes an eastward direction and flows through the Rangapahar- Dimapur plains. Again it runs northward until it drains into the Brahamaputra (Fig. 2).The Dikhu river has its source near Zunheboto from central Nagaland near the Nuhuto Hill and flows in a northerly direction. The river traverses towards the north along the border of the Ao, Phom and Konyak tribes and drains their territories. The Dikhu river has two main tributaries, one from Kuthur above Tuensang town and the other from the Konyak region. Towards north the Dikhu is joined by its main tributary. The Yangu which is an important river in the territories of the Phoms and Konyaks. This river flows below Longkhum, Ungma and Mokokchung. From Ungma, the Dikhu river forms the boundary between Mokokchung and Tuensang districts. The Dikhu flows further north through the hills of the Konyak area and finally takes leave of the Naga Hills at Naginimara. It flows into the Brahamaputra river in Sibsagar district of Assam.

The Milak river has its source at Mokokchung and flows in a northerly direction till it reaches Tuli range in the northern part of Mokokchung district. Before entering Assam it is joined by Tsurang river. The Tsurang river flows through the valley of Changki in a north to south direction near the boundary between Mokokchung and Wokha districts. It then flows west right through the Desoi valley in a northern direction till it enters Assam. The Tiru and Tizit rivers lie in the wettest parts of Nagaland which receives heavy rainfall, thereby producing two middle-sized rivers, the Tiru and the Safrai rivers. Both the rivers flow almost parallel east to west and join up as they enter Assam. The Tizit river has its source in the northern most point of Nagaland in Mon district and flows in a westerly direction at first and then turns west in the Tizit valley until it enters Assam at Namsa. The Tizit river is joined by the Tekang river at Namsa and their confluence area is covered by the dense forest (Fig. 2).

Rivers of the Chindwin River System in Nagaland

The Zungki river, the longest tributary of Tizu river has its source at the north- western part of Chendong forest in the south of Teku and flows in a southerly direction towards Noklak, Shamator and Kiphire till finally joins Tizu river below kiphire. The Likimro is another tributary of the Tizu river and has its source at the Saramati mountain. The Lanye river has its source in the north Henopong forest in Tuensang district and flows in a northerly direction towards Phek. Below the Satoi mountains it turns in an easterly direction and joins the Tizu river and then it later joins the Likimro river some 25 km downstream. After the Lanye joins Tizu, the Zungki and the Likimro rivers join the Tizu river and pass the mountainous region into Myanmar where it flows into the Chindwin river. The Tizu river forms an important drainage system in the eastern part of Nagaland and runs in a northeast direction for about 20 Kms. It then takes a bend and assumes a south easterly course. The river finally leaves Nagaland and exhausts itself into the Chindwin River in Myanmar (Fig. 2).

Rivers of the Meghana River System in Nagaland

Barak River and its tributaries have small watershed area in Nagaland covering its area in Peren district and some parts of

Kohima district. This river also makes natural boundary line between small part of Nagaland and Manipur. Finally Barak is merging with the Meghna River.

The Ground Water Regime

The Groundwater is our hidden asset which plays a significant role in our economy and in our daily lives. Groundwater is being increasingly recognised as an important and critical ingredient in sustainable development. The current patterns in development and use of fresh water are not sustainable in economic, social and environmental terms. Groundwater meets 30% of total supply of water; remaining 70% supply is met by surface water resources. The urgent need is to emphasis on environmentally sound integrated water resources planning for management supported by a scientifically proven methodology with the theme “Replete groundwater before it depletes”. Exploratory drilling of few tube wells in some district Headquarters in Nagaland had proven the availability of potential groundwater resource. The members of Central Ground Water Board have found that the deep aquifers are thinly bedded down to 300 m. The yields of tube wells on the bank of Dhansiri and Dikhu rivers is around 2 m³ per hour. The low yield is because of finer nature of aquifer materials. Besides the foothill zones, some intermundane valleys have also been observed like at Tizit, Tiru, Longnoth and Baghty valleys. Yield of wells in these areas vary from 16 to 62 m³ per hour. The thickness of saturated zone is 30 to 70 m within 300 m depth. On an average the wells of 250 m depth can yield between 20-30 m³ per hour. The quality of groundwater is generally good. As per the personnel discussion with the Regional Director, Central Groundwater Board (Govt. of India), NER, Guwahati during September 2009 that Nagaland is endowed with enormous surface and groundwater resources. He apprised the Groundwater Board had started exploration in Dimapur valley in 1975 and explored the area by constructing eight deep tube wells to the maximum depth of 300 m. Later, exploration was extended to Longnok valley under Mokokchung district and constructed two exploratory wells down to the depth of 130.9 m. From the analysis of the data pertaining to exploration, it was, found that a very fine to medium grained granular zones prevailed in these valleys with low to medium discharge potential with higher lifts. Groundwater recharge projects should be developed and implemented for augmenting the available supplies. There should be a periodical reassessment on a scientific basis of the groundwater potential taking into consideration the quantity and quality of the water available and economic viability. Exploitation of groundwater resource should be so regulated as not to exceed the recharging possibilities, as also to ensure social equity.

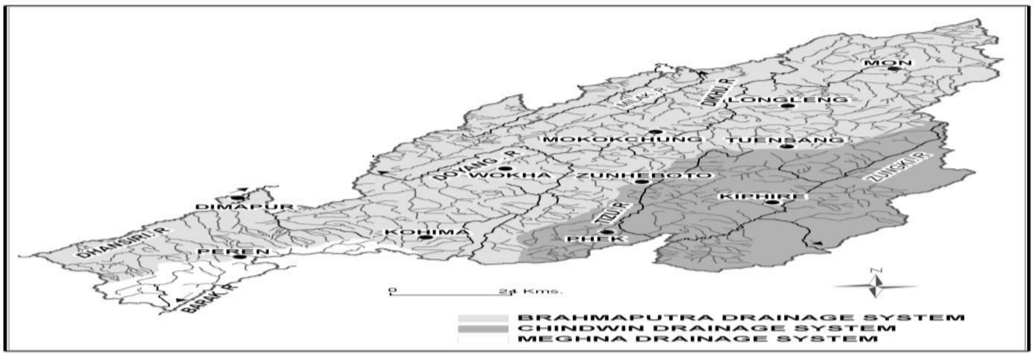

Figure 2: River System of Nagaland India.

The Rainwater Regime

Rainfall is considered one of the natural gifts of the nature to the mankind and that is vital for its very survival. There is just one source of freshwater i.e., the rainfall, the water that falls from the sky. Lakes, glaciers, rivers, springs, wells and groundwater all fed by rain or snow. In the absence of rain they can not last for long. Rain is the only everlasting resource which is in good measures. India receives adequate amount of rainfall annually through the four different types of weather phenomena viz., south-west monsoon (74%), northeast monsoon (3%), pre monsoon (13%) and post monsoon (10%). All India average rainfall is 1170 mm but it varies respectively from 100 to 12000 mm in western deserts to northeast region. More than 50% of precipitation takes place in about 15 days and less than 100 hours altogether in a year. The rainy days may be only about 5 in deserts to 150 in the northeast India (Patel, 2009). The rainfall distribution is most uneven and vary widely both in space and time. The knowledge of total rainfall and its distribution throughout the year is important for efficient agricultural planning of an area. Rainwater is the single most important potential source of soil moisture for agriculture. Precipitation is one of the most important factors deciding success of rain fed agriculture in hills, where only 10% area is under irrigation and crop yields entirely depend on the distribution of rainfall. The North Eastern Region is the highest rainfall zone of the country. The annual variation in rainfall is very wide from one place to another and its duration is most uncertain. The distribution of rainfall in various North Eastern States is given in Table 1.

Table- 1: Distribution of monthly rainfall (mm) in the North Eastern Region (after: Annual Report for the year 2002-03, I.C.A.R. Research Complex for N. E. H. Region, Umiam).

Month	Assam (Guwahati)	Arunachal Pradesh (Basar)	Manipur (Imphal)	Meghalaya (Barapani)	Mizoram (Kolasib)	Nagaland (Jharnapani)	Tripura (Lembucherra)
Jan	18.4	26.5	9.7	21.2	0.0	24.6	10.0
Feb	38.4	117.5	416.7	28.5	0.0	50.0	51.2

Mar	81.5	139.0	168.8	19.1	91.0	102.0	290.4
Apr	212.6	229.0	213.4	137.7	212.4	119.9	116.3
May	237.6	234.5	268.4	270.5	544.5	117.6	199.0
Jun	484.3	484.0	418.8	377.8	335.0	342.8	192.4
Jul	446.8	336.7	225.3	444.8	347.7	202.3	238.6
Aug	395.9	133.5	297.9	336.5	547.6	143.4	243.8
Sep	317.1	213.0	104.0	377.9	114.0	79.5	84.7
Oct	144.1	181.6	34.8	259.0	205.2	99.2	110.6
Nov	30.8	11.2	13.0	62.4	8.24	13.0	51.2
Dec	8.9	18.5	0.0	17.3	4.2	0.0	0.0
Total	**2416.4**	**2124.5**	**2170.1**	**2352.7**	**2409.84**	**1294.3**	**1588.2**

The northeast India, which boasts of world's wettest place. Inspite of receiving fairly good amount of rainfall, the region has witnessed the highest rainfall deficit in last 30 years and meteorologists say there is a clue to global warming in the phenomenon. As a fall-out, summer temperatures have shot up by almost 5º C on an average over the last two decades in the northeast India, a region nestled in hills and surrounded by rivers. Manipur and several districts of Assam have already been declared as affected by drought like situation. The long-term continuous meteorological data analyzed by the Regional Meteorological Centre, Guwahati reveal that the region has recorded deficit rainfall throughout the decade with only the year 2003 witnessing 4% above normal rainfall. In the year 2009 the south-west monsoon was withdrawn from the region in the third week of October which has suffered a 20% rainfall deficit in that year. The analysis further reveals that Nagaland was suffered the maximum deficit among the north eastern States. It recorded a rainfall deficit of 49%. It is also obvious from the above facts that the weather systems taking different paths resulting in global circulation anomalies. There is a change in climatic conditions during the last few decades. Although short-term rainfall data is insufficient to know the rainfall pattern and the future predictions, but these data may be helpful to know a temporary phase of rainfall pattern under existing climatic conditions. Table 2 is presenting the total annual rainfall at different meteorological stations in Nagaland recorded during the year 2008 which is showing the spatial distribution of rainfall varies from minimum as 893.0 mm at Kiphire to a maximum as 2518.3 at Mokokchung. In this year the annual average rainfall of Nagaland was recorded 1619.8 mm (Table 8).The annual total rainfall of the State's capital Kohima recorded during between the years 1997-2007 have been presented in table 9 depicting the 13 years of annual rainfall which varied from 1242.2 mm to 2003.7 mm. The average of 13 years was recorded as 1675.8 mm. The summary of nine years of daily rainfall data as total annual rainfall and the number of rainy days per year have been presented in table 10 which reveals the total rainy days at Zunheboto varies from 118 to 190 and the average total annual rainfall from 1108 mm to 2530 mm. These data are showing remarkable variations in the rainfall pattern in Nagaland.

Table- 2: The total annual rainfall recorded at different meteorological stations in Nagaland during the year 2008 (Source: Directorate of Soil and Water Conservation, Govt. of Nagaland, Kohima).

Sl. No.	Meteorological Stations	Total Rainfall (mm)
1	Kohima	2003.3
2	Sechu	1742.3
3	Tseminyu	1888.2
4	Dimapur	1138.8
5	jalukie	1393.4
6	Mokokchung	2518.3
7	Mangolemba	2143.3
8	Phek	1371.0
9	Meluri	914.1
10	Wokha	2387.7
11	Bhandari	1988.2
12	Kiphire	893.0
13	Mon	1516.8
14	Zunheboto	1133,1
15	Tuensang	1323.1
A V E R A G E		**1619.8**

Table- 3: The total annual rainfall of the State's capital Kohima recorded during between the years 1997- 2009 (Source: Directorate of Soil and Water Conservation, Govt. of Nagaland, Kohima).

Sl. No.	Year	Total Rainfall (mm)
1	1997	1242.2
2	1998	1384.2
3	1999	1778.0
4	2000	1958.2
5	2001	1730.6

6	2002	1577.3
7	2003	1866.6
8	2004	1871.8
9	2005	1599.3
10	2006	1338.4
11	2007	2003.7
12	2008	1999.1
13	2009	1436.4
	A V E R A G E	1675.8

Table- 4: Monthly and annual total rainfall (mm) and total number of rainy days in the central part of Nagaland recorded at the Meteorological Station, Zunheboto town (Source: Directorate of Soil and Water Conservation, Govt. of Nagaland, Kohima).

Year/	*2002*		*2003*		*2004*		*2005*	
Month	*Total Rainfall*	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*
Jan	39.9	8	30.4	5	30.4	5	39.9	8
Feb	17.6	3	36.4	11	0.0	0	6.0	1
Mar	46.0	9	80.6	13	11.5	2	0.0	0
Apr	219.2	23	183.6	15	436.2	28	42.0	6
May	273.0	26	173.9	18	448.0	29	497.2	30
Jun	377.3	26	349.6	25	228.1	19	365.5	28
Jul	429.1	31	403.5	29	NA	NA	494.5	31
Aug	364.3	17	537.4	28	428.0	25	480.2	30
Sep	246.8	16	259.8	26	356.6	26	484.9	28
Oct	70.0	12	214.8	19	116.2	9	105.7	12
Nov	67.8	6	37.6	1	18.5	2	14.2	2
Dec	4.2	2	0.0	0	0.0	0	0.0	0
Year	2155.2	179	2343.6	190	2073.5	145	2530.1	176

2006		*2007*		*2008*		*2009*		*2010*	
Total Rainfall	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*	*Total Rainfall*	*No. of Rainy days*
0.0	0	0.0	0	18.2	6	0.0	0	2.0	1
3.3	1	11.2	2	0.0	0	0.0	0	2.3	1
0.0	0	10.1	3	16.2	7	30.6	5	35.8	5
84.0	11	51.2	6	31.3	5	35.2	10	93.6	12
141.7	17	141.8	17	211.1	22	122.6	23	208.0	25
365.8	24	268.0	26	318.3	27	208.6	23	437.8	29
338.8	24	354.3	23	191.0	21	88.7	16	366.2	26
160.2	25	198.4	20	242.9	19	302.2	18	245.6	23
243.5	22	240.8	26	104.3	11	220.0	18	180.8	25
55.8	8	0.0	0	0.0	0	83.2	13	77.0	14
0.0	0	17.4	5	0.0	0	17.6	3	3.6	1
0.0	0	0.0	0	0.0	0	0.0	0	10.2	3
1393.1	132	1293.2	128	1133.1	118	1108.7	129	1662.9	165

Water Resources Development and Management in Nagaland

Chorley (1969) remarks that the study of water provides a logical link between an understanding of physical and social environments. Water is a biological necessity and also of great economic significance. Water resources are at the heart of sustainable development. Proper planning for development, management and optimal utilization of water resources is having paramount importance for socio-ecological development which can provide a basis for dynamic sustainable economic growth. Despite the fact that Nagaland is endowed with adequate water resources such as springs, perennial rivers, enough rainwater and groundwater aquifers, the State is facing threat due to scarcity of fresh water. In view of the ever-growing demand, water- a finite resource- will become a major limiting factor in socio-economic development, unless early action is taken. The seriousness of the situation calls for the highest priority to be given to the development and management of water resources in Nagaland. Though Nagaland is blessed with such bounty by nature, available water is not harnessed and utilised efficiently. The reasons attributed for these lacunae may be multifarious. Distribution of water has not received due attention during the past. Harnessing of water resources has received a massive setback. The growing demand for fresh water and the conflicting demands on water resources in densely populated areas are significant issues facing most parts of Nagaland. There is clear and convincing evidence that State faces a worsening water quantity and quality problems, largely as a result of poor water allocation, wasteful use of the resource and lack of adequate management action. Women collect water and manage it for household use, ensuring adequate supply, storing and keeping it clean while stored in the house. They also play key community management roles in domestic water supply at community level including maintenance of traditional sources (DPC, 2011b). Inspite of having an average yearly rainfall of 2500 mm from the later part of May till September faces water shortage during the dry months. Almost all the villages and towns are situated on the hill tops and the headwater areas where there are no rivers, very less number of spring, deep groundwater table. Therefore, water management is the greatest challenge for fulfilling the daily requirement of fresh water to rural and urban people in Nagaland. For providing safe water supply in desired quality and quantity, we need an efficient dependable water supply system to be implemented by adopting appropriate technology as well as ensuring the quality and workmanship, efficient and adequate site investigation and situation assessment, proper and efficient design and planning, proper installations and construction and supervision are the basic criteria to be dealt with more cautiously in the days to come to carry forward the status of rural and urban water supply sectors to a better one. The integrated use of water resources for drinking, irrigation, generation of hydropower and recreation etc have been assumed a very vital role as far as the sustainability of the stable agro-ecosystem and enhancement of agricultural production are concerned.

The important priority of water resources development and management in many regions is increasingly addressed to harness the local rivers and streams (Rawat, 2011a). The availability of the surface water in the form of rivers combined with mountainous topography has offered great prospects for irrigation and generation of hydropower in Nagaland. Hydropower is one of the major infrastructures for economic development whose potential have not fully been exploited in the State. The water from the reservoirs / dams and from downstream of the dams can be use for large and small scale irrigation. Development is technology driven and power is the basis of all technology. The current power generation in Nagaland is insignificant i.e., only 1.39% of its total requirement. Proper planning for development, management and optimal utilization of water resources is urgently required in the State. The sector wise water resources development and management may be describe briefly as follows-

Harnessing Rivers for Hydropower Development

The tremendous water goes waste- without its potential being tapped. It may be noted that the Brahmaputra river system in the region has the potential of generating 9888 megawatts of electricity and about 12.3 million m^3 can be used for irrigation. The availability of this vast natural resource of water , combined with mountainous topography characterized by the mighty hill ranges, has offered great prospects for generation of hydro power in the region, the potential is assessed as about 44% of that of the whole country of which about 3% has so far been tapped for human use. If the hydropower generation activity will be a part of the respective watershed management activities, there will be none or least negative impact of large dams in terms of their viability and sustainability vis-à-vis the delicately poised geo-environmental base, ecological balance, ethno-cultural heritage and the extreme dynamism of geophysical processes in the region. But due to very high risk of earthquake hazards, smaller dams would better serve the purpose of harnessing energy and storing water. Long-term engineered taming of rivers is not good in this region. Since high dams are known to generate environmental imbalance and cause enormous socio-cultural problems, and it would be imprudent to go in for high dams in region's highly earthquake-prone region, smaller dams must be preferred. The smaller dams cost less, start giving benefits quite early, bring greater profits and cause less damage to environment and distress to human habitations (Valdiya, 2002). An environmentally sound and economically feasible and beneficial method of water resource development is what the Chinese have adopted in a big way. The cascade development scheme involves multipurpose utilization of water of streams and small rivers, planned and developed locally, requiring less investment, having shorter period of construction and the benefits coming quite early. The river water is fully utilized by building a number of 30 to 50 m high dams. Each project can 6 to 12 megawatts power. These smaller hydel power stations can be linked to form a state wide grid to meet the need of Nagaland. The water resource development project sites could become locales of new townships- vibrant forward looking urban centres with requisite amenities and safeguards against natural hazards. The new settlements would not only open up avenues of employment but also provide opportunities for businessmen, traders and skilled craftsmen and also help the ramification of tourism, trade and commercial ventures.

Table-5: Hydropower potential of different regions in India (after Chakraborty, 2002).

Region	Potential at 60% load factor	Percent Developed	Percent Under development
Northern	30155	14.30	8.03
Western	5679	31.94	26.97
Southern	10763	49.21	10.27
Eastern	5590	16.41	12.73
North-Eastern	31857	1.02	0.96
All India	84044	14.07	7.23

Table-6: The current hydropower generation in different hydroelectric projects in Nagaland.

Sl. No.	Hydroelectric Projects	Capacity in (MW)
1	Doyang	75
2	Likimro	24
3	Dzuza	1.5
4	Duilmroi	0.5
5	Kithuri	0.2
6	Tsutha	0.7
7	Horangki	0.5
8	Dikhu	1.0
9	Khekau	1.0

Table 6 above is showing the current hydroelectricity generation in different Hydro electric projects in Nagaland which is insignificant i.e., only 1.39 % of its total requirements. The generation of hydroelectric power during the years 1962-63 was only 0.2 MW, it was increased 29 MW in 2001-02. The achievement in water resources development had remained very insignificant placing the state in the group of underdeveloped States of the country despite good potential. The development can be achieved through the utilization of the potential of water resources for power generation and other benefits in an environment friendly manner. The State with its numerous rivers and streams has the potential to generate more than sufficient for its power requirement. On the basis of general observations, for example, some of the rivers around Kohima from which water and power may be harnessed. The most important of these seem to be Dsuku river on which a waterfall of 25 metres exists at a distance of about 13 kms (air distance) to the southwest of Kohima. Another point lies at the confluence of Dzuna river and Dzulu river at a distance of about 9 km to the east-southeast of Kohima. Dzulu is a perennial stream and is a more dependable source of power. A fourth point lies on the Dzuza river to the west of Kohima. Here the river flows to the north through a fault controlled valley occurring in a seismically sensitive zone. However, a mini hydel project may not pose danger to the environment since the area is a sparsely populated upland. The generation of hydro-electricity may reduce the demand for fuel wood thus save the greenery of the land preserving another attraction for the development of ecotourism. There are several other streams and rivers in the State which may generate power sufficient to satisfy the demand of the respective locality. Moreover, this power may replace the fuel power needed for year round demand for cooking as well as additional demand for a comfortable living during the winter season. Even rope-ways to interesting tourist destinations may also be constructed depending on these power projects, to make the State a more attractive tourist centre to boost her economy through the development of ecotourism. Water and power supply need to be developed without having any adverse impact on environment, and the only way to achieve that goal is to develop hydro-power, based on the swift flowing streams.

Water Harvesting-An Option for Coping with Water Scarcity

Water harvesting may be defined as the collection and storage of any form of water either runoff or creek flow for irrigation use. Water harvesting systems in various forms were prevalent in India since ancient times. Numerous references of such practices are available in Vedas and other ancient scriptures. Over a period of time, these systems/practices have undergone continuous refinements and modifications depending upon the location specific objectives and needs of the people (Samra et al., 2002). A water harvesting system is a complete facility or collecting and storing precipitation run off and stream run off, comprising a water collecting area, water storage structure and other components like piping and fencing. Water harvesting, though is an old practise, is emerging as a new paradigm in water resources development and management in all over the world. Water harvesting can no longer be labelled a technology of the past and fit only for the poor, and it is as relevant for urban areas as it is for rural areas. It is universal technology which is relevant to all situations with location-specific applications. The need and importance of Water harvesting and water conservation have been stressed in the national water policy and national agricultural policy of government of India. World Water Council has recently emphasised that without full public participation it is impossible to envisage or implement sustainable solutions for water resources development and management. In Nagaland, spring water is often carried over distances with the help of bamboo pipes, people continue to build simple bamboo pipelines to carry water from natural springs to a convenient point, where it can be used for drinking and irrigation. The Zabo system of irrigation is practiced. It is a combination of forestry, agriculture, animal care and small scale fisheries with a soil erosion control. The water resources generated locally provide benefits to the local community and minimize social conflicts. Participatory management of harvested water resources ensures effective utilization, maintenance and sustainable operation of these systems. It has a great potential of improving land and water resources by integrating recent development with the indigenous traditional knowledge (Smara et al., 2002). Rainwater harvesting systems are relatively more equitable and environmentally sound.

Rain Water Harvesting: A Life Line for Human Well Being

Rainwater harvesting means harvesting and storing water in days of abundance, for use in lean days. In other words, it is refers to the deliberate collection of rainwater either from a gentle slope surface (catchment) or roof top catchment and its storage to provide a supply of water. It is a fact that any land anywhere can be used to harvest rainwater. Therefore, rainwater harvesting can be implemented efficiently and economically as a viable alternative to drinking water supply schemes and irrigation projects. This is an ideal solution to water problem where there is inadequate and insufficient surface and groundwater resources are available. The rainwater harvesting has been practiced for ages in India but has gained momentum in the recent past (Radhakrishana, 1997 and Vyas, 2002). Rainwater harvesting structures can provide water every household. This has become popular recently due to its apparent advantages e.g., bring water for all economic prosperity, drought proofing, sustainable water systems in light of the limited water resources and increasing water demands due to population growth and economic development. Every drop of rainwater needs to be harvested to increase the availability of water. Rainwater harvesting systems are site-specific, equitable, environmentally- sound, integerable with indigenous knowledge, skills and materials, minimise the social conflicts and meet multiple objectives. This system has tremendous potential in satisfying our needs as a domestic resource, quality potable water, self sufficiency, water conservation, groundwater replenishment, irrigation and enhancing the quality of environment.

Rainwater Harvesting for Irrigation Requirement

The practice of rainwater harvesting in ponds and reusing the stored water for life saving irrigation of crops and also for domestic purpose is prevalent in India since ancient times. One can find efficient management of water in the northeast region in traditional farming system like Zabo System of Nagaland, Bamboo drip irrigation of Meghalaya and Apatani valley system in Arunachal Pradesh. The mainstay of economy of Nagaland is agriculture, which is currently exhibiting trends of increasing unsustainability. Table 7 is presenting the annual decreasing trend of rice production due to lack of irrigation facilities in the jhum cultivation areas in Nagaland. The analysis of yearly shortfall rice production of jhum cultivation areas in Nagaland is showing that the rice production from jhum is meeting only four months of rice requirement. The farmers who are practising terraced cultivation with irrigation, the rice production may be sufficient for the year. Where there is no irrigation facility on the jhum lands, there is a shortfall of rice requirement for about 8 months. Therefore, food security is one of the daunting challenges in the rural Nagaland now-a-days.

Table-7: Annual decreasing trend of rice production due to lack of irrigation facilities in the jhum cultivation areas in Nagaland (Source: Statistical Hand Book of Nagaland (2007).

Year	Area Under Jhum Paddy In Ha.	Production In Mt	Population of Jhumia	Production/ Ha	Area/Person Ha.	Production/ Person of Milled Rice Kg	Yearly Consumption/ Person	Yearly Shortfall/ Person Kg
1	2	3	4	5	6	7	8	9
2003	88500	128000	1102175	1.45	0.08	58.07	240.00	181.93
2004	87100	133500	1158361	1.53	0.08	57.62	240.00	182.38
2005	88150	134100	1217411	1.52	0.07	55.08	240.00	184.92
2006	99980	160000	1279471	1.60	0.08	62.53	240.00	177.47
2007	97420	166460	1344695	1.71	0.07	61.90	240.00	178.10
2008	95780	171080	1413244	1.79	0.07	60.53	240.00	179.47
2009	90940	175510	1485287	1.93	0.06	59.08	240.00	180.92

The efficient utilization and management of available rainwater is important if the cropping intensity and production are to be enhanced. The rainwater or runoff in the form of a spring or stream can be harvested using simple, eco friendly and cost effective technologies such as UV resistant plastic lined ponds, Ferro-cement tanks etc. The previous studies suggested that these technologies are sustainable, locally adoptable, economical and affordable to the farmers (Samuel and Satapathy, 2008). Rainwater harvesting can become effective technology for uplifting the socio-economic conditions of the people in Nagaland where irrigation sector is very poor which is very important for development of agriculture. The development of sustainable, localized irrigation facilities that safeguard environmental and social concerns and the introduction of environmentally sound and cost effective methods. Previous studies show that subsistence agriculture in hills could be successfully transformed into a profit earning enterprise by tapping and utilizing water resources (Singh et al., 2006). Rainwater harvesting is not being used at all for the groundwater recharge due to lack of awareness of groundwater resources and its importance in Nagaland.

Today, agriculture occupies 40% of the land surface and consumes 70% of global water resources and helps manage biodiversity at the genetic, species and ecosystem levels (FAO, 2007). Traditional agriculture, an indigenous form of farming is the result of the co-evolution of local, social and environmental systems. It exhibits a high level of ecological rationale expressed through the intensive use of local knowledge and natural resources including the management of agro-biodiversity in the form of diversified agricultural systems (DPC, 2011a). There are four diversified forms of traditional agriculture practiced by the villagers of Nagaland - the jhum system (shifting cultivation), terrace rice cultivation, firewood reserve forests and home gardens. The practice of slash and burn agriculture is known locally as *'jhum'* as the word derived from Assamese language meaning 'collective work'. The Naga way of life revolves around this system of cultivation which governs most of their life, culture and tradition. In Nagaland, over 40% of the area is subject to jhum cultivation (NEPED & IIRR, 1999). The extent area under jhum is also maximum in the State compared to other states of North east India. According to the village profile of the Department of Agriculture (2001), there are 184127 farming households consisting of 1360925 persons comprising 68.44% of the total population. Of the total Naga farmers, 70% have been practicing jhum cultivation on the steep slopes with only the Angamis and Chakhesang tribes practicing terrace rice cultivation on steep slope. Mostly women are engaged in agriculture leading to feminization of agriculture in the State, a trend that is happening globally among the developing countries. For rural people to have sustainable livelihoods, the key is having access to secured land, water, forests and other means of production. Food security should be assured with an increasing access to water for domestic and irrigation purposes, land and markets as well as other economic opportunities. Rural women and nature work in partnership with each other with a special relationship (Mies and Shiva, 1993). The area under production per hectare under terrace rice cultivation is increasing across the State. Perhaps because of the increase in TRC with proper water management, the shortfall of rice from jhum is somewhat mitigated. The main source of energy for both lighting and cooking in the households of rural areas is firewood. Zabu is also a farming system practiced mostly by the Chakesang tribe where combination of forest, water and agriculture incorporating livestock and fishery, which is well founded soil and water conservation base. The limit to terrace construction is not the slope but availability of irrigation water. '*Give water and you have terrace'*.

Rainwater Harvesting for Domestic Water Requirement

Rainwater harvesting has tremendous potential in satisfying our needs as a domestic resource. Due to the rapid growth of population coupled with modern standard of living, the per capita demand for water has surged enormously during the recent past. Most of the villages and towns are situated on the hill tops in Nagaland where there is a great scarcity of drinking water. Unhygienic roof top rainwater harvesting had been a traditional practice since time immoral. In the present scenario, people had been so reliant on government's water supply system, water management and distribution which have resulted in disruption of community participation in water management and collapse of traditional water harvesting system. The government water supply department like PHED face huge crisis to meet the growing demands of the rapidly increasing population and urbanization. As the water crisis continues to become severe, there is a dire need to reform the present water management system and revitalize the traditional water harvesting systems. Nagaland today needs a people's movement to meet its water needs and to protect its water resources. Encouraging a people's movement means a redefinition of everybody's role. As a matter of policy, small and micro water harvesting structures should form an essential component of water resources planning, development and management at the local and regional level. Accordingly, resources and priorities should be allocated for rainwater harvesting structures in the plan. Roof top rainwater harvesting for drinking and other domestic uses is common in Nagaland but still temporary in every households. Rainwater harvesting besides helping to meet the ever increasing demand for water, helps to reduce the runoff which is choking storm drains, avoid flooding of roads, augment the groundwater storage and to control decline of water level, reduce groundwater pollution, improve quality of groundwater and reduce soil erosion (Anonymous, 2004). The rainwater is bacteriologically pure and free from organic matter and soft in nature. Rainwater harvesting is viewed as a water security measure with two broad types of programmes as given in figure 4. The roof top rainwater harvesting is rather a temporary measure focusing on human needs providing immediate relief from water scarcity. Rooftop rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, mostly in tanks. In domestic rooftop rainwater harvesting systems, rainwater from the house roof is collected in a tank for use during the period of scarcity. This system usually comprises a roof, a storage tank and guttering arrangement to transport the water from the roof to the storage tank. The quantity of water that can be harvested is determined by the amount of rainfall, and the size of the area from which the water is collected. For example, 10 mm of rainfall can provide 100000 litres of water per hectare. The use of roofs for rainwater collection is widely practices throughout Nagaland.

Discussion

The existing land use in Nagaland and its management in the last few decades have aggravated the problems of environmental degradation resulting not only in decreasing overall productivity of land, but its gradual destruction by floods, landslides, accelerated erosion and the diminishing water resources etc. Water-the blue gold of the 21st Century is a critical element for sustainable livelihood and poverty reduction. Fresh water is a scarce resource for improving quality of life. The availability of water resources, their management and distribution to the individuals, households and communities and among different user groups is critically important. Management of water resources is associated with household water supplies, irrigation, flood control, wet land preservation and fisheries. Rainwater harvested after continuous rain is used for drinking and other domestic purposes. Thus conserving rainwater during monsoon season by each household could be one of the best options for solving the water crisis. Traditionally harvested rainwater conserved in ponds is used for cultivation of paddy. Integrated watershed management has emerged as a new paradigm for planning, development and management of land, water, biomass resources with focus on social and institutional aspect in addition to environment and ecology. Efficient environmental management is a prerequisite for sustained economic and other components of local and State level planning for economic development and environmental management to achieve sustainable development. The irrigation potential for the agricultural development may be tapped to the maximum by using the natural sources, the rainwater and by better water harvesting techniques. The need of hour is to harvest every drop of rainwater for the purpose of irrigation for agriculture, horticulture and floriculture and fisheries so as to create sustainable source of income for the village community in Nagaland.

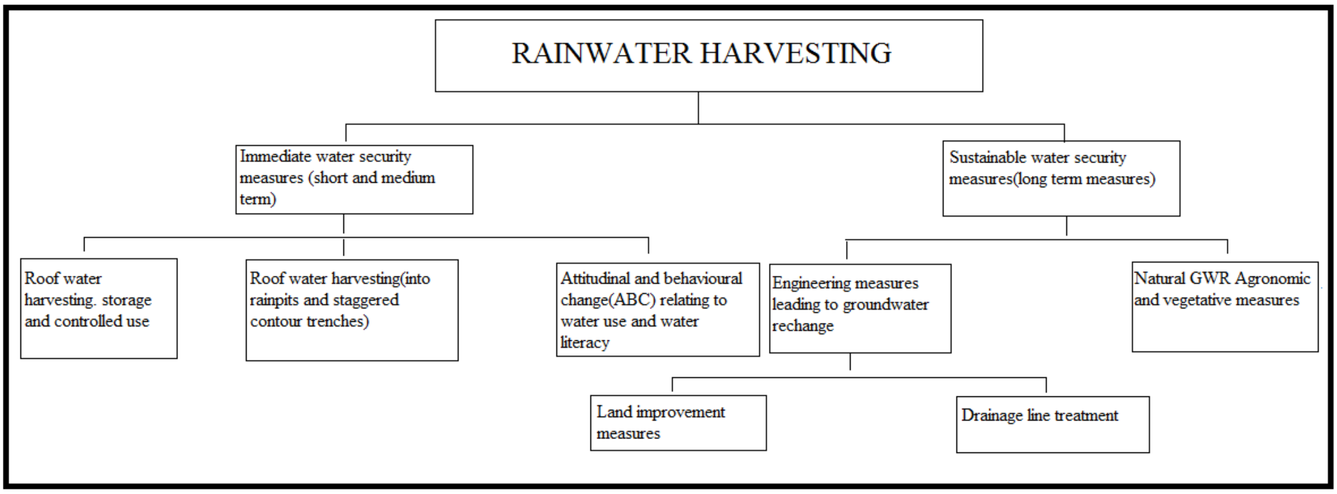

Figure 4: Two broad areas of rainwater harvesting (after Samuel and Satapathy, 2008).

The hydrological regime of Nagaland has been greatly affected by changes in land use, deforestation, accelerated soil erosion and landslidings. There has been a phenomenal increase in the pressure on the land, water and forest resources of the area, and this has had a serious impact on both the surface and underground hydrological regimes. The hydrological responses of watersheds- manifested in changes in the water yields of springs, floods in the valleys, erosion, sediment transport and water quality are affected by geological conditions, the land use pattern and disturbances from shifting cultivation and other human activities. Water is one of the most important components of the environment and an integral part of the ecological cycle. In the present juncture of rapid development and consequent increasing demands for this precious natural asset, the judicious use and sustainable development of water resources are the need of the hour. Due to lack of proper adequate storage facilities, about 37% of the total fresh water is drained out. Accelerated conversion of forest land due to intensive agricultural activities, rapid urbanization and other anthropogenic activities have resulted changes in land use and land cover pattern. Significant land use/land cover changes have been reported during the last 50 years both on spatial and temporal scale, mainly due to economic development and population growth (Sharma at el., 2011). Land use conversion is accelerating throughout north east India and is the cause of main environmental problems. The socio-economic status of the people need to be improved if the stride in tune with the concept of the sustainable development. Watershed based development and management efforts are emerging as potential approach for sustainable use of land and water resources though it is at evolving stage at present. This approach demands precise estimates of water availability (from all sources) and its demands (for all purposes) of the area for planning development and management strategies (Singh, 1998). The environmental degradation and development experience over the last 50 years indicate that the existing development planning strategy is needed to be modified to ensure that the resources meet the needs of the local people. Water resources development planning so far has failed to move in right direction and the pace of sustainable development has been slow. There has been an alarming growth of the population and the numbers of educated unemployed Nagas have been rising at the rate of about 10% per annum. This distress migration drains the hills of its active man power affecting development potential in terms of resources and skills. After 4-5 decades of economic development, primary sector (Agriculture) still continues to dominate the economy with low productivity, environmental degradation with population explosion. Despite abundant natural resources and potential and huge capital inflow from centre, Nagaland could not attain the level of economic development as was expected.

'*Integrated Watershed Manageme*nt' should be the main strategy for sustainable development through optimizing the use of land, water, vegetation, man, animal and environment to prevent soil erosion, moderate floods, improve water availability increase food, fuel, fodders, fibre and timber production in the watershed on a sustained basis (Rawat, 2011b). Water and power supply need to be developed without having any adverse impact on environment, and the only way to achieve that goal is to develop hydro power based on the swift flowing streams and rivers. The generation of hydro electricity may reduce the demand for fuel wood thus save the greenery of the land preserving another attraction for the development of eco tourism. Due to very high risk of earthquake hazards, smaller dams (Micro Hydel Projects) would better serve the purpose of harnessing energy and storing water. For providing safe water supply and desired quality and quantity, Nagas need an efficient dependable water supply system to be implemented by adopting appropriate technology as well as ensuring the quality and workmanship, efficient and adequate site investigation and situation assessment, proper and efficient design and planning, proper installations and construction and supervision are the basic criteria to dealt with more cautiously in the days to come to carry forward the status of rural and urban water supply sectors to a better one. The integrated use of water resources for drinking, irrigation, generation of hydro power and recreation etc have been assumed a very vital role as the sustainability of the stable agro-ecosystem and enhancement of agricultural production are concerned. The quantity of water that can be harvested is determined by the amount of rainfall and the size of the area from which the water is collected. For example, 10 mm rainfall can provide 100000 litres of water per hectare. Nagaland today needs a people's movement to meet its water needs and to protect its water resources. Encouraging a people's movement means a redefinition of everybody's role.

Conclusion

There has been a phenomenal increase in the pressure on land, water and forest resources of the study area and this has had a serious impact on both the surface and underground hydrological regimes in the study area. Conflicts between landowners and government, inter tribal/community misunderstandings, lack of management ethics etc. are main causes of water crisis in both urban and rural areas. Increasing population is putting increasing pressure on the available water resources of the area. Development and management of the water resources in Nagaland should be environment oriented for better outcome and sustainability.

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