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State Specific Action Plan for Water Sector-Arunachal Pradesh

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Declaration:

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For more information

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1 Introduction

Managing water resources in Arunachal Pradesh in effective manner implies ensuring sustainable utilization of the immense water resources of the State. In terms of utilization of water resources, it is estimated that Arunachal Pradesh has more than one-third of the country's proven hydropower potential. Several projects, large and small are been planned to tap this enormous hydropower potential. Apart from the planned large power projects, State's Small Hydro Power Policy 2007 envisages that these eco-friendly and renewable micro/ mini/small hydro projects that are low in gestation period will be ideal for viable investment for State's domestic power requirement. The policy calls for formulation and notification of an Action Plan for Small Hydro Power Generation.

In terms of utilization of water for State's agriculture, the Agriculture Policy 2001 provides rapid expansion of area under agriculture through the innovative use of technology, expand irrigation facilities and build supporting infrastructure. State is keen to use its natural resources, water, and land for overall economic development. Creation and maintenance of necessary developmental infrastructure would necessitate strong policy interventions backed by operational plans, importantly, including efficient management and sustainable utilization of State's water resources. Expansion of irrigation accessibility for increased agriculture acreage and productivity; State's remoteness, and lack of communication (road) infrastructure will be the biggest barrier for such large-scale development.

1.1 Background

Himalayan ecosystems are amongst the most fragile environments on the earth and are characterized by a high degree of remoteness, fragility, marginalization and low accessibility (ICIMOD, 2010). Sustainability of the Himalayan ecosystem is crucial for the livelihood of about 1.3 billion people in Asia. The perennial river system of north and north-east of India depends upon the sustainability of glaciers and the ecosystem of the Himalayan region.

With the increasing demand of growth and development, people living in the Himalayan states are seeking access to various developmental choices but at the same time, it is important to structure our developmental paths which are aligned and consistent with the sustainability of the existing ecosystem. Moreover, the state is not only climate sensitive, but it is characterized by its geological phenomena and hazards of natural disasters like landslides and earthquakes.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has concluded that there is an unequivocal evidence of global warming of earth's atmosphere caused by anthropogenic emissions. The IPCC also estimates that global average temperature could rise by 2.6 – 4.8^{o}C by 2100 (according to the IPCC's highest emissions scenario). Climate change variability in temperature and precipitation patterns is likely to influence the regional mountain ecosystem. The changes can be expected to be complex and more unpredictable. The effects of climate change on the environment and people's livelihoods could impact human health, agriculture, forests, water resources, species and natural habitat. Hence, there is a compelling need for a concerted effort to understand the implications of climate change on the Himalayan States to develop special strategies for sustaining fragile ecosystems on which many people are dependent.

1.2 The scope of the study

In the above context, the need to define problems related to all the aspects of water resources specific to the State arises. Also, identifying probable solutions and evaluation of alternatives covering the impact of climate change, cost-benefit analysis, technological gaps, and policy framework including legal and institutional linkages for optimization of water resource utilization and conservation holds utmost importance. The present study aims to assess and evaluate the impact of climate change on water availability of both surface and groundwater resources at the sub-basin level to provide technological options for sustainable water resources planning and management.

1.3 National Action Plan on Climate Change (NAPCC)

Climate change is one of the most critical global challenges of our times. Recent events have emphatically demonstrated our growing vulnerability to climate change. Climate change impacts will range from affecting agriculture – further endangering food security – to sea-level rise and the accelerated erosion of coastal zones, increasing intensity of natural disasters, species extinction, and the spread of vector-borne diseases. India's National Action Plan on Climate Change (NAPCC) launched on June 30, 2008, outlines its strategy to meet the challenge of Climate Change. NAPCC is guided by the principles of Sustainable Development (SD) and aligns the environmental and economic objectives. It outlines a national strategy that aims to enable the country to adapt to climate change and enhances the ecological sustainability of India's development path. It stresses that maintaining a high growth rate is essential for increasing living standards of majority of people of India and reducing their vulnerability of the impacts of climate change. Eight "National Missions" which form the core of the National action plan are: National Solar Mission, National

Mission on Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Eco-system, National Mission for a Green India, National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change. They focus primarily on promoting the understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation.

1.4 National Water Mission (NWM)

The main objective of the National Water Mission (NWM) is "conservation of water, minimizing wastage and ensuring its more equitable distribution both across and within States through integrated water resources development and management". The five identified goals of the Mission are: (a) comprehensive water database in public domain and assessment of impact of climate change on water resource; (b) promotion of citizen and state action for water conservation, augmentation, and preservation; (c) focused attention to vulnerable areas including over-exploited areas; (d) increasing water use efficiency by 20%, and (e) promotion of basin level integrated water resources management.

Various strategies for achieving the goals have been identified which lead to integrated planning for sustainable development and efficient management with the active participation of the stakeholders after identifying and evaluating the development scenario and management practices towards better acceptability based on assessment of the impacts of climate change on water resources based on reliable data and information.

1.5 State Specific Action Plan for Climate Change (SAPCC)

In August 2009, the Government of India directed all state governments and union territories to prepare State Action Plans on Climate Change (SAPCC), consistent with the strategy outlined in the National Action Plan on Climate Change (NAPCC). Broadly the State level action plans are envisioned to be an extension of the NAPCC at various levels of governance, aligned with the eight National Missions. Building on such a need, a National Consultation Workshop was held on 19th August 2010 in New Delhi for discussing the common framework/approach for preparing State-level action plans on climate change. During the workshop, it was suggested that States can take their lead from the Mission documents while formulating mitigation/adaptation strategies under the State level strategy and Action plan (SAPCC). It was recommended that all state governments finalize their SAPCC by 31st March 2011. Delhi and Orissa became the first two states in the country to complete and launch their State Action Plans. Although all State governments are implementing climate-friendly strategies (broadly aligned with the missions) as a part of their development programmes, some states have taken specific leads in the matter.

2 About State: A water perspective

The erstwhile North Eastern Frontier Agency (NEFA), became Union Territory of Arunachal Pradesh on 20-01-1972 under the provisions of North-Eastern Areas (Reorganisation) Act 1971 (81 of 1971) and attained statehood on 20th February 1987. Arunachal Pradesh is situated in North Eastern Part of India stretching between longitude 91°30'E to 97°30'E and Latitude 26°30'N and 29°31'N. It spreads over an area of 83,743 Sq.km touching the international boundaries with Bhutan (160 Km) in the west, China (1080 Km) in the north, Myanmar (440 Km) in the south-east and the plains of Assam to the south. It borders the states of Assam in the south and Nagaland to the east and southeast. At present, it has 18 districts with a population of 13, 83,727 of which 7, 13,902 males and 6, 69, 815 female and a literacy rate of 65.38% as per Census of India 2011.

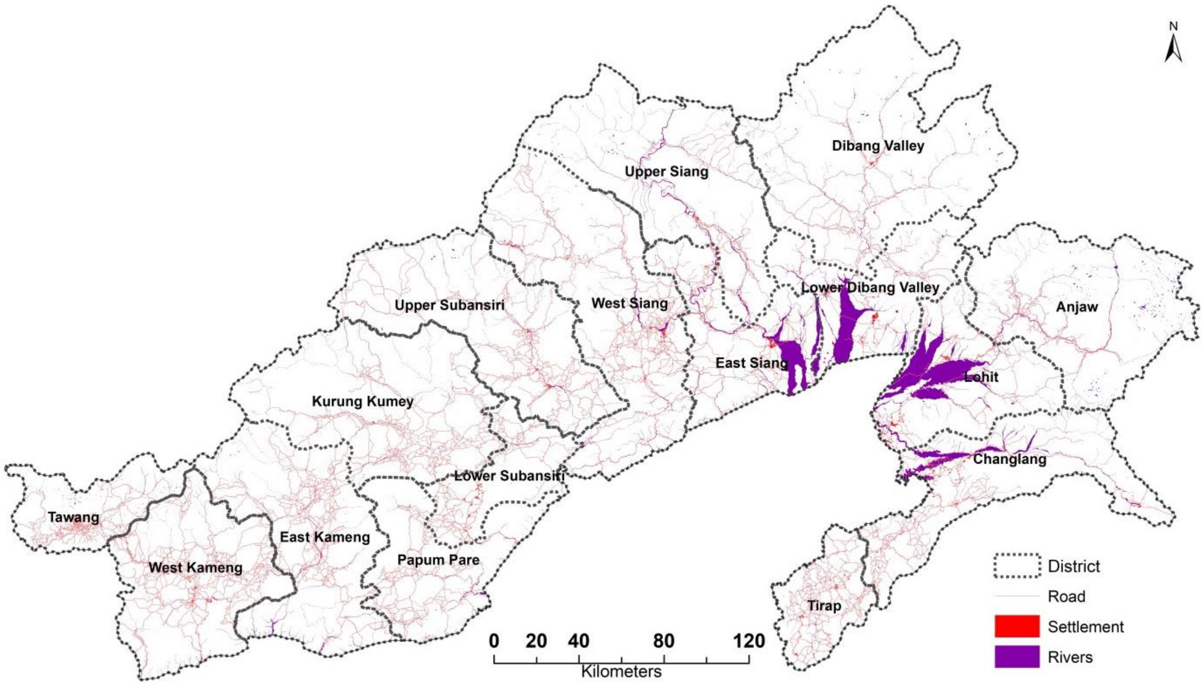

Figure 2-1: Base map of the state

2.1 Nature and Culture

There are over 27 major tribes and many sub-tribes inhabiting the State. Though, most communities are ethnically similar, having descended from an original common stock. But their geographical isolation from each other has brought amongst tribe's certain distinctive characteristics in language and customs. Nature has also provided the people with a deep sense of beauty which finds delightful expression in their songs, dances, crafts, and festivals. The climate of Arunachal Pradesh varies from hot and humid to heavy rainfall in the Shivalik range. It became progressively cold as one moves northward higher altitudes. Trees of great size, plentiful climbers, and abundance of cane and bamboo make Arunachal evergreen. The richness of flora and fauna that occur in these forests presents a panorama of biological diversity with over 5000 plant species, about 85 terrestrial mammals, over 500 birds and many butterflies, insects, and reptiles. Arunachal Pradesh is also considered to be a treasure home to orchids, known for their exquisitely beautiful blooms, with more than six hundred species occurring in varying elevations and climatic conditions throughout the state.

2.2 Climate

The climate of the state is influenced greatly by the Himalayan mountains and large variations in altitude across the state. At a very high elevation in the Greater Himalayas close to the Tibetan border experience alpine and tundra climates. Middle Himalayas prevails temperate climate and areas at the sub-Himalayan (lower Himalaya) belt generally experience humid sub-tropical climate with hot summers and mild winters. The rainfall of Arunachal Pradesh is amongst the heaviest in the country receiving more than 3500 mm in a year. The state receives rainfall over a period of 8 to 9 months excepting the drier days in winter, however, most of the rainfall is between May and September. Higher altitude experiences snowfall during winter. The average annual rainfall is 1000 mm in the higher elevations and 5750 mm in the foothills to the north of Brahmaputra River. Winter months have average temperatures in the range 15ºC to 21ºC, and the monsoon month temperatures are in the range of 22ºC – 33ºC, and the summer months temperatures sometimes are higher well over 37ºC. The foothills experience maximum temperatures around 40ºC during summer.

2.3 Physiography

Physiography of the state has several deep valleys rising to steep mountains mostly covered by the Eastern Himalayas. The northeastern region of India presents a unique mosaic of landforms with great diversity reflecting a complex geotectonic setup. The major domains of this area are the rugged hills of the high Himalaya characterized by glaciers, glacial valley, and moraines; the low Himalayan foothills; the valley of Brahmaputra and its tributaries. The area under different landforms in Arunachal Pradesh is categorized (table 1).

Table 2-1: The area under various landforms

Code	Landforms	Area (Sq. km)	Area (%)
1	Snow Cover / Glacial Area	12195.94	14.56
2	Glacier	94.96	0.11

Code	Landforms	Area (Sq. km)	Area (%)
3	Glacial Valley	106.25	0.13
4	Lateral Moraine	3.62	0.00
5	Terminal Moraine	2.95	0.00
6	River Terrace	120.03	0.14
7	Channel Island	182.65	0.22
8	Point Bar	8.80	0.01
9	Cannel Bar	45.99	0.06
10	Stabilized Channel Bar	9.80	0.01
11	Meander Zone	112.13	0.13
12	Interfluve	148.22	0.18
13	Intermountain Valley	93.72	0.11
14	Valley	664.18	0.80
15	Fracture Valley	0.78	0.00
16	Alluvial Plain	870.87	1.04
17	Flood Plain	406.06	0.49
18	Palaeo Channel	4.68	0.01
19	Piedmont Alluvium	2610.40	3.13
20	Piedmont Zone	45.78	0.05
21	Pediment	47.15	0.06
22	Residual Hill	5.75	0.01
23	Denudational Hill - Highly Dissected	4769.68	5.72
24	Denudational Hill - Moderately Dissected	7208.62	8.64
25	Denudational Hill - Slightly Dissected	165.60	0.20
26	Structural Hill - Highly Dissected	10584.68	12.68
27	Structural Hill - Moderately Dissected	6888.62	8.26
28	Structural Hill - Slightly Dissected	260.73	0.31
29	Structural Hill	34037.85	40.79
31	River (Dry)	23.76	0.03
32	River (Wet)	2022.75	2.42
	Total	83743.00	100.00

The Hilly area covering 76.6% of the total geographical area of the state is under the category of either structure hills or denudational hills or residuals hills followed by snow cover area which covers 14.56% of the total geographical area of the state. This explains that geomorphologically the state having a low potential of groundwater development and catchment/basin of these areas have a high rate of runoff. The three basic landforms namely denudational, depositional and structural are characterized by structural hills of the upper catchment, the piedmont zone, and the vast Brahmaputra alluvial plain. The major river in the state is the Brahmaputra. Other rivers are Changlang, Dibang, Kameng, Lohit, Subansiri, Papum pare, Tawang, Tirap, and Siang.

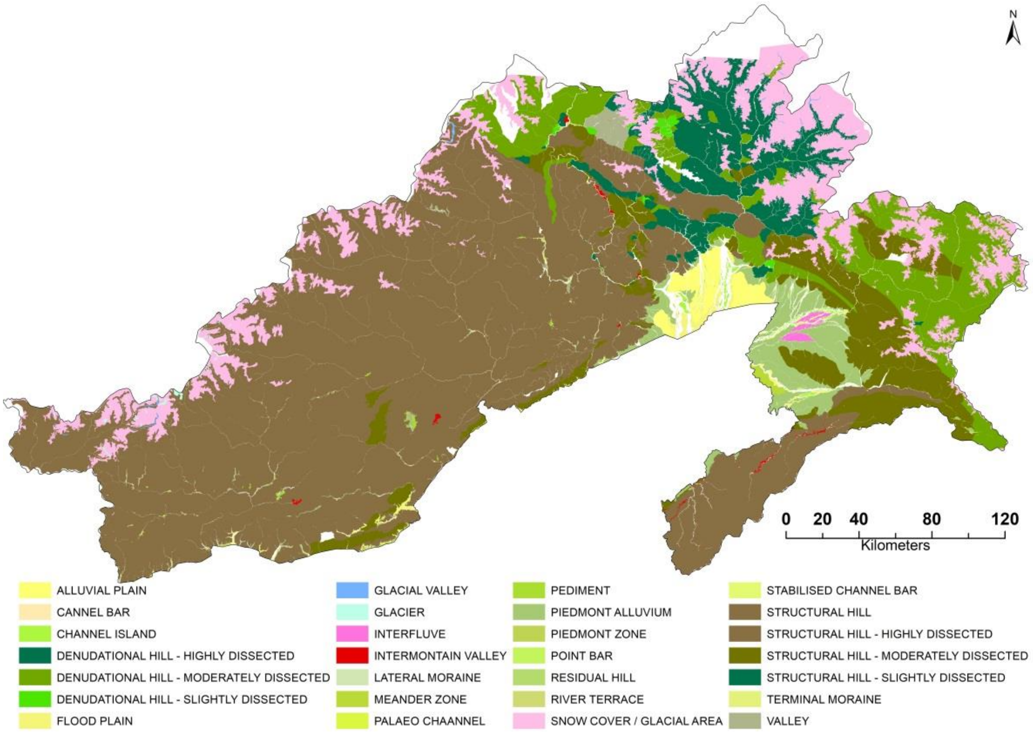

Figure 2-2: Landforms of state

2.4 Demographic profile

Arunachal Pradesh is administratively divided into 16 districts, 188 circles, covering 5258 villages. According to Census 2001, Arunachal Pradesh has the lowest population density (17 per sq. km) in India. The decadal growth rate (Figure 2-1) of the state is 25.92 % (against 21.54% for the country) and the population of the state continues to grow at a much faster rate than the national rate.

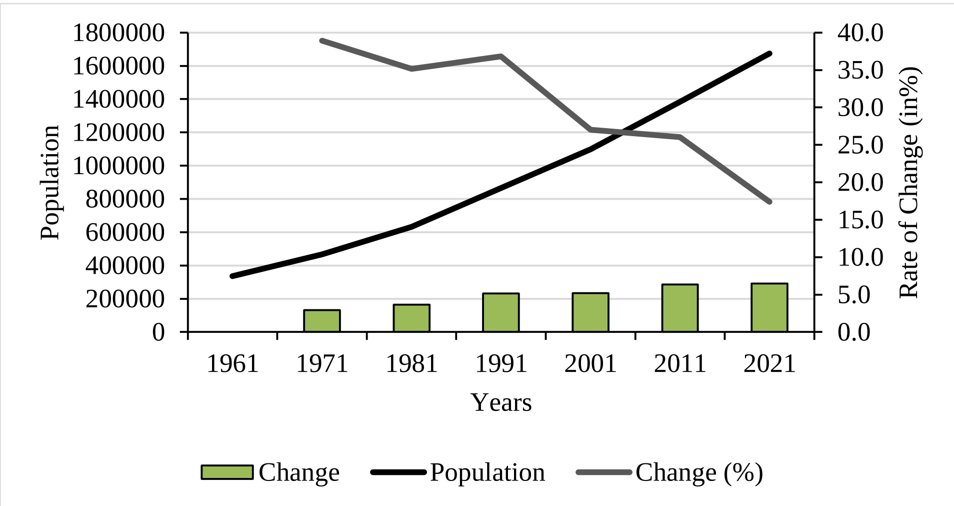

Figure 2-3: Population Growth

The figure 2.1 depicts an increase in population over years from 1961 to now and projected to the year 2021. The change is the population in consecutive years is also plotted and shows a decreasing rate of growth in population from 2011 to 2021.

2.5 Economic profile

Arunachal Pradesh is predominantly an agrarian economy. Most of the state is covered with dense and rich forest. About 54.6% of the population is engaged in agriculture and allied activities and 80% of the population living in the rural area is dependent on agriculture and about 62 % of total working populations are engaged in agriculture. Forest-products are the lifeline in the State and provide income and employment to many people. Food grains cultivation includes; rice, maize, millet, wheat, pulses, sugarcane, ginger and oilseeds. Arunachal is also ideal for horticulture and fruit orchards. Major industries of sawmills and plywood, rice mills, fruit preservation units and handloom handicrafts contribute their share to the economy of the state. There are many small-scale and handloom industries in Arunachal Pradesh strengthening the economy of the state. Cane and bamboo work, weaving, mat making are some indigenous employments in Arunachal Pradesh.

Agriculture and Horticulture

Agriculture is the main occupation for Arunachal Pradesh. Jhum/shifting cultivation and terrace farming/wetland rice cultivation are the two major patterns that farmers employ. About 53% of the total cultivated area is under Jhum and the rest under permanent cultivation.

Topography and climate of Arunachal Pradesh are conducive for the cultivation of rice, millets, wheat, maize, pulses, sugarcane and potatoes. Horticulture is an important sector in Arunachal Pradesh having tremendous potential for rural livelihood. Due to the existence of varied agro-climatic zone and high adaptability to hilly topography of the state; spices, aromatic and medical plants, flowers, and mushroom are highly cultivated in Arunachal Pradesh. Apple, mandarin, pineapple, ginger, large cardamom, besides off-season vegetables have a big opportunity in the domestic markets. Kiwi, though grown in a small area, has good potential to scale it up to the commercial level. Various steps were taken to diversify the agriculture economy by encouraging the cultivation of cash crops like potatoes, and horticulture crops like apple, oranges, guavas, and pineapples, etc.

Table 2-2 Area Production and yield of major crops

	Area (Lakh ha)			Production (MT)			Yield (kg/ha)		
Crops	2014-15	2015-16	2016-17*	2014-15	2015-16	2016-17*	2014-15	2015-16	2016-17*
Rice	441.10	434.99	431.94	105.48	104.41	110.15	2391	2400	2550
Wheat	314.65	304.18	305.97	86.53	92.29	98.38	2750	3034	3216
Cereals	251.70	243.89	247.71	42.86	38.52	44.19	1703	1579	1784
Pulses	235.54	249.12	294.65	17.15	16.35	22.95	728	656	779
Food grains	1243.00	1232.18	1280.26	252.02	251.57	275.68	2028	2042	2153
Oilseeds	255.96	260.87	262.06	27.51	25.25	32.10	1075	968	1225
Sugarcane	50.66	49.27	43.89	362.33	348.45	306.72	71512	70720	69886
Cotton @	128.19	122.92	108.45	34.80	30.01	33.09	462	415	519
Jute and Mesta #	8.10	7.82	7.66	11.13	10.52	10.60	2473	2421	2490

*4th advance estimates
@ Production in million bales of 170 kg each
# Production in million bales 180 kg. each

2.6 Natural Resources

2.6.1 Forest Resources

Forest is the most important resource in Arunachal Pradesh with the predominantly large tribal population living in close association with forests and highly dependent on it. Traditional shifting cultivation also known as Jhum cultivation is practiced by the people and has devastating effects on the ecology of the region thereby degrading the local environment. Arunachal Pradesh in the Eastern Himalaya is among the 200 globally important Ecoregions. The important forest types found in the state are tropical evergreen, semi-evergreen forests, deciduous forests, pine forests, temperate forests and alpine forests. In the degraded forests, bamboos and other grasses are of common occurrence. The total geographical coverage of forest area is 73.13% in 2012.

2.6.2 Biodiversity

Arunachal Pradesh, by its geographical position, climate conditions and altitudinal variations, is a biodiversity-rich region in northeast India, with large tracts of tropical wet evergreen, subtropical, temperate and alpine forests. It possesses India’s second highest level of genetic resources. Although occupying only 2.5% of India’s geographical area, the state occupies a significant place in terms of floral and faunal biodiversity, being considered one of the world’s 18 biodiversity hotspots and home to 85 species of terrestrial mammals, 760 species of birds, 4,500 species of angiosperms and 550 species of orchids. It has been recognized by International World Conservation Union in 1995 as one of the major centers of plant diversity.

Table 2-3 Forest Types of Arunachal Pradesh

Sl	Broad Forest Type	As per Champion & Seth	Altitudinal Range	Important Species
1	Tropical Semi Ever Green	2/B/C1/Ia, 2/B/C1b/ISI	Near Alluvial Plains	Amoora wallichii, Pterospermum acerifolium, Stereospermum chelonoides, Altingia excelsa.
2	Tropical Ever Green	1/B/C1, 1/B/C2	Up to 610 meters	Kayea assamica, Mesua ferrea, Dysoxylum procerum, Echnocarpus sp.
3	Tropical Wet Ever Green	8/B/C1	Up to 900 meters	Phoeba paniculata, Actinodaphne obovata, Alnus nepalansis, Phoebe attenuata.
4	Sub-tropical broad leaved	3C3/Bb, 3C/IS2	Up to 900-1900 meters	Bombax ceiba, Lagerstroemia parviflora, Terminalia bellirica, Sterculia villosa.
5	Sub-Tropical Pine	III/9/DS/1	1000-1800 meters	Pinus Roxburghii, Pinus wallichiana and Pinus merkusii.
6	Wet Temperate Forests	IV/11/IIB/C1, IV/11/IIB/C2	1800-2750 meters	Quercus lamellosa, Quercus sp. Castanopsis indica, Acer hookeri.
7	Mixed Coniferous Forests	IV/12/C1/3a, IV/12/C/3b	2300-3350 meters	Abies sp. Tsuga dumosa.
8	Alpine	V/C2, VI/ISC3, VI/16/C1, E1	3000-5500 meters	Rhododendron, Primula, Saussaurea, Saxifraga.
9	Bamboo Brakes	1B/2S		Bambusa pallida, Schizostachyum polymorphum, Bambusa tulda, Dendrocalamus hamiltonii

Source: Forest Statistics of Arunachal Pradesh (Up to the Year 2000-2001)

Table 2-4 Forest change and distribution

District	Forest Area (in Km^2)		District Area (Sq^2)	% of Forest Area		Change (%)
	2005	2012		2005	2012	
Anjaw	4562.50	4412	6982	65.35	63.19	-2.16
Changlang	4168.02	4072.12	5069	82.23	80.33	-1.89
Dibang Valley	4181.07	4162.23	8959	46.67	46.46	-0.21
East Kameng	3596.11	3591.26	4134	86.99	86.87	-0.12
East Siang	3419.27	3419.27	4687	72.95	72.95	0.00
Kurung Kumey	5620.02	5620.02	7141	78.70	78.70	0.00
Lohit	2610.92	2565.77	4420	59.07	58.05	-1.02
Lower Dibang Valley	2847.72	2847.72	4070	69.97	69.97	0.00
Lower Subansiri	2387.30	2684.07	2994	79.74	89.65	9.91
Papum Pare	2563.85	2539.59	2875	89.18	88.33	-0.84
Tawang	861.38	861.38	2172	39.66	39.66	0.00
Tirap	1547.12	1324.94	1955	79.14	67.77	-11.36
Upper Siang	4584.59	4545.08	6188	74.09	73.45	-0.64
Upper Subansiri	5431.65	5431.65	7032	77.24	77.24	0.00
West Kameng	5584.19	5584.19	7422	75.24	75.24	0.00
West Siang	6247.72	6247.72	7643	81.74	81.74	0.00
Total	60213.44	59909.02	83743	71.90	71.54	-0.36

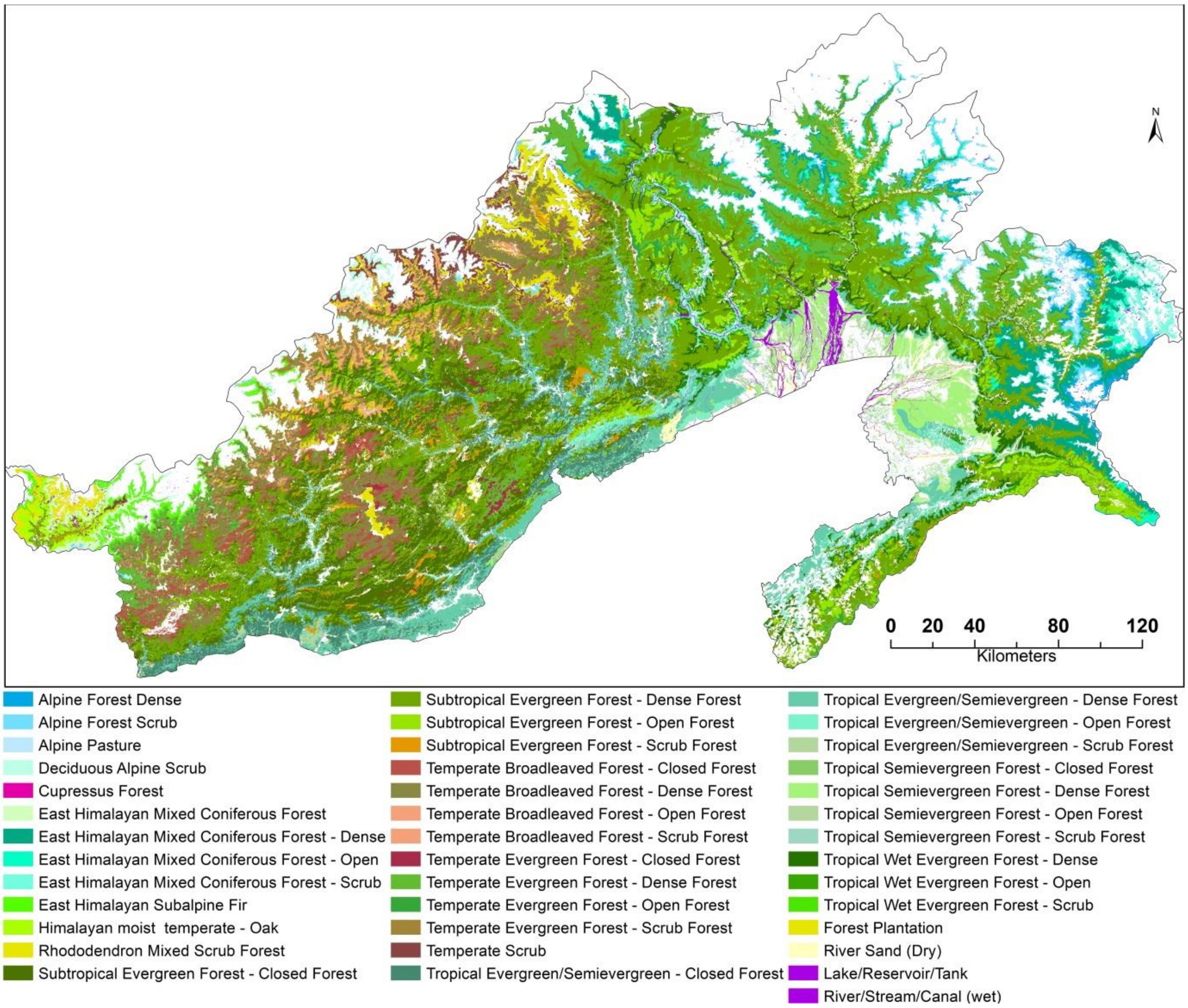

Figure 2-4: Forest types

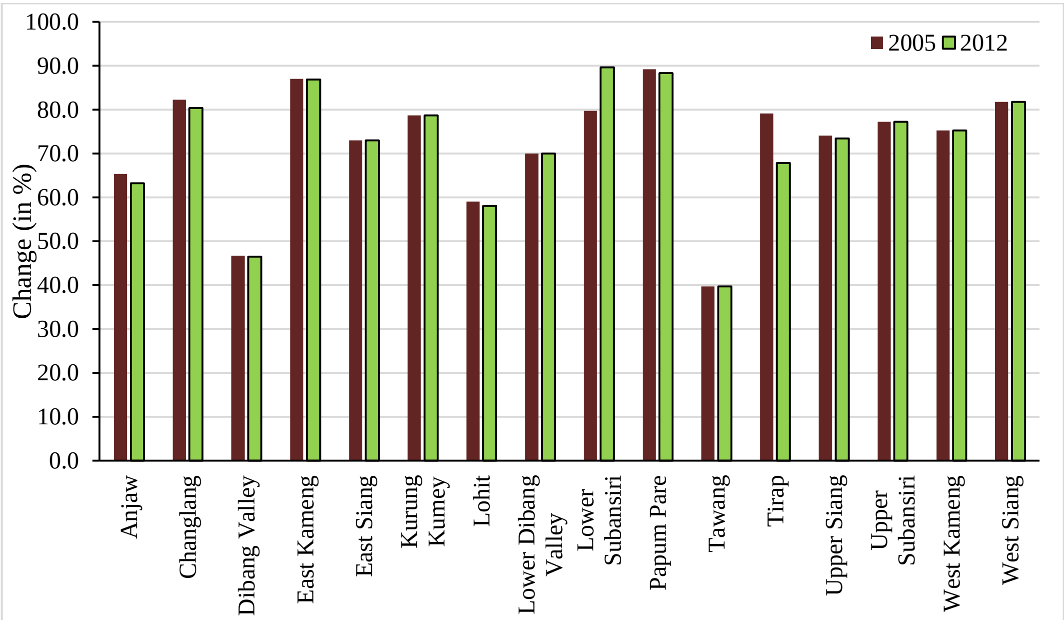

Figure 2-5: Change in forest cover

2.6.3 Glaciers

Arunachal Pradesh has the lowest concentration of glaciers in India. Glaciers are found in the Kameng Basin (52 glaciers covering an area of 66 km^2), Subansiri Basin (91 glaciers covering an area of 146 km^2) and Dibang Basin (14 glaciers covering an area of 11 km^2). The snow melting contribution in the basin is a major source of water resources in most of the river systems. The contribution of snowmelt in the basin is higher in the upper catchments followed by lower catchments. This rate of snowmelt is affected by local land use practices and climate change.

2.6.4 Soil

A good understanding of soils with reference to their nature and distribution is essential to formulate any land-based production system. The soil is a major element in the natural environment linking climate and vegetation. Soil is known for its unique behaviour under irrigated and non-irrigated conditions and therefore soil surveys are undertaken to plan optimum management systems for the sustainable development of the region. Detailed soil mapping is an important aspect in establishing management guidelines on land capability/ irrigability classification and soil suitability for agriculture under rainfed as well as irrigated conditions. National Bureau of Soil Survey & Land Use Planning (NBSS & LUP) map is prepared on 1:250,000 scale and is incorporated with satellite data to provide vital information for soil resource of Arunachal Pradesh.

Table 2-5 Areal statistics of different type of texture in the soil

Code	Texture	Area (Sq^2)	Area (%)
1	Coarse	4935.80	5.89
2	Medium	42091.57	50.26
3	Fine	21323.50	25.46
4	Deep	1696.35	2.03
5	Snow Cover	7497.66	8.95
6	Stony	3905.53	4.66
7	Built-up	139.42	0.17
8	Water body	1188.80	1.42
9	No data	964.37	1.15
	Total	83743.00	100.00

The soil information was grouped into several texture classes and it is observed that 50.44% of the total soil series are under medium texture followed by a fine texture with 25.55%. Snow area covers 9% of the total geographical area of the State (table 2-5). This indicates that most of the area has the potential to store the surface run-off in the region. The drainage condition and the distribution of soil texture map shown in Figure:

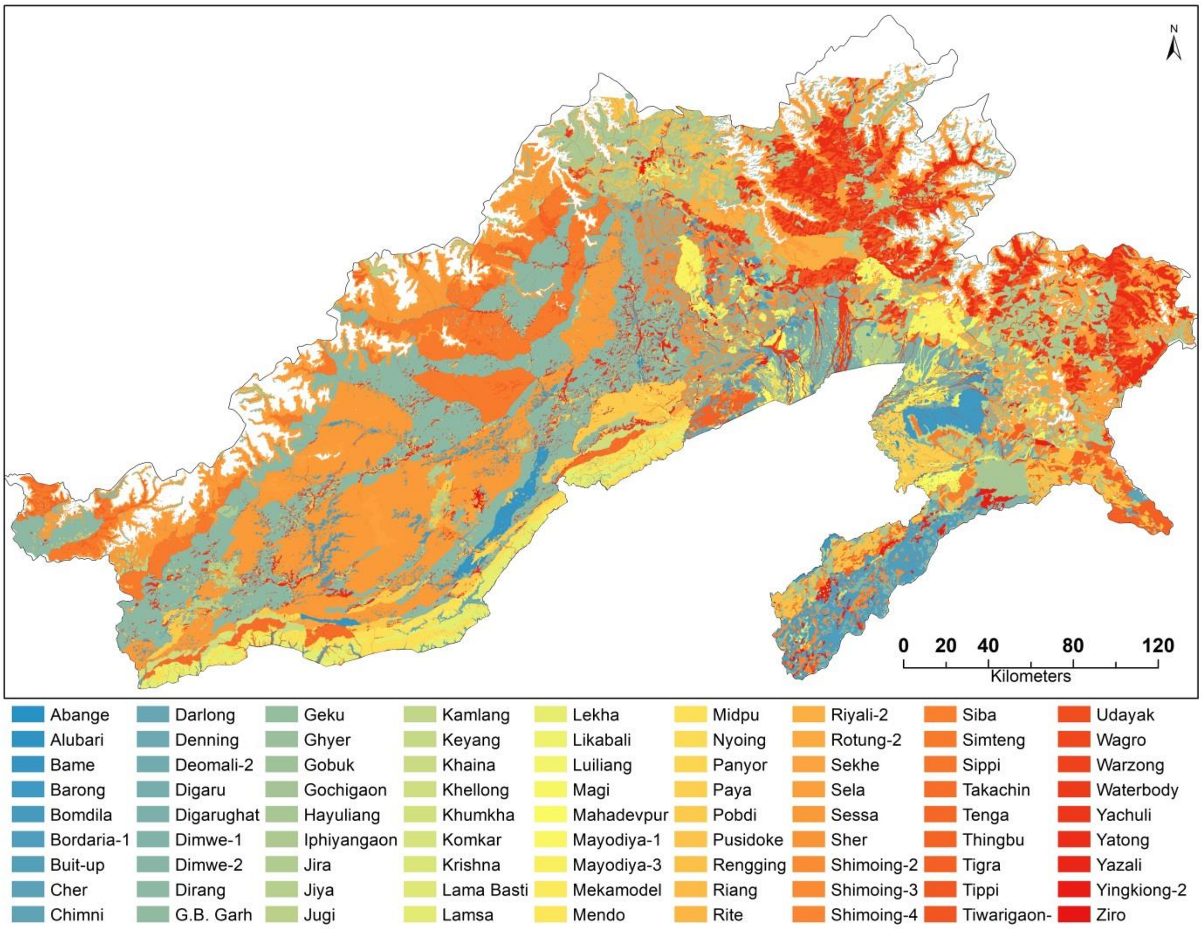

Figure 2-6: Soil types

2.6.5 Mines & Minerals

Arunachal Pradesh has a vast reserve of mineral oils and gas. This state has also coal reserves. Coal is explored from Namchik-Namphuk mines in Tirap district. Besides coal oil and gas there is a huge reserve of dolomite, limestone, graphite, marble, lead and zinc etc. It is also assumed that there is the reserve of iron and copper. The main mineral-rich districts are Lohit, Tirap, Chanlang, West Kameng, Upper Subansiri, Dibangghati etc.

2.6.6 Surface water resources

Brahmaputra is one of the major rivers of Asia and 41.88 % of its basin is shared by Arunachal Pradesh. The state has the highest average run-off of 350 BCM. About 80% of the mean annual flow of River Brahmaputra is contributed by more than 3,000 small and big river tributaries. Within Arunachal Pradesh, there are 19 major river catchments consisting of

46 major and medium type rivers. The 10 major basins are: Tawang, Kameng, Dikrong, Subansiri, Siang, Sisiri, Dibang, Lohit, Tirap-Dehing and Tissa river basins. Numerous rivers originating from these basins ultimately drain to Brahmaputra river. This is a boon for the State for development of agriculture, power and industry sectors but at the same time, these rivers have the destructive potentials unless certain preventive and protective measures are taken up in the State. Rivers of Arunachal Pradesh could be broadly classified into three types namely (i) Hilly reach (incised rivers), (ii) Foothill sub-montane reach (boulder rivers) and (iii) Floodplain (alluvial rivers).

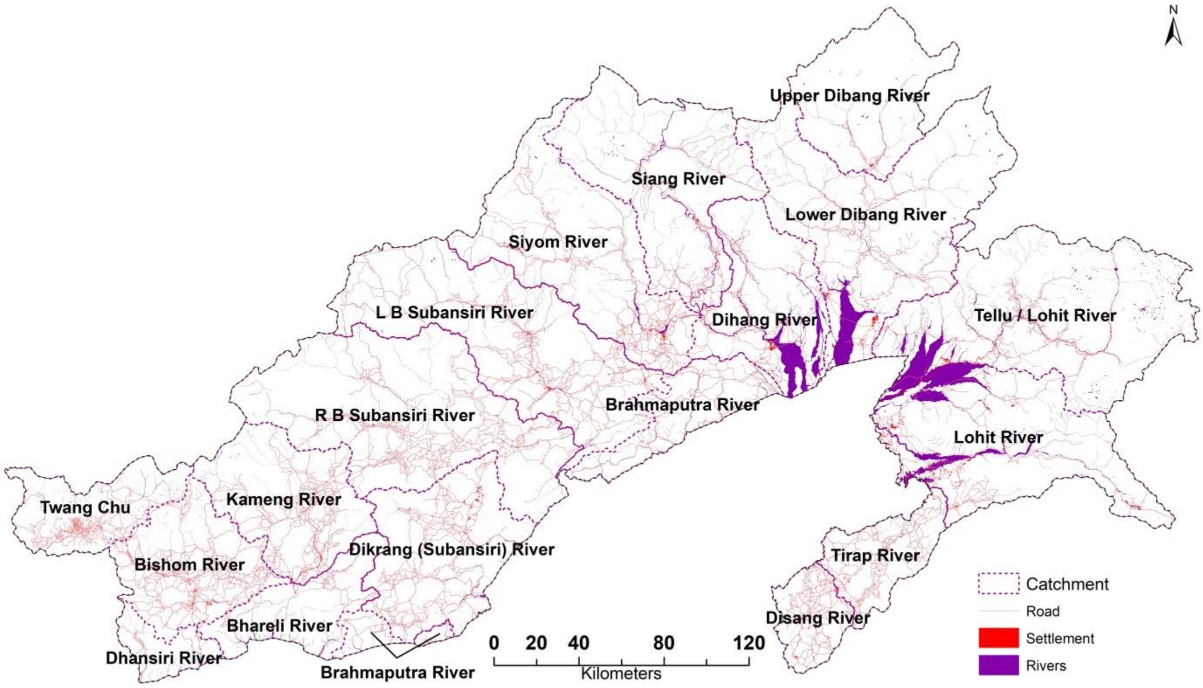

Figure 2-7: Major Catchment of Arunachal Pradesh

2.6.7 Ground water resources

Arunachal Pradesh has 2.56 BCM annual replenishable ground water resources and net annual groundwater availability of 2.30 BCM. The groundwater potential exploited so far is negligible. With the depletion of surface water resources in the foothill areas of Arunachal Pradesh, especially Changlang, Lohit, Lower Dibang Valley, East Siang, Papum Pare and East Kameng districts, the need to exploit groundwater potential for meeting the requirements of drinking water and irrigation is increasing day by day. The CGWB had assessed an irrigational potential about 18,000 hectares through groundwater in the State. An area of more than 87,500 hectares has been irrigated in Arunachal Pradesh. Based on rock type it is found that about 15.4% of the area is covered with Biotite Granite Gneiss & Biotite

Tourmaline Gneiss. The next predominant underlying rock type is Sillimanite Bearing Schists and Gneisses & Migmatites covering 9.7% followed by Metavolcanics, Limestone, Dolomite, Marble & Phyllite (6.9%). These rocks are basically Palaeo Proterozoic age and have less or negligible importance for any groundwater development, these are basically runoff zone and carrying less groundwater drawdown. Diverse geological formation, lithological variations, tectonic complexity, geomorphological and hydro-meteorological dissimilarities exist in the state and which result in various groundwater situations.

Table 2-6: Aquifer type / Geological formation and their Ground water potential in the Arunachal Pradesh

Formation	Lithology	Groundwater potential
Unconsolidated	Sand, clay, silt, gravel, pebble, cobble, and boulder	Moderate yield, 30-50m3/hr. Drawdown within 10-15m.
Semi consolidated	Shale, siltstone, sandstone, interbedded with coal seams and limestone	Low yield, up to 20 m3/hr. Drawdown within 25m.
Consolidated		
Fissured formation	Phyllites, schist, slates, quartzites	Low yield 5 to 15 m3/hr.
Meta sediments	Gnessic complex with acid and basic intrusive	Yield up to 5 m3/hr

The entire foothill belt running along the Himalayan front can be correlated to the "Bhabar belt" of Ganga basin with exception of some areas of Lohit and Tirap districts. Groundwater occurs under unconfined to semi-confined conditions. In Namsai and Mino sub-divisions, the depth to water levels is essentially governed by topography. Sediments down to 106 meters below ground level (bgl) are predominantly sandy and discharge of tube wells ranges up to 160 m^3/hr. Open wells in Namsai and Mino sub-division tap 3 to 5 m of saturated sand and yield up to 100 m^3/day.

Table 2-7: Rock types and distribution

Code	Rock Type	Area (Km^2)	Area (%)
1	Amphibolite Mica Schist & Biotite	690.21	0.83
2	Biotite Granite	4660.49	5.58
3	Biotite Granite Gneiss & Biotite Tourmaline Gneiss	12830.95	15.38
4	Boulder Bed and Friable Sand Stone	1491.61	1.79
5	Colluvium	2610.4	3.13
6	Colluvium - Boulders, Cobbles, Pebbles, Sand & Clay	45.78	0.05
7	Compact Micaceous Sand Stone	1849.33	2.22
8	Diamictite, Phyllite, Sand Stone & Carbonaceous Shale	1244.79	1.49
9	Data Not Available	676.7	0.81
10	Ferrugenous Sandstones With Interbedded Clays,Grit, Conglomerate, Sandstone & Shale	1149.42	1.38

Code	Rock Type	Area (Km^2)	Area (%)
11	Garnet-Muscovite-Biotite Schist, Quartzite & Phyllite	3728.04	4.47
12	Granodiorite	2578.78	3.09
13	Hornblende Gneiss & Biotite	294.56	0.35
14	Limestone, Shale, Metavolcanics, Tuffs, Siltstone	585.08	0.70
15	Mafic Volcanics	120.21	0.14
16	Metavolcanics, Limestone, Shale & Coal Beds	856.73	1.03
17	Metavolcanics, Limestone, Dolomite, Marble & Phyllite	5813.7	6.97
18	Metavolcanics, Serpentinite, Limestone, Shale & Coal Beds	1995.38	2.39
19	Newer Alluvium (River Alluvium, Sand, Silt & Clay)	1432.72	1.72
20	Older Alluvium (River Alluvium, Sand, Silt & Clay)	650.22	0.78
21	Phyllite, Quartzite, Dolomite, Mica Schist & Shale	5303.67	6.36
22	Sandstone with Shales	1284.47	1.54
23	Sandstone, Pebbles, Boulder Conglomerate & Clay	1644.28	1.97
24	Schists, Sandstone, Orbitoline Limestone, Shale, Ultrabasic Rocks & Coalbeds	1629.18	1.95
25	Serpentinite	168.05	0.20
26	Shales Interbedded with Sandstones	2566.28	3.08
27	Sillimanite Bearing Schists and Gneisses & Migmatites	8124.56	9.74
28	Undifferentiated	3390.11	4.06
29	Unsorted Glacial Sediments	6.56	0.01
30	Volcanogenic Sediments	553.76	0.66
31	Glacier	11720.87	13.99
32	Underlying Geology (Water bodies)	2046.11	2.45
	Total	83743	100.00

The thematic maps of geology and landforms have been generated on 1: 50,000 scale using satellite data and other collateral information and put as a standardized database. The geology and geomorphology map are integrated together to prepare a hydrogeological map which is superimposed by geological structures to identify the different level of groundwater potential in the state. With the help of the information drawn from a survey of India toposheet and by visual interpretation of satellite imagery different thematic maps such as geomorphology and lineaments, drainage and land use/land cover are prepared. These thematic maps have been superimposed and finally, a groundwater potential zone map is delineated on a survey of India toposheet.

Table 2-8 Areal distribution of ground water potential zone

Code	Ground Water Potential	Area (Km^2)	Area (%)
1	Very Good	3091.02	3.70
2	Good	3702.91	4.44
3	Moderate	625.95	0.75
4	Poor	4181.37	5.01
5	Very Poor	71845.43	86.10
	Total	83446.68	100.00

The previous resource information like geology, geomorphology and soil clearly indicate that the potential for groundwater irrigation in the state is limited. Only 3.7% of the total geographical area of the state identified for very good potential sites under groundwater resources (table 2.11). Sustained development and efficient management of groundwater resource are essential to meet acute water scarcity especially drinking water problem in different parts of the state.

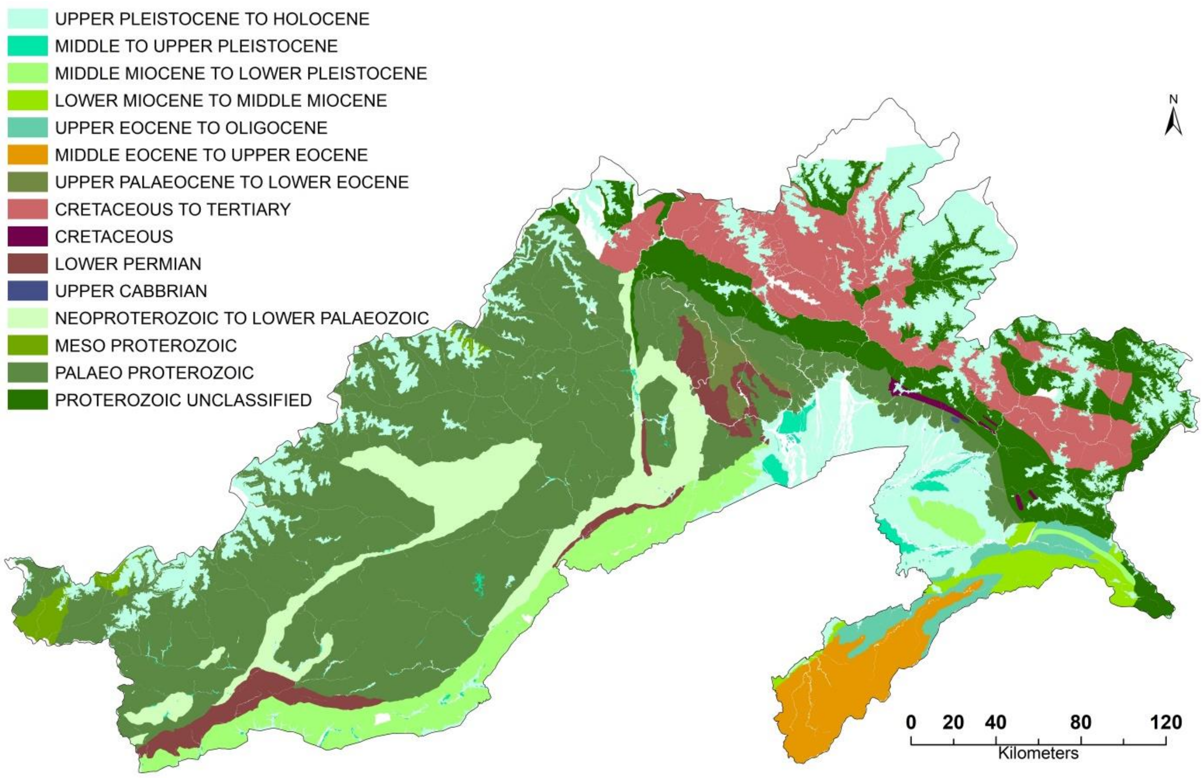

Figure 2-8: Geological age Structure

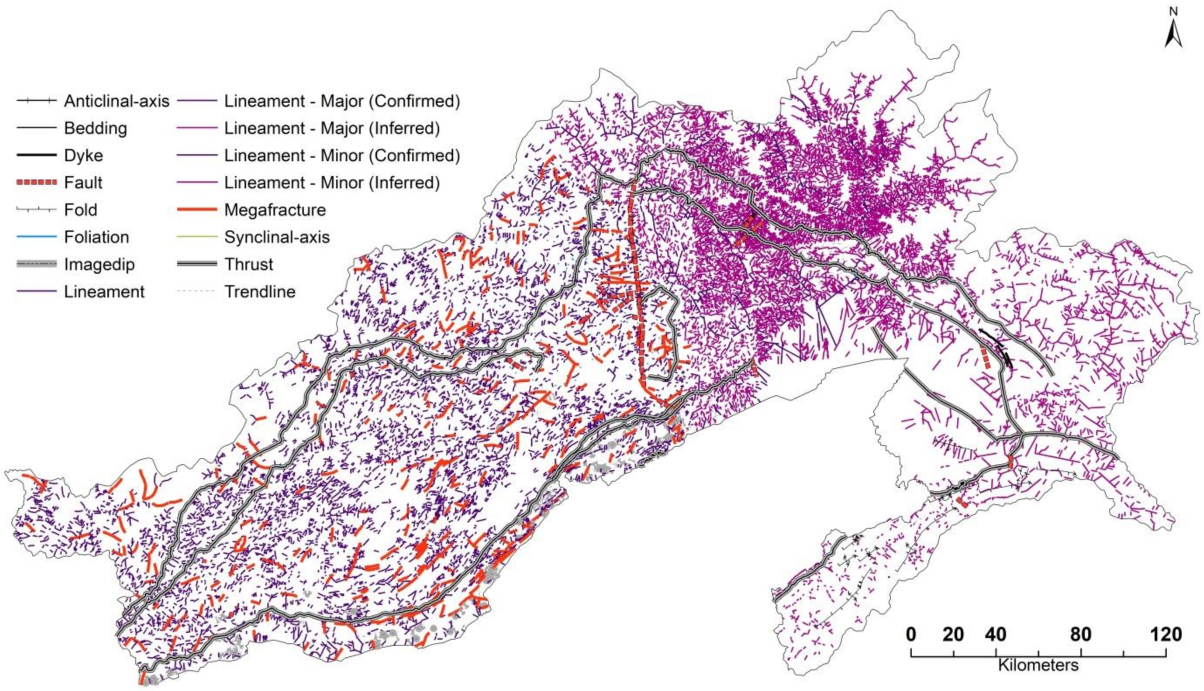

Figure 2-9: Geological structure

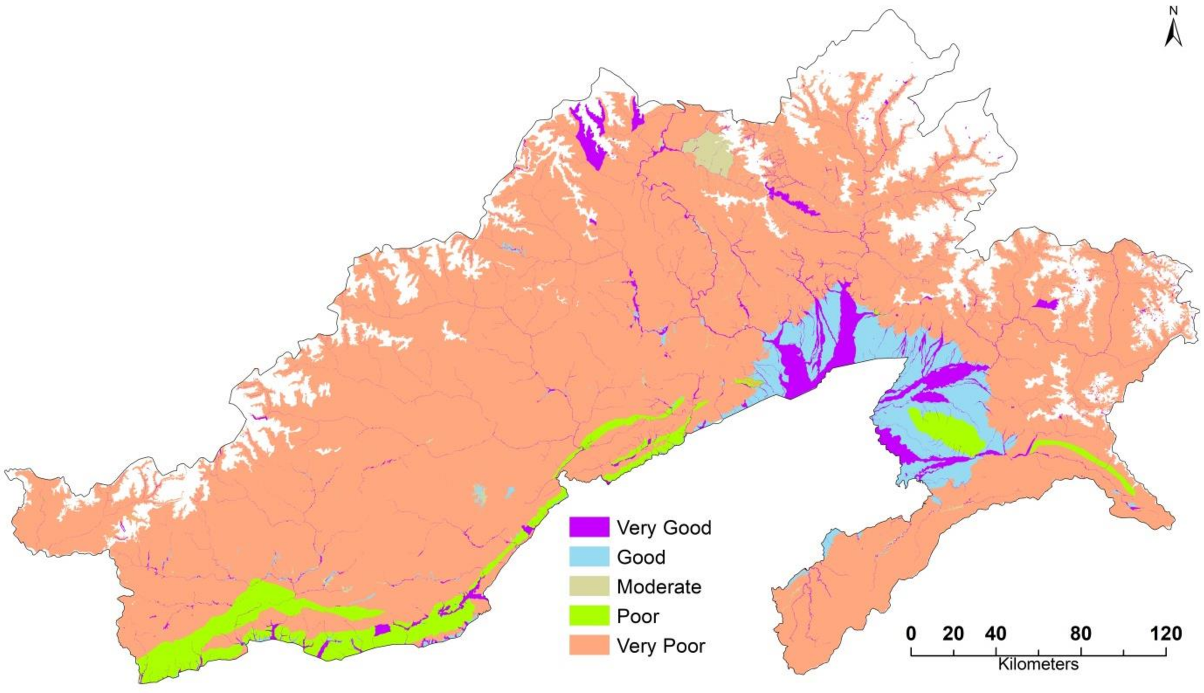

Figure 2-10: Ground Water Potential

2.7 Land use Pattern

The land use in Arunachal Pradesh is largely influenced by customary laws and tradition, wherein a clan or an extended family owns vast territories which includes forest areas, hills and slopes etc. The community extends user rights to the entire community, however, ownership rights are vested and tightly controlled. The land use and land cover of Arunachal Pradesh include forest areas, areas under agriculture and human settlements, snow-covered areas, lakes and water bodies, large sand bodies along the wide river channels, mountain slopes under shifting/jhum cultivation, and areas affected by old and active landslides.

A change assessment of different land use classes has been made from the year 2005 to the year 2012. There has been an increase of more than 50% in settled cultivation which accounts for total 2.71% increase at the state level. A decrease of 86.4% in Current shifting cultivation shows controlled practices of agriculture. Abandoned shifting cultivation also reflects more than 4.5 times decrease due to land reclamations. This indicates that the future water demand in the agriculture sector has increased. The dense forest shows a decrease of 8% of the total geographical area and has been converted into open forest, which seems to be a major challenge in terms of water resources for the state. The degraded and scrub forest has also decreased by 100%. There is a slight decrease in glacier and snow cover that may influence the water resources of the state.

Table 2-9: Land Use / Land Cover

Code	Land use / land cover	2005		2012		Change		
		Area (Km^2)	Area (in %)	Area (Km^2)	Area (in %)	Change (Km^2)	Class level (in %)	State level (in %)
1	Settled cultivation	1783.93	2.13	3732.17	4.46	1948.24	52.20	2.33
2	Current shifting cultivation	919.54	1.10	493.32	0.59	-426.22	-86.40	-0.51
3	Abandoned Shifting cultivation	1078.87	1.29	234.99	0.28	-843.88	-359.11	-1.01
4	Plantation/Orchards	49.71	0.06	77.40	0.09	27.69	35.78	0.03
5	Evergreen /Semi evergreen forest (Dense)	44529.16	53.17	39367.51	47.01	-5161.65	-13.11	-6.16
6	Evergreen /Semi evergreen forest (Open)	12771.88	15.25	18236.81	21.78	5464.93	29.97	6.53
7	Alpine grass	4473.90	5.34	5076.29	6.06	602.40	11.87	0.72
8	Degraded/Scrub forest	2870.81	3.43	2253.42	2.69	-617.39	-27.40	-0.74
9	Forest Plantation	41.59	0.05	51.29	0.06	9.71	18.93	0.01
10	Grass land/Grazing land	645.54	0.77	817.26	0.98	171.73	21.01	0.21

Code	Land use / land cover	2005 Area (Km^2)	2005 Area (in %)	2012 Area (Km^2)	2012 Area (in %)	Change (Km^2)	Change Class level (in %)	Change State level (in %)
11	Land with scrub	1263.05	1.51	1319.60	1.58	56.55	4.29	0.07
12	Land without scrub	1238.77	1.48	898.25	1.07	-340.53	-37.91	-0.41
13	Land slide/Open grass	743.57	0.89	558.23	0.67	-185.34	-33.20	-0.22
14	Barren rocky/Stony waste/Sheet rock area	236.03	0.28	195.06	0.23	-40.97	-21.01	-0.05
15	Town	58.05	0.07	98.56	0.12	40.51	41.10	0.05
16	Village	251.29	0.30	441.50	0.53	190.21	43.08	0.23
17	Lake/Reservoir/tank	44.14	0.05	35.94	0.04	-8.20	-22.82	-0.01
18	River/Stream/Canal (Wet)	1134.22	1.35	1054.33	1.26	-79.89	-7.58	-0.10
19	River sand (Dry)	703.62	0.84	740.01	0.88	36.39	4.92	0.04
20	Snow covered/Glacial area	8905.33	10.63	8061.05	9.63	-844.28	-10.47	-1.01
	Total	83743.0	100	83743.0	100			

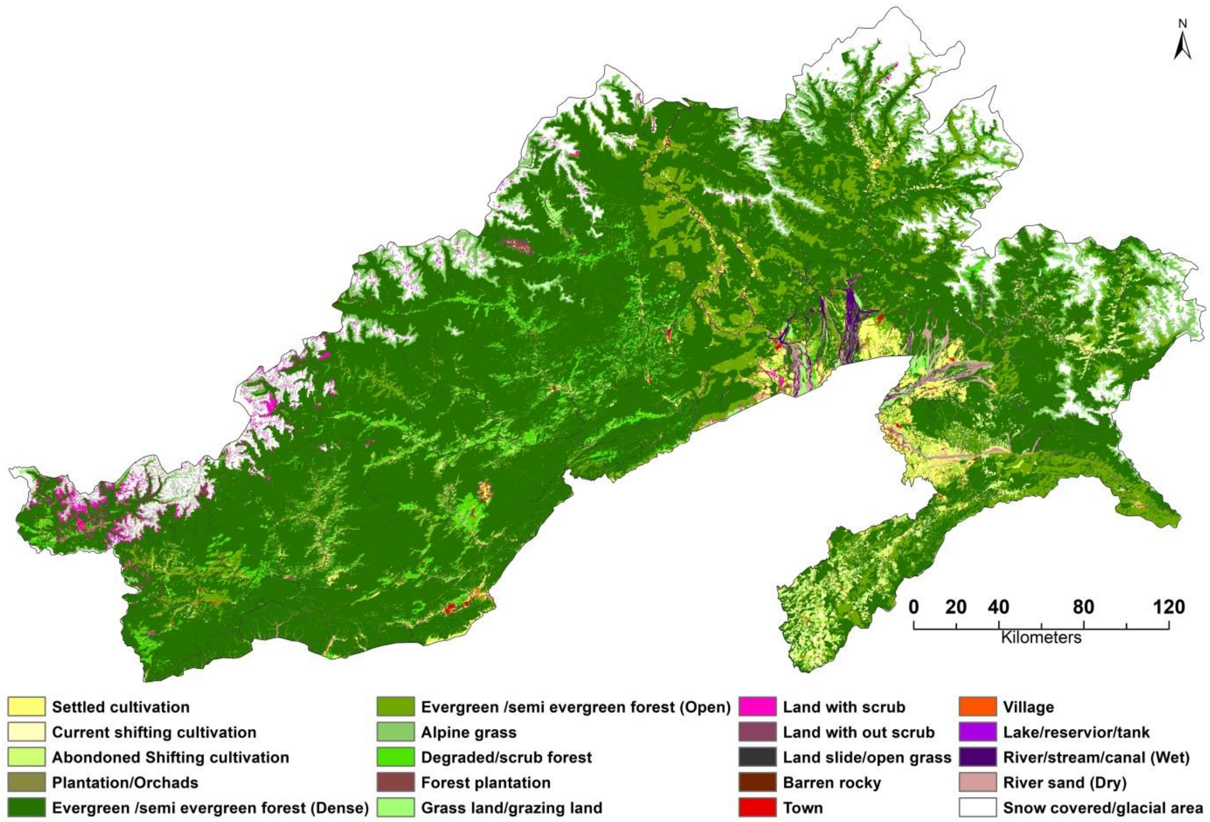

Figure 2-11: Land Use / Land Cover (2005)

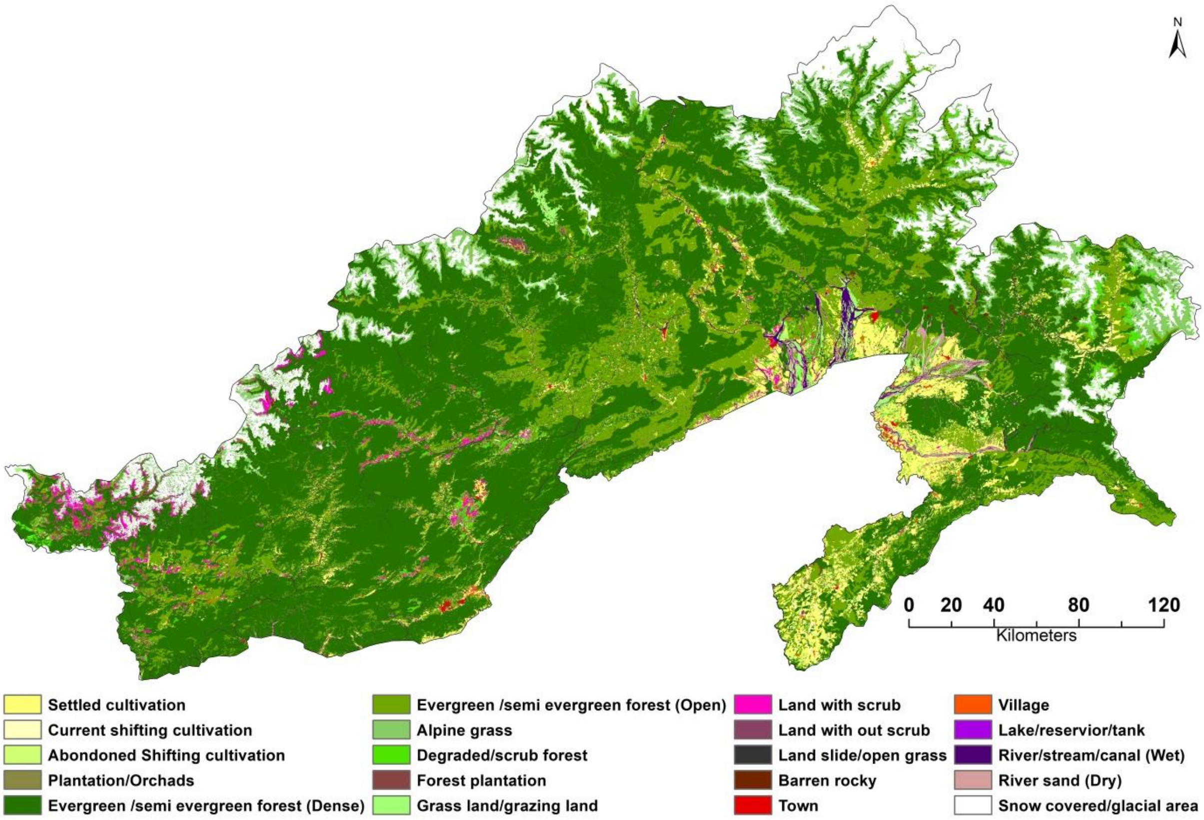

Figure 2-12: Land Use / Land Cover (2005)

3 Water Challenges and Opportunities

3.1 Physical challenges

Physical challenges can be caused by rough topography or other existing physical barriers to manage and exploit the water resources. Following listed are the major physical water resources challenges in the state:

3.1.1 Flood inundation and soil erosion

Flood-related problems mostly occur in foothill sub-montane reach and floodplains. Population concentration of the State is also on these reaches. In the theoretical perspective, there are no flood inundation problems in hilly and foothill sub-montane reaches. Nevertheless, the problem persists in these reaches not because of flood inundation but because of erosion that is equally as destructive as floods. Because of a steep slope in mountainous areas combined with human interference in the catchments area, large-scale soil erosion and bank erosion occur in agricultural field and dwelling areas. Massive bank erosion takes place in every monsoon destroying crops, livestock, infrastructure (irrigation, roads and bridges, other public assets) and flood problem of Assam could be attributed to soil erosion within Arunachal Pradesh.

3.1.2 Siltation

Foothill areas of Arunachal Pradesh are mostly the floodplains of major rivers originating from mountainous regions. The hilly rivers flowing down with high energy dissipates its energy in the foothill region. After dissipation of its energy, the heavy silt carried by the rivers are deposited on its bed causing braiding and spreading overland. This is a common problem at Seijosa in East Kameng, Likhabali in West Siang, Pasighat in East Siang, Roing in Lower Dibang Valley, Tezu & Namsai in Lohit District, Diyun in Changlang District etc.

The heavy silt-laden rivers coming down from steep slopes dissipate its energy at the floodplains (mostly foothill area of the State) and deposit silt on its beds due to which river water and excess silt spread overland causing braiding of rivers and submergence of agricultural land, towns and other public assets. In fact, this has interstate ramification and govt. of Assam with the govt. of India should also focus its attention on the catchment treatment mostly within Arunachal Pradesh.

3.1.3 Land slide

Landslide is a common phenomenon in Arunachal Pradesh. Every year reports have been received from the districts regarding road blockages, mudslides in dwelling area, damages to irrigation structures and other public assets

Due to high seismicity and geological fragility of Himalayan geology and high annual rainfall, the state is highly vulnerable to water-related disasters.

3.2 Technical challenges

Technical challenges refer to development and infrastructure related gaps. The excessive flow of the Brahmaputra and Barak rivers and their tributaries during the annual monsoon causes floods, erosion, and drainage problems that continue to afflict the Northeast. In addition, the adverse physiography of the region, excessive sedimentation, frequent earthquakes, landslides, deforestation and watershed degradation, and encroachment of the riverine areas; all pose unusual challenges to the development of water infrastructure in the region. The problems of the Barak valley, with its high elevation, large areas subject to inundation and drainage congestion, and the prolonged high-water regime, are particularly complex.

3.2.1 Surface water resources operational challenges

- The undulating topography does not offer much scope for taking up major and medium irrigation projects. The irrigable command areas are limited to small patches of about 10 to 15 hectares in the river valleys and plateaus, because they do not meet the eligibility criteria under the AIBP programme, GoI.
- High rainfall and landslide related damages on the completed irrigation projects render the completed projects defunct. Due to this problem many completed projects, are not yielding benefits as additional maintenance works are required to make these projects operational.
- WRD has been facing financial constraints for implementation of schemes. State government finds it difficult to contribute even its minor share of 10% which in effect truncates the central government’s share. The release of funds at the far end of the year further constrains the department to implement schemes.
- Existing schemes being taken up under irrigation sector are essentially micro in nature and they are not enough to cater the actual demand. They only assist in diverting water from seasonal streams/rivers to the fields. To address the demand for need-

based and perennial irrigation, medium size irrigation projects must be taken up in all the predominant food grain producing areas of the State. This will entail heavy investment for which special assistance is required.

- At present, a proper database management system which facilitates decision making is lacking in the department. This, therefore, leads to inefficiencies in project planning and execution.
- Average per capita supply of water in the cities is 119 lpcd, higher than the desired supply of 150 lpcd.

3.2.2 Groundwater challenges

- The overall development of groundwater in the state is 0.04% of the total available resource which is quite low. Sustainable groundwater development requires scientific management in the fields of resource allocation, estimation, development, conservation and protection.
- It is understood that from the field observations, that the barriers in groundwater development are difficult terrain condition, impenetrable forest, lack of adequate surface communication, energy shortage, land holding size (local factors), and poor coordination between various agencies.
- Coordination of activities is hindered by several factors, including lack of communication between different departments; institutional instability; weak interstate coordination; lack of priority given to water conservation issues; and absence of demonstrated successful endeavours.
- There is no regional consensus about how to confront various water sector issues in a systematic and balanced manner. Stakeholders have diverse proposals and views, some of them are contradictory. Convergence of views requires transparent and mutual dialogue amongst the stakeholders leading to the collective construction of a future scenario for the development of the water sector in the region and the guidelines to achieve it.

Thus, there is scope in the North-eastern region to promote an extensive regional dialogue and participatory strategic planning process to produce a common agenda for water resource development within an overall strategy for sustainable development.

3.2.3 Infrastructure related challenges

Creation and maintenance of necessary developmental infrastructure would necessitate strong policy interventions backed by operational plans, importantly, including efficient management and sustainable utilization of State's water resources. Expansion of irrigation accessibility for increased agriculture acreage and productivity, State's remoteness and lack of communication (road) infrastructure will be the biggest barrier for such large-scale development. There exists immense scope to boost agriculture production by increasing area under irrigation coverage.

- Though the state has abundant rainfall and perennial rivers, it also faces constraints particularly in terms of high cost of construction and maintenance of irrigation infrastructure. This is especially from the point of view of difficult hilly terrain, inaccessible villages, difficulty in movement of rigs and other equipments.
- Importantly recurring flash floods that destroy irrigation infrastructure. However, the terrain offers considerable scope for development of gravity water supply schemes, adoption of rainwater harvesting and other traditional water harvesting methods in this region.
- Lack of infrastructure and modules for data collection related to climatic and hydrological variables is another major concern for the State.
- State has the lowest road development index in the country with a road density of 25.16 km per 100 sq. km (national average is 73 km per 100 sq km). The National highways account for about 1992 km, and major district roads are about 12169 km.

3.2.4 Energy

The state has not established State Electricity Regulatory Commission (SERC) who would frame Power Policy wherein mandatory purchase of power from renewable energy could be made. Due to lack of such a regulatory body, there is no proper policy to diffuse the use of renewable energy in the state.

The current demand for power is 170 MW as against the generation/supply capacity of 115 MW. The transmission losses are also high said to be around 50%. The state lacks grid of its own and there are high voltage/extra high voltage transmission lines.

3.2.5 Silt and WQ collection network status

According to an investigation carried out by the Central Ground Water Board (CGWB) and

Central Water Commission (CWC) Arunachal Pradesh has zero number of sewage treatment plants since the major rivers of the State are free from pollution and the groundwater is of excellent quality with all the parameters within permissible limits (CPCB, 2015).

3.2.6 Frequency of measurement

- The G&D sites measure parameters at hourly, 8 hourly daily bases.
- A quantitative estimate of domestic sewage/ industrial effluents and treatment. This data is not yet available.
- The second level workshop should emphasize on obtaining data from different industries and their effluents. Similarly, sewage treatment plant capacity data must be obtained.

3.3 Financial challenges

- While traditionally, investments in the sector have been financed by the governments, as in other core infrastructure sectors, the state can no longer finance all such development activities on its own. The lack of capital expenditure in this sector has resulted in low coverage and poor quality of service.
- National and international experience suggests that to ensure continued financial sustainability and quality of supply and service to farmers, adequate cost recovery from delivery of service is necessary. In case, the cost of providing service is not passed on to the consumers of water (in this case farmers), the burden on the department and subsequently on the governments continues to increase and such a situation is not sustainable in the long run.
- Non-recovery or under-recovery of costs translate into lower investments leading to higher losses and deteriorating service over a period. This also impedes the development of the private capital market, the other alternative of raising funds in the sector. Further, provision of free water in the form of an input subsidy for agriculture makes it difficult to track efficiency across sectors and leaves little incentive for efficiency inducement.
- This form of a subsidy may also encourage overuse of the resource - this degrades the environment and promotes the inefficient on-farm use of water. This may also lead to long-term effects in the agriculture sector. Finally, the central government need to provide additional financial support for infrastructure creation in the water sector.

3.4 Climate change

Himalayan mountain system stretching from north-eastern Afghanistan through Kashmir to Nepal, Darjeeling-Sikkim-Bhutan Himalaya to Assam Himalaya and at the eastern margin Mizo hills of part of Eastern Himalaya.

- Himalayas are known as the water towers of Asia and provides water to three major basins of Indus, Ganga and Brahmaputra rivers. These rivers are lifestyle and culture of the basins and economic and cultural value is based on the Himalayan mountain system.
- ICIMOD stated that the Himalayas is one of the ecologically fragile ecosystems, economically underdeveloped and densely populated mountain ecosystems.
- According to a 4 × 4 assessment of MOEF, the projected climate change parameters in the 2030s with respect to 1970s there will be a rise in temperature and precipitation. Under 4 X 4 assessment, Himalaya is one of the regions and water is one of the sectors.
- The capacity of the Himalayan ecosystem to adapt to climate change is inadequate, therefore; it is unable to cope with, adverse effects of climate change and is susceptible to the impacts and consequences of climate change *(IPCC, 2012).*
- IPCC, 2012 report express that flood and drought will be increased by 2030.
- It was also stated that the intensity and numbers of rainy days will be erratic. This affects the agriculture and domestic water demand of the local communities and alters the livelihood of the society.
- With large variations in rainfall amounts, the risk of occurrence of extreme rainfall events (droughts and floods) tends to increase and hence, on a whole the climate change affects the soil moisture, groundwater recharge, groundwater levels and flood/drought frequency (Mall et al., 2006).
- Climate change has the potential to impact societies through changing the regional water availability in turn affecting the irrigated agriculture, energy use to flood control, municipal and industrial water supply, environmental flows and much more.
- Therefore, an increasing number of researchers are attempting to assess the future impact of climate change in specific regions or certain river basins.

The challenges being faced by water resource managers for any given location are a unique combination of mainly physical, cultural, engineering financial factors. The key characteristic of the freshwater resources is their uneven distribution and variability with respect to time and space basically, challenges to be met out by the water managers are of three types: shortage, surplus, and quality. Effective mitigation measures are needed to cope up with climate change along with an adaptive strategy (IPCC, 2012).

- Innovations in institutional arrangements and management structures are a necessary precondition for tackling the problems of management of the supply of good quality and adequate quantity of water for its citizens.
- Waste and inadequate management of water are the main culprits behind growing problems, particularly in poverty-ridden regions.
- Agriculture is the predominant consumer of water. For the past few decades, efforts have been made to increase irrigation in the country; this has resulted in overexploitation of our water resources.
- The use of poor quality and quantity of water for irrigation especially in water-stressed zones not only increases the risk to public health but also have a visible impact on per capita water availability in rural and urban areas.
- Over extraction and inadequate recharge is quite a common problem.

Socio-economic conditions, governance and gender drivers are determining factors leading to vulnerability. Many mountain dependent communities of Eastern and Western Himalayas are highly vulnerable to water risks due to development pressures, population increase, and further uncertainties associated with climate change. Bio-physical conditions, isolation and socio-economic marginalization pose constraints to the adaptive capacities of the communities and limit their ability to plan.

At the same time, people do adapt to changes in social-ecological conditions with varying capacities with several factors interacting across individual, household, community and higher jurisdictional levels. Of course, poor people have tended to suffer the greatest health burden from inadequate and poor-quality water supplies and resultant poor health (WHO,2015) have been unable to escape from the cycle of poverty and waterborne diseases.

The climate of the state is influenced greatly by the Himalayan mountains and large variations in altitude across the state. The critical issues that are spread across the sectors and domains include: climate change vulnerability assessment studies across sectors, strengthening of database and infrastructure for climate-related data collection and analysis, Capacity building and training, IPR and traditional knowledge protection, documenting traditional practices, local knowledge and folk traditions, gender-sensitive adaptation options like effective strategies for ensuring water supply and quality and reducing the burden on women caused by water collection, gender-specific use of health facilities, women's access to new technologies, extension services and credit facilities etc.

Priority areas for research should include: documenting biodiversity status, traditional and folk knowledge, long-term monitoring for understanding state specific climate change aspects, research in the identification of alternative means of livelihood and low and alternative energy options, preparing communication strategies. About 59 % of GHG emissions come from the energy category. Agriculture sector contributes 75 % of CH_4 and 39 % of NO_2 emission in the state.

3.4.1 Impact on Water resources

Flood is a recurring phenomenon in the State due to high precipitation. The magnitude of floods and river bank erosion problems are increasing every year in the State. Analysis for entire Brahmaputra basin reveals an increase in the annual precipitation of 2.3 % for the middle of the century (2030s) as compared to baseline. However, for the Brahmaputra basin lying within Arunachal Pradesh, analysis projects a decrease in annual precipitation of about 5% to 15% by mid-century. The change in water availability show spatial variation from marginal reduction (5%) to no change across the state towards 2030s. The green water flow (evapotranspiration) shows increase but the magnitude is marginal under mid-century as compared to baseline. The situation of green water storage (soil water) shows no change from the baseline under mid-century scenario. These projections are derived from SWAT distributed hydrologic modelling.

3.4.2 Impact on Forest

Under the impact of climate change on forest it was shown that significant proportion of the forests in Arunachal Pradesh is vulnerable to climate change risks. There are no scientific studies to recommend specific vulnerability reduction measures suitable for different vulnerable forest types and regions.

The forests in Arunachal Pradesh are subjected to human interventions in many districts leading to loss of biodiversity, even though it is lower compared to the other states of North-east India. There is a need for conducting preliminary studies to identify locations for implementing the vulnerability reduction measures. The exact area for implementing the vulnerability reduction interventions is not readily available but a preliminary estimate of the investment required is provided.

Apart from projected vulnerability due to climate change, the forests in Arunachal Pradesh also face several threats and biotic pressures in the form of shifting cultivation, grazing, forest fires, encroachment, commercial plantations, human-wildlife conflicts and illegal extraction of forest products along interstate borders with Assam and Nagaland.

Forest sector provides a large opportunity for mitigation of climate change, through reducing CO_2 emissions by reducing deforestation and forest degradation as well as increasing carbon sinks in the existing forests and creating new sinks in degraded lands through afforestation. Carbon sequestration of forests of Arunachal Pradesh is very significant in India.

3.4.3 Impact on Agriculture and Horticulture

Heavy precipitation leads to waterlogging, salinity and oxygen depletion in agricultural land. Acute shortage of fodder for livestock and damage grazing lands during a flood or due to a landslide; Prolonged flooding damage crop yields and increased runoff that affect the watershed management. Jhum and shifting cultivation areas are becoming more vulnerable during such situation and lead increase runoff, flood and landslide. Jhum is a local and traditional practice and cannot be banned due to the individual periodical occurrence or community rights of ownership over the forest land and non-availability of other livelihood options. This promotes removal of the vegetation coverage for Jhum cycle. Rehabilitation of shifting cultivation areas and improvements in current practice need major thrust in this region.

There lacks a constant monitoring of climate change signals/climate variability and creating meteorological database/forecasting for decision support system. There is no exclusive R&D on shifting cultivation in the state, its impact on climate change, documentation on the loss of flora and fauna etc.

3.4.4 Disaster

The State of Arunachal Pradesh is prone to a variety of natural disasters such as cloudbursts, landslides, flash floods and forest fires. The state is prone to earthquakes and is in the seismic zone V. The changing climatic conditions may hamper lives and property, cause disruption of economic activity and damage to the environment and degrade the continuity and sustainability of development of the State.

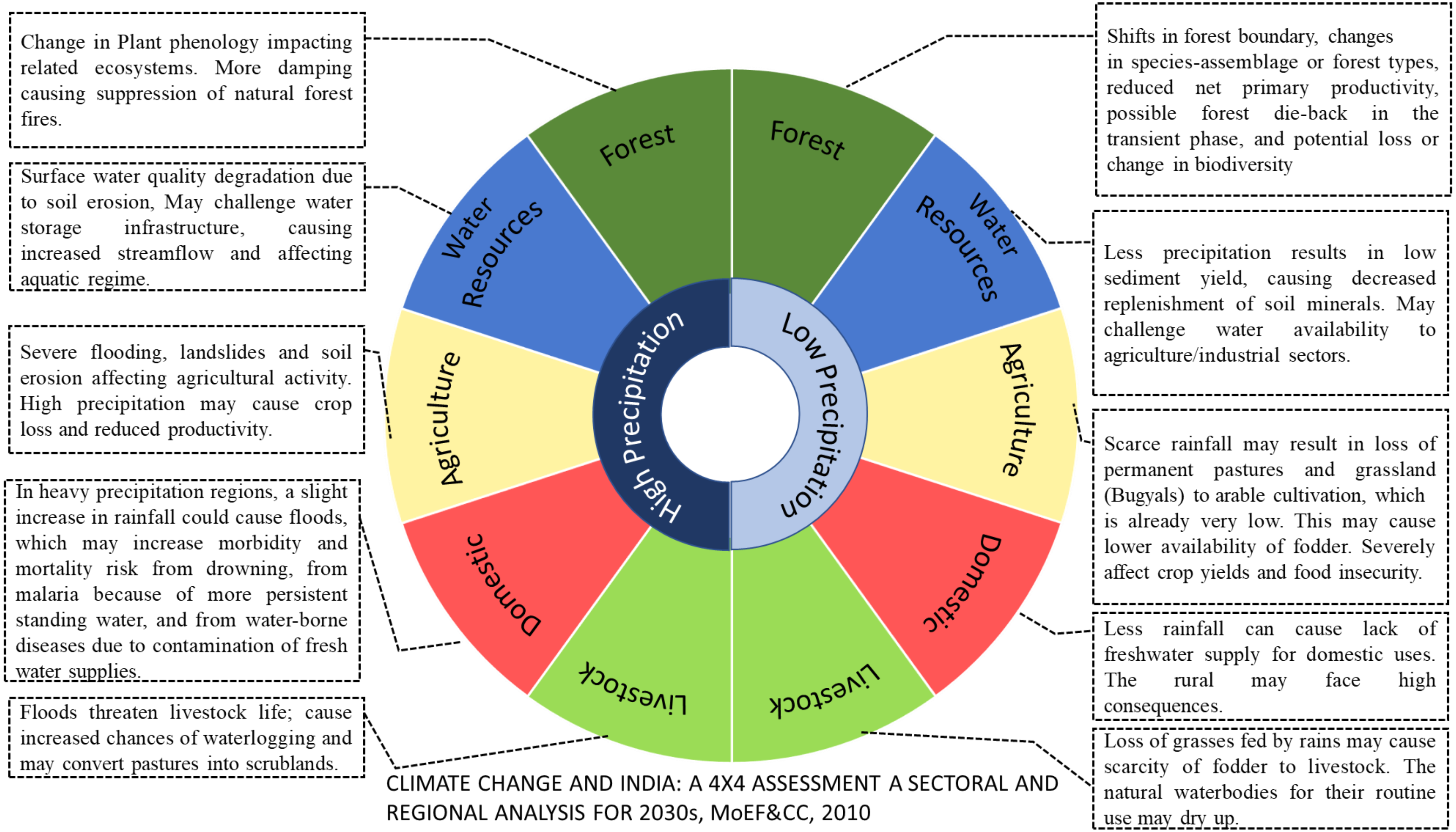

Figure 3-1: Impact of Climate Change reported by MoEF & CC

3.5 Water opportunities

3.5.1 Irrigation created and utilised

The importance of irrigation in the growth of agricultural production hardly needs any emphasis. All around the world irrigation projects have benefited agriculture in numerous ways. Irrigation directly benefits by assuring food security through increased production. Indirect benefits include improvement in the socio-economic welfare of local people and controlling deforestation (caused by expansion of NSA) by increasing output-land ratio. At a policy-making level, the expansion of irrigation infrastructure can play a very important role towards the goal of achieving higher agricultural productivity and thus, food security. In brief, irrigation can contribute to the development of the state in the following ways:

- **Boosting agriculture productivity and ensuring food security**: Empirical studies and field survey show that irrigation has a potential to increases crop yields (2-3 times) owing to the increase in availability and reliability with respect to water supply, thereby, directly addressing the issue of food deficit.
- **Increasing cropping intensity and crop diversification:** Irrigation facilitates availability and better control of water in deficient periods thereby facilitating double cropping. Moreover, irrigation facilitates the use of High Yield Variety (HYV) seeds as these seeds need assured irrigation and more water than normal seeds. Studies also show irrigation also enables crop diversification towards horticulture and commercial crops by reducing the risk in production with respect to water availability.
- **Employment and Rural Livelihood:** Irrigation leads to improvement in the welfare and facilitates employment opportunities at the farm level. By providing stability in production, irrigation also ensures a steady stream of income to the farmers.
- **Deforestation due to Jhum:** The high productivity of agriculture induced by irrigation can reduce the pressure on land and thereby reduce deforestation caused due to the expansion of agriculture land. Moreover, high productivity on irrigated land can induce Jhum cultivators to adopt permanent cultivation, hence, slowing the pace of deforestation due to Jhum.
- **Groundwater Irrigation potential:** The CGWB had assessed an irrigational potential about 18,000 hectares through groundwater in the State. An area of more than 87,500 hectares has been irrigated in Arunachal Pradesh.
- **Surface water irrigation potential:** Minor Irrigation Census of the State reveals that

about 0.12 million-hectare (about 66.67% of available potential) area is irrigated. Fresh Potential Assessment is being done under GIS environment and ultimate potential is expected to increase to around 0.85 million hectares.

3.5.2 Groundwater opportunities

Strategies for sustainable development of groundwater in the state:

- Co-operative ownership and incentives for management of resource
- Zonation of the state to implement the strategies. The basis of zonation should be similar hydrogeological and hydro-meteorological features.
- The uninterrupted power supply is required to harness the potential created in an optimal manner. Alternate energy sources should be explored.
- Groundwater development schemes should be aligned with the canal irrigation schemes.
- In hilly areas where surface runoff is high, the rainwater should be harvested to provide continuous drinking water at low cost.
- Political will, better infrastructure, trained manpower and incentive to the private investors.

3.5.3 Water Resource Management

Agriculture is the primary driver of the Arunachal's economy with around 70% of the state's population being dependent on agriculture and allied activities. According to Agriculture Census 2000-01, the total Net Sown Area (NSA) was reported as 2, 00,210 hectares, out of which, nearly 42% was under shifting cultivation (Jhum).

Out of the total net sown area, cereals (rice, wheat, maize and millets) hold a predominant share. State agriculture is subsistence in nature and modernization of farm practices has mostly eluded the state as is evident by poor yield rates, low consumption of fertilizers and wide scale practised mono cropping. (***Moreover, key infrastructure facilities like irrigation, the supply of input, marketing, institutional credit and extension services are inadequate)***

The irrigation potential created is brought underutilization through Command Area Development Programme. Under this programme, construction of on-farm-development (OFD) components like field channel, field drain, reclamation of water-logged areas within the command and correction of system deficiency are taken care of as on farm activities of the programme.

It also covers regulatory water distribution activity called *WARABANDI*, the formation of registered water user association (WUA), training to the officers and farmers as soft activities of the programme. The programme aims at establishing a close partnership between the farmers (water users) and the implementing Govt. Department with the ultimate objective of transferring the responsibility of irrigation management system to the farmers.

Out of 1.20 lakh, hectare net irrigation potential created, about 0.48 lakh hectare only has been brought under the utilization. The utilized area works out to be 40% only leaving 60% potential created unutilized. With the help of Govt. of India, CSS Command Area Development programmes are under implementation in a phased manner to narrow down the existing gap of 60%. The agriculture in the state is predominantly dependent on rains with less than 23% (44,478 hectares) of the net sown was under irrigation as per the Minor Irrigation Census 2000-2001.

Table 3-1 Net Sown Area (NSA) and Net Irrigated Area (NIA) (in ha)

Sl	District	NSA	NIA
1	Anjaw	8080	555
2	Changlang	27117	3487
3	Dibang Valley	576	0
4	East Kameng	10653	1563
5	East Siang	26555	11904
6	Kurung Kumey	19042	3710
7	Lohit	11083	688
8	Lower Dibang Valley	14015	3529
9	Lower Subansiri	16543	6461
10	Pampum Pare	13053	4783
11	Tawang	4495	366
12	Tirap	13342	228
13	Upper Siang	3277	1562
14	Upper Subansiri	8409	1081
15	West Kameng	4616	106
16	West Siang	19354	4455
	Total	200210	44478

As of now, the total surface water used for irrigation is approximately 4000 MCM in the state. As already explained, the state has very low groundwater potential, it is only surface water which is primarily used for irrigation. The total surface water supplied for irrigation purposes at the district level is a follow:

Table 3-2 Total surface water supplied (in MCM) for irrigation purposes

Sl	District	Surface Irrigation	Groundwater	Total
1	Anjaw	88.69	-	88.69
2	Changlang	205.89	0.26	206.15
3	Dibang Valley	99.45	-	99.45
4	East Kameng	136.97	0.15	137.12
5	East Siang	659.00	0.71	659.71
6	Kurung Kumey	694.00	-	694.00
7	Lohit	303.66	0.05	303.71
8	Lower Dibang Valley	51.70	0.34	52.04
9	Lower Subansiri	308.00	0.05	308.05
10	Papum Pare	373.00	0.58	373.58
11	Tawang	71.41	-	71.41
12	Tirap	236.40	0.03	236.43
13	Upper Siang	187.90	-	187.90
14	Upper Subansiri	170.52	-	170.52
15	West Kameng	96.18	-	96.18
16	West Siang	310.19	-	310.19
	Total	3992.95	2.15	3995.10

Canals: In Arunachal Pradesh, despite heavy annual rainfall the availability of surface water is insufficient in the higher hills and mountain areas. This further deteriorates in the drier spells. Storage facility for excess water is negligible. Canal irrigation is developed in a very limited area. The area under canal irrigation is shown in Table…

Table 3-3 Area under canal irrigation

Sl	District	Area (Ha)
1	Anjaw	
2	Changlang	239
3	Dibang Valley	160
4	East Kameng	372
5	East Siang (Including Upper Siang)	1013
6	Kurung Kumey	-
7	Lohit (Including Ajnaw)	580
8	Lower Dibang Valley	-
9	Lower Subansiri	188
10	Pampum Pare	190
11	Tawang	325
12	Tirap	100
13	Upper Siang	
14	Upper Subansiri	152
15	West Kameng	135
16	West Siang	450
	Total	3904

Table 3-4 Summary of Information collected though state and central document

Heads	Sector	Scenario	Cause	Policy
Supply/ Source side	Ground Water	Poorly developed and unexplored groundwater resources	Rough terrain, financial and infrastructure developments and support	Policy should target investing more on infrastructure development to address water use efficiency issues
		Poor water conservation practices	Lack of knowledge and exposure to available technology for water conservation and better precision irrigation methods.	Central/ state level Skill development schemes convergence with the water sector related policies/schemes.
		Lack of conjunctive use of Ground-Surface water	The sites where ground water can be exploited do not seem to be conducive for community farming, since large tracts of lands are owned by individual farmers, thus most of the ground water schemes have benefited only individual farmers	The basic objective of ground water scheme is not to benefit one farmer. The schemes should be modified to benefit group of farmers who can collectively maintain and manage the system
	Surface Water	Decline in base flow in non-monsoon	Inadequate Water conservation	Water conservation; Artificial Recharge; Afforestation
		Flow of large runoff into sea	Inadequate reservoir storage	Funding towards Medium Irrigation structure
	Tanks & Wetlands	Low storage capacity and defunct due to poor maintenance	Siltation, Erosions and flood damage are major cause	A proper financial and maintenance support should be provided for rejuvenations of tanks and wetlands.
	Springs	Drying	Human factors and Climate change	Separate schemes for springs rejuvenation are required
	Waste Water	Underutilization of Waste water	Poor drainage systems and less established water sewage treatment plants	Promotions in sewage treatment plants establishment and enhancing sewage network in urban local bodies.
	Precipitation	High rainfall causing floods, landslides and erosion	Heavy precipitations during monsoons and steep slopes due to mountainous topography	Plans for investing in robust and periodical measurement of climatic variables and flow in major streams. A detailed policy and schemes should be launched for all major rivers for flood control measures and providing water conservation for dry periods.
	Glaciers	Retreating glaciers and high melting.	Changing climatic conditions.	A detailed research required for data collection/ monitoring of extent and loss of glaciers.
Demand side	Drinking Water	Less-availability of safe Drinking Water	Stress / Scarcity at source	More plans for site identification for planting more water extraction units

Heads	Sector	Scenario	Cause	Policy
	Farm Sector	Large consumer; Poor Water Use Efficiency	Inadequate storage; Seasonal shortages, poor maintenance of irrigation structures due to lack of fund	Additional surface water storage; Revival of traditional water bodies
	Industry and infrastructure	No data related to water consumption or demand in small/ large scale industries	Poor technology; Poor recycling Location in water scarce areas;	High WUE; Water Audits; Recycling
	Establishments and institutions	Lack of monitoring systems of water consumption and demand.	Lack of policies pertaining to water requirements at institutional level.	Policies must target demands/consumptions in different establishments and secure water allocation guideline sin annual budgeting
	Forest and wildlife	Forest degradation, conversion of dense into open forests, loss or migration of species.	Shifting cultivation, Human invasion,	There should be strict protected land policies, also ensuring natural flow in streams crossing these forest lands, to maintain diversity. Also promoting afforestation and plantation
Quality	Ground and Surface Water	Pollution / Contamination:	Geo-genic & anthropogenic; Inadequacy- measurement & regulation	No STP as of now in state. Should be invested more in water treatment plants, and more water quality measurement stations for enforcing strict rules on contaminating points. Also, water infrastructure should be developed to a standard, for combating any leakages, and maintenance checks.
	Drinking Water	Deteriorating Water Quality- Physical, Chemical and Biological Contamination: Sewage	Geo-genic & anthropogenic contamination; Poor regulation Poor Water supply infrastructure and maintenance; Inadequate and ineffective treatment facility	
	Farm Sector	Deteriorating Water Quality; Salinity	Irrational application of Fertilizers, Pesticides; poor farm management practices	Use in Agriculture/ Industry Infrastructure for robust drainage systems for avoiding any water quality deterioration during flow. High quality crop varieties and fertilizers are to be invested in. More research should be promoted to increase water use efficiency and crop productivity.
	Industry	Contamination of Industrial effluents SW and GW	Poor monitoring, regulation and enforcement	There should be policies to categorize and conduct recycling of possible industrial effluents or leftovers. Also, dumping of different type of effluents

Heads	Sector	Scenario	Cause	Policy
				should be regularized, their outlets to be marked and properly managed. The norms and regulations should be enforced.
Climate Change	Source	Glaciers, Springs-Melting/ Drying.	Climate Change and GHG emission	Research & Inventory
		Low Precipitation	Low precipitation causes soil moisture depletions and may also cause low crop production. Less rain alter forests covers and grazing lands converting into scrub lands Inadequate precipitation causes droughts and Alter environmental flow and lead to drying of water bodies also lead poor water quality.	Soil and moisture conservation techniques; Conjunctive use of surface and groundwater and Integrated Watershed Planning for agriculture productivity. Forest restoration and agro-forestry for ecological. Drought proofing techniques-Rainwater harvesting, Percolation ponds, Farm ponds and de silting of tanks can help in combating drought situations.
		High Precipitation	Causes silt load, flood and land slide that directly defunct the water resource infrastructure.	A detailed policy and schemes should be launched for all major rivers for flood control measures and de-siltation.
Institutional	Water Governance	No control on consumption exceeding availability	State Subject; GOI: only advisory role; No Single Agency for coordination	State Water Budgeting; Rigorous awareness campaign led by centre with full active support from State
	Ground Water	There is lack of Ground water monitoring stations in valleys, while only few lies in lower plains of the state.	The infrastructure development in groundwater sector is very poor and terrain condition poses a challenge in new developments.	More monitoring stations should be established, and regular measurements and analysis of the observations should be made. This may also require different funding for infrastructure development.
	Measurement/ Assessment	Poor monitoring of resource availability (supply) and consumption (demand)	Measurement is almost nil Except Reservoir, Rivers & Ground Water resources	Measurement meters required for observing domestic and industrial requirement /consumptions.
	Infrastructure	Dams and CAD - are old; Inefficient and Inadequate reservoir storage capacity	Poor maintenance; Poor management etc.	Need for effective organizational structures and allocate fund for maintenance of old structures.
	Benefits/ Services	Wide gap in IPC & IPU (112.53-89.26 MHa)	Leakages and Seepage; Method (Flood) of irrigation; Poor Management system / Scheduling and Low	Incentivization

Heads	Sector	Scenario	Cause	Policy
-------------		Sub-optimal Water Use Efficiency- more Wastage	Investment Inefficient (unlined/ unpiped) water distribution system	More investment towards technological advancements is required, this also includes funds for progressive and supportive research and development for WUE or similar studies.
	Regulation	Water Regulatory Authority- Inter-coordination between various water users	No measurement; unaccounted use of water in different sectors	Detailed documentation is required to account water resources inter and intra-sectors.
Technology	Farm Sector	Precision irrigation area is very less	Mostly flood irrigation.	More investment towards technological advancements is required, this also includes funds for progressive and supportive research and development for WUE or similar studies.
		Cropping pattern does not coincide with available water resources	Lack of knowledge and price-based agriculture practices	A detailed framework is required for water energy and food nexus
		High Chemicals usage	Lack of knowledge and price-based agriculture practices	Organic farming must be promoted
	Industry	Less WUE /Water saving Lack of WWTP	No Water Audits, less awareness about reusing waste water	Establishing more WWTPs, Proper water auditing, and reusing water for efficient consumption and saving.
	Drinking Water	Leakages; Less WUE /Water productivity	Water saving technology / containing leaks	investments
Economics	Value for resource	Not valued; No water tariffing Wastage,	Lack of Infrastructure to monitor and control wastages	Awareness programs for efficient and judicious use of water
Financing	Investments	Inadequate investments	Fund allocated by the central govt is uniform for the nation.	keeping the terrain conditions and infrastructure cost in north-eastern region, it requires special funding for completing the projects on time.
Transparency	Data Resources Funds	No data transparency in Supply, Demand and Quality	Poor measurement systems; No data transparency in Supply, Demand and Quality	A water budget portal is mandatory for auditing the demand supply and consumptions of each sector.
Democracy	Public involvement	In Arunachal even in the PIM schemes, many rules concerning the distribution of water are established and followed in customary practices based on their own agreed	Customary norms of water allocation are respected by the community. Hence in the current context water distribution does not assume significant importance to assess the impact of PIM	It was observed that although farmers wanted to claim ownership, they did not want to take up responsibility of the irrigation systems. This need strengthening of PIM norms and educating them about O&M of the water infrastructure. Government generally lacks the fund for

Heads	Sector	Scenario	Cause	Policy
		allocation rules rather than the written water distribution schedule		continuous wear and tear of the structures.

Table 3-5 Climate and Infrastructure based research grant and financial support from State and central

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
Supply/ Source side	Ground Water	Poorly developed and unexplored groundwater resources	Rough terrain, financial and infrastructure developments and support	Policy should target investing more on infrastructure development to address water use efficiency issues	Infrastructure developments led project support
		Poor water conservation practices	Lack of knowledge and exposure to available technology for water conservation and better precision irrigation methods.	Central/ state level Skill development schemes convergence with the water sector related policies/schemes.	Skill Development Programme on available technology for water conservation and better precision irrigation methods.
		Lack of conjunctive use of Ground-Surface water	The sites where ground water can be exploited do not seem to be conducive for community farming, since large tracts of lands are owned by individual farmers, thus most of the ground water schemes have benefited only individual farmers	The basic objective of ground water scheme is not to benefit one farmer. The schemes should be modified to benefit group of farmers who can collectively maintain and manage the system	Grant on conjunctive use of Ground and surface water where ground water can be exploited do not seem to be conducive for community farming
	Surface Water	Decline in base flow in non-monsoon	Inadequate Water conservation	Water conservation; Artificial Recharge; Afforestation	Fund to support Water conservation
		Flow of large runoff into sea	Inadequate reservoir storage	Funding towards Medium Irrigation structure	Fund for Medium and Large irrigation projects

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
					for reservoir storage
--------	Tanks & Wetlands	Low storage capacity and defunct due to poor maintenance	Siltation, Erosions and flood damage are major cause	A proper financial and maintenance support should be provided for rejuvenations of tanks and wetlands.	Fund allocation for rejuvenations of tanks and wetlands
	Springs	Drying	Human factors and Climate change	Separate schemes for springs rejuvenation are required	Separate research grant on springs rejuvenation
	Waste Water	Underutilization of Waste water	Poor drainage systems and less established water sewage treatment plants	Promotions in sewage treatment plants establishment and enhancing sewage network in urban local bodies.	Infrastructure support grant on Sewage network for Urban local bodies
	Precipitation	High rainfall causing floods, landslides and erosion	Heavy precipitations during monsoons and steep slopes due to mountainous topography	Plans for investing in robust and periodical measurement of climatic variables and flow in major streams. A detailed policy and schemes should be launched for all major rivers for flood control measures and providing water conservation for dry periods.	Infrastructure grant for AWS and River gauge stations in all major watersheds
	Glaciers	Retreating glaciers and high melting.	Changing climatic conditions.	A detailed research required for data collection/ monitoring of extent and loss of glaciers.	Research Grant on Snow melt and runoff modelling
Demand side	Drinking Water	Less-availability of safe Drinking Water	Stress / Scarcity at source	More plans for site identification for planting more water extraction units	Case base study Grant – Pilot projects
	Farm Sector	Large consumer; Poor Water Use Efficiency	Inadequate storage; Seasonal shortages, poor maintenance of irrigation structures due to lack of fund	Additional surface water storage; Revival of traditional water bodies	Grant for maintenance of irrigation structures
	Industry and infrastructure	No data related to water consumption or	Poor technology; Poor recycling	High WUE; Water Audits; Recycling	Establishment for Water Auditing framework

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
		demand in small/ large scale industries	Location in water scarce areas;		
---------	Establishments and institutions	Lack of monitoring systems of water consumption and demand.	Lack of policies pertaining to water requirements at institutional level.	Policies must target demands/consumptions in different establishments and secure water allocation guideline sin annual budgeting	Infrastructure grant for metering the consumption of water
	Forest and wildlife	Forest degradation, conversion of dense into open forests, loss or migration of species.	Shifting cultivation, Human invasion,	There should be strict protected land policies, also ensuring natural flow in streams crossing these forest lands, to maintain diversity. Also promoting afforestation and plantation	Grant for Skill Development programme
Quality	Ground and Surface Water Drinking Water	Pollution / Contamination: Deteriorating Water Quality- Physical, Chemical and Biological Contamination: Sewage	Geo-genic & anthropogenic ; Inadequacy- measurement & regulation Geo-genic & anthropogenic contamination ; Poor regulation Poor Water supply infrastructure and maintenance; Inadequate and ineffective treatment facility	No STP as of now in state. Should be invested more in water treatment plants, and more water quality measurement stations for enforcing strict rules on contaminating points. Also, water infrastructure should be developed to a standard, for combating any leakages, and maintenance checks.	Infrastructure grant on STP Research grant on Establishment of Drinking Water testing labs Infrastructure grant on Ground and Surface Water monitoring station
	Farm Sector	Deteriorating Water Quality; Salinity	Irrational application of Fertilizers, Pesticides; poor farm management practices	Use in Agriculture/ Industry Infrastructure for robust drainage systems for avoiding any water quality deterioration during flow. High quality crop varieties and fertilizers are to be invested in. More	Research grant for water use efficiency and crop productivity

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
--------				research should be promoted to increase water use efficiency and crop productivity.	
	Industry	Contamination of Industrial effluents SW and GW	Poor monitoring, regulation and enforcement	There should be policies to categorize and conduct recycling of possible industrial effluents or leftovers. Also, dumping of different type of effluents should be regularized, their outlets to be marked and properly managed. The norms and regulations should be enforced.	Policy led research grant on Industrial effluents SW and GW
Climate Change	Source	Glaciers, Springs-Melting/ Drying.	Climate Change and GHG emission	Research & Inventory	Climate Change and GHG emission base research grant
		Low Precipitation	Low precipitation causes soil moisture depletions and may also cause low crop production. Less rain alter forests covers and grazing lands converting into scrub lands Inadequate precipitation causes droughts and Alter environmental flow and lead to drying of water bodies also lead poor water quality.	Soil and moisture conservation techniques; Conjunctive use of surface and groundwater and Integrated Watershed Planning for agriculture productivity. Forest restoration and agro-forestry for ecological. Drought proofing techniques- Rainwater harvesting, Percolation ponds, Farm ponds and de silting of tanks can help in combating drought situations.	Grant and support for forest restoration, conjunctive use of Surface and Groundwater
		High Precipitation	Causes silt load, flood and land slide	A detailed policy and schemes should be launched	Financial Support on Flood control and de-siltation

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
			that directly defunct the water resource infrastructure.	for all major rivers for flood control measures and de-siltation.	
--------	Water Governance	No control on consumption exceeding availability	State Subject; GOI: only advisory role; No Single Agency for coordination	State Water Budgeting; Rigorous awareness campaign led by centre with full active support from State	Establishment of A nodal agency for Water Auditing and budgeting
	Ground Water	There is lack of Ground water monitoring stations in valleys, while only few lies in lower plains of the state.	The infrastructure development in groundwater sector is very poor and terrain condition poses a challenge in new developments.	More monitoring stations should be established, and regular measurements and analysis of the observations should be made. This may also require different funding for infrastructure development.	Grant for more monitoring stations
Institutional	Measurement/ Assessment	Poor monitoring of resource availability (supply) and consumption (demand)	Measurement is almost nil Except Reservoir, Rivers & Ground Water resources	Measurement meters required for observing domestic and industrial requirement /consumptions.	Funded Scheme for Measurement meters required for observing domestic and industrial requirement /consumptions
	Infrastructure	Dams and CAD -are old; Inefficient and Inadequate reservoir storage capacity	Poor maintenance; Poor management etc.	Need for effective organizational structures and allocate fund for maintenance of old structures.	Allocate of fund for maintenance of old structures
	Benefits/ Services	Wide gap in IPC & IPU (112.53-89.26 MHa)	Leakages and Seepage; Method (Flood) of irrigation; Poor Management system / Scheduling and Low Investment	Incentivization	Fund to restore the Leakages and Seepage
		Sub-optimal Water Use Efficiency- more Wastage	Inefficient (unlined/ unpiped) water distribution system	More investment towards technological advancements is required, this also includes funds for progressive and	Funds for progressive and supportive research and development for WUE or similar studies.

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
				supportive research and development for WUE or similar studies.	
--------	Regulation	Water Regulatory Authority- Inter-coordination between various water users	No measurement; unaccounted use of water in different sectors	Detailed documentation is required to account water resources inter and intra-sectors.	Establishment of A nodal agency for Water Auditing and budgeting
Technology	Farm Sector	Precision irrigation area is very less	Mostly flood irrigation.	More investment towards technological advancements is required, this also includes funds for progressive and supportive research and development for WUE or similar studies.	More investment towards technological advancements is required
		Cropping pattern does not coincide with available water resources	Lack of knowledge and price-based agriculture practices	A detailed framework is required for water energy and food nexus	Skill development programme on water energy and food nexus
		High Chemicals usage	Lack of knowledge and price-based agriculture practices	Organic farming must be promoted	Skill development programme on water energy and food nexus
	Industry	Less WUE /Water saving Lack of WWTP	No Water Audits, less awareness about reusing waste water	Establishing more WWTPs, Proper water auditing, and reusing water for efficient consumption and saving.	More investment on more WWTPs
	Drinking Water	Leakages; Less WUE /Water productivity	Water saving technology / containing leaks	investments	Investment on Water saving technology
Economics	Value for resource	Not valued; No water tariffing Wastage,	Lack of Infrastructure to monitor and control wastages	Awareness programs for efficient and judicious use of water	Infrastructure to monitor and control wastages
Financing	Investments	Inadequate investments	Fund allocated by the central govt is uniform for the nation.	keeping the terrain conditions and infrastructure cost in north-eastern region, it requires special funding for completing the	Special and additional grants for Arunachal Pradesh due to topography and poor connectivity.

Heads	Sector	Scenario	Cause	Policy	Research Grant / Financial Support
				projects on time.	
Transparency	Data Resources Funds	No data transparency in Supply, Demand and Quality	Poor measurement systems; No data transparency in Supply, Demand and Quality	A water budget portal is mandatory for auditing the demand supply and consumptions of each sector.	Fund for water budget online portal
Democracy	Public involvement	In Arunachal even in the PIM schemes, many rules concerning the distribution of water are established and followed in customary practices based on their own agreed allocation rules rather than the written water distribution schedule	Customary norms of water allocation are respected by the community. Hence in the current context water distribution does not assume significant importance to assess the impact of PIM	It was observed that although farmers wanted to claim ownership, they did not want to take up responsibility of the irrigation systems. This need strengthening of PIM norms and educating them about O&M of the water infrastructure. Government generally lacks the fund for continuous wear and tear of the structures.	Government generally requires additional fund for continuous wear and tear of the structures.

4 Water resources

The water resources have two facets - dynamic and static. The dynamic resource, measured as flow, is more relevant for most of the developmental needs. The static or fixed nature of the resource, involving the quantity of water, the geometry of the water bodies is also relevant for some activities like pisciculture, navigation etc.

The water resources potential of Brahmaputra basin is the highest in the country, but its present utilization is the lowest. The Brahmaputra is a major international river covering drainage of 5,80,000 Sq.km, 50.50% of which is lying in China, 33.60% in India, 8.10% in Bangladesh and 7.80% in Bhutan. Its basin in India is shared mostly by Arunachal Pradesh (41.88%), Assam (36.33%), Nagaland (5.57%), Meghalaya (6.10%) Sikkim (3.75%) and West Bengal (6.47%). Within Arunachal Pradesh, there are 10 major river basins consisting of 19 catchments of rivers. Numerous rivers originating from these basins ultimately drain to Brahmaputra River. This is a boon for the State for development of agriculture, power and industry sectors but at the same time, these rivers have the destructive potentials unless certain preventive and protective measures are taken up in the State.

The Himalayan Rivers carry heavy sediment loads because of steep bed slope, soft and friable Himalayan rock. This is further aggravated by population growth with unscientific human activities on the valleys and high seismicity of the region. Consequent upon major seismic disturbance in 1950, large-scale landslide and heavy sediment transportation started. Rivers started braiding in the foothill area and this dynamic process is still actively continuing. It can compensate the deficit in other basins. Even though the economy of the state depends on agriculture. Agricultural productivity is low because of a combination of factors like climatic, infrastructural, biophysical, managerial and socio-economic. Irrigation development is still in infancy as only 18.06% of the net cropped area is brought under irrigation. 32.08% of the total area of Arunachal Pradesh is considered a problem area due to soil erosion and land degradation.

The rich water resources of Arunachal Pradesh are required to be harnessed with a view of developing irrigation and hydropower. High rainfall combined with some other factors cause soil degradation which results in low agricultural activity. The water resources developments influence the land resource management to a great deal. Therefore, it is necessary to develop, conserve and efficiently utilized the available water. This requires infrastructure and financial support from the centre.

About 80% of the mean annual flow of River Brahmaputra is contributed by more than 3,000 small and big river tributaries. Within the state, there are 19 major river basins consisting of 46 major and medium type rivers.

4.1 Available Surface water Resources:

The water balance study finds wide applicability in land and water resource management, agriculture, horticulture irrigation and domestic and thus it has potential to affect the development of a state, whose economy largely depends on agriculture production. The state of Arunachal Pradesh has varying degrees of seasonal & climatic inputs and this specific characteristic of the state contributes to great variability in the magnitude of agriculture production across the region. The factors accounted to estimate the water balance are:

a) Hydrometeorological elements like precipitation, temperature, wind velocity and humidity

b) The geomorphologic factors such as area, shape, slope, soil properties, drainage network characteristics and elevation and

c) Land practices and pattern of the catchment

The issues like accessibility, socio-cultural factors, lack of observatories and climate severity were accounted for in determining the water balance.

Table 4-1 Sources of data

Subject area	Data basis	Source and map scale
Basic data	Administrative boundaries, stream networks	Survey of India; scale 1: 50 000
Climatic data	**Present Climate (1900-2013):** Daily precipitation, daily maximum and minimum temperature, solar radiation, wind speed and potential evaporation	Indian Meteorological Department
	Future Climate (2019-2030): Daily precipitation, daily maximum and minimum temperature, solar radiation, wind speed and potential evaporation	Community Climate System Model (CCSM) V4 (RCP 4.5)
Soil data	Soil type and physical characteristics (composition of silt, sand, clay, rocks), field capacity, bulk density, saturated hydraulic conductivity, depth to water table, soil depth	National Bureau of Soil Survey and Land use planning (NBSS & LUP); scale 1:250 000, ICAR Basar
Land use data	Land use pattern	NRSC/ ISRO 2005 and 2012
Digital Elevation Model	Topography data/SRTM	Survey of India; scale 1:50 000

Potential Evaporation (PET) was used to implement the Thornwaite's method. The rate of evapotranspiration depends on three factors: solar radiation, wind velocity and supply of moisture on the surface from where evaporation occurs. Reference evapotranspiration is defined by the Food and Agriculture Organization as the rate of evapotranspiration from an extensive surface of 8-15cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water.

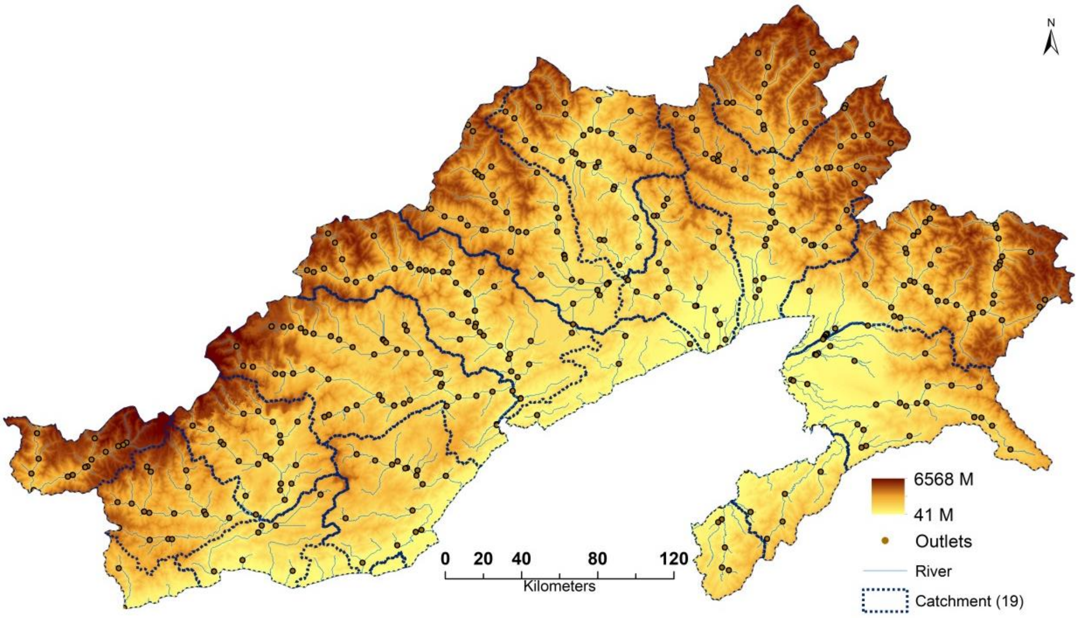

Figure 4-1: streams and outlets

The approach followed here used a modeling technique where the land phase of the hydrological cycle simulation was carried out for whole Arunachal Pradesh.

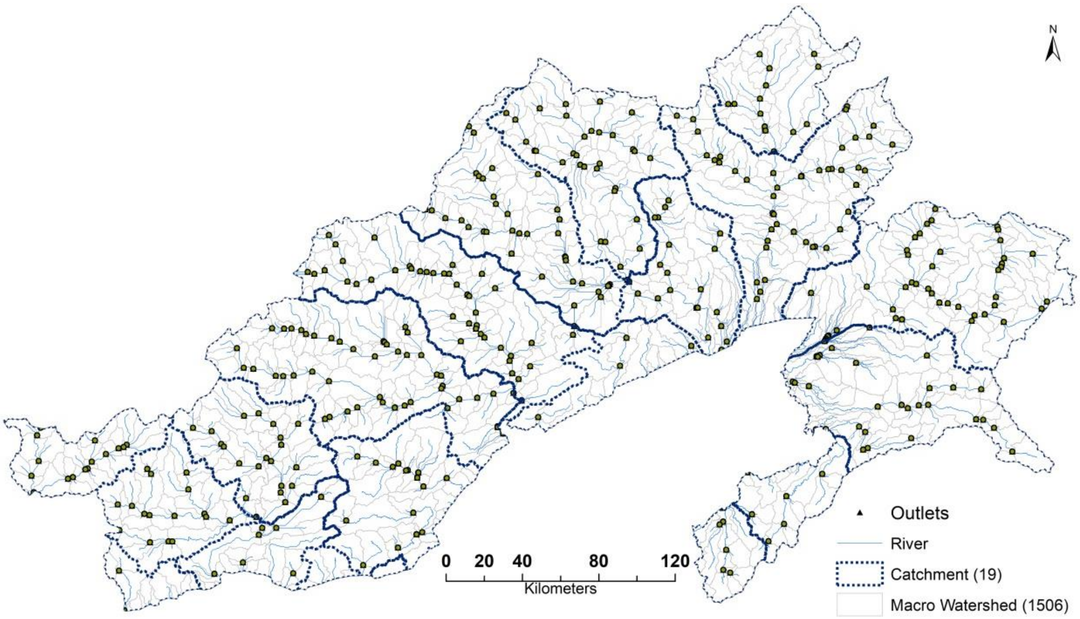

Figure 4-2: Macro watershed delineation

The land phase of the hydrological cycle was simulated using SWAT (Soil and Water Assessment Tool) model SWAT has been tested and used successfully for ungauged river basins mainly due to its spatially explicit parameterization capability.

Table 4-2 Water availability (in MCM) in different catchments

ID	Code	Catchment	Catchment Area (km^2)	2005	2012	Change (in%)
1	3A2C	Dhansiri River	911.73	2809.93	1725.85	-38.58
2	3A2D	Twang Chu	2344.23	5757.93	3732.18	-35.18
3	3A3A	Bhareli River	2316.43	6192.44	5415.38	-12.55
4	3A3B	Bishom River	3490.83	11139.53	5491.32	-50.70
5	3A3C	Kameng River	4027.56	11946.74	8591.54	-28.08
6	3A3D	Brahmaputra River	604.76	678.97	1684.91	148.16
7	3A3E	Disang River	1353.35	2648.32	3548.57	33.99
8	3A4A	Dikrang (Subansiri) River	4490.06	11344.15	14889.36	31.25
9	3A4B	R B Subansiri River	8275.50	23020.56	25973.14	12.83
10	3A4C	L B Subansiri River	7277.42	18411.54	22438.36	21.87
11	3A5A	Brahmaputra River	2295.80	6520.87	6567.44	0.71
12	3A5B	Dihang River	3918.21	9662.66	11541.24	19.44
13	3A5C	Siang River	6077.36	16135.11	20780.59	28.79
14	3A5D	Siyom River	5899.13	15601.69	19031.56	21.98
15	3A5F	Tirap River	1972.39	4368.08	4765.17	9.09
16	3D4A	Lohit River	6277.6	13659.08	13241.22	-3.06
17	3D4B	Tellu / Lohit River	9483.08	20335.84	16191.16	-20.38
18	3D4C	Lower Dibang River	8485.37	19049.97	23758.64	24.72
19	3D4D	Upper Dibang River	4242.09	9371.72	15393.83	64.26
			83743	207263.93	218652.97	5.49

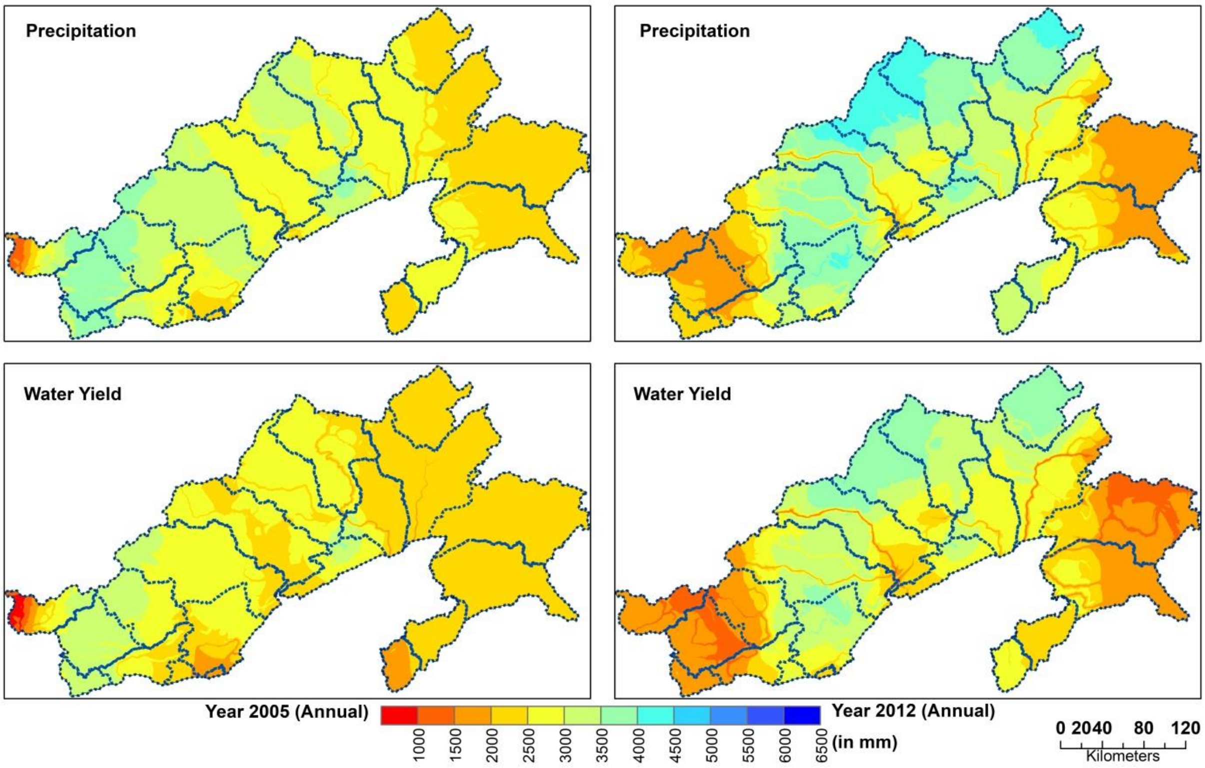

Figure 4-3: Change in Total Water availability due land practices at catchment level

Table 4-3 Water availability (in MCM) in different districts

Code	District	Total water availability (in MCM) 2005	2012	Change (in %)
1	Anjaw	14900.95	10982.67	-26.30
2	Changlang	11013.48	10237.11	-7.05
3	Dibang Valley	20104.98	27968.77	39.11
4	East Kameng	11923.97	9246.95	-22.45
5	East Siang	12832.55	14046.25	9.46
6	Kurung Kumey	20503.53	23038.09	12.36
7	Lohit	9772.13	10207.98	4.46
8	Lower Dibang Valley	9096.37	10685.38	17.47
9	Lower Subansiri	7722.73	9368.93	21.32
10	Papum Pare	6799.06	8948.70	31.62
11	Tawang	5334.90	3457.98	-35.18
12	Tirap	3866.22	5046.01	30.52
13	Upper Siang	15884.57	20909.93	31.64
14	Upper Subansiri	17789.33	21980.00	23.56
15	West Kameng	23268.58	12244.17	-47.38
16	West Siang	20053.04	23981.20	19.59
	Total	207263.93	218652.97	5.49

4.2 Glaciers, Lakes and Other storages

Glaciers:

Arunachal Pradesh has the lowest concentration of glaciers in India. Glaciers are found in the Kameng Basin (52 glaciers covering an area of 66 km^2), in the Subansiri Basin (91 glaciers covering an area of 146 km^2) and in the Dibang Basin (14 glaciers covering an area of 11 km^2).

Table 4-4 Snow melt contribution in the catchment

ID	Code	Name	Snow melt (in mm)		Change (in %)
			2005	2012	
1	3A2C	Dhansiri River	60.10	0	-60.10
2	3A2D	Twang Chu	248.45	186.68	-61.77
3	3A3A	Bhareli River	30.29	0.00	-30.29
4	3A3B	Bishom River	70.48	80.67	10.19
5	3A3C	Kameng River	148.64	8.37	-140.27
6	3A3D	Brahmaputra River	0	0	0.00
7	3A3E	Disang River	135.78	0.00	-135.78
8	3A4A	Dikrang (Subansiri) River	11.64	0.31	-11.33
9	3A4B	R B Subansiri River	123.57	4.70	-118.86
10	3A4C	L B Subansiri River	115.57	113.19	-2.38
11	3A5A	Brahmaputra River	0	0	0

ID	Code	Name	Snow melt (in mm)		Change (in %)
			2005	2012	
12	3A5B	Dihang River	115.35	52.24	-63.11
13	3A5C	Siang River	437.21	233.33	-203.87
14	3A5D	Siyom River	228.82	282.28	53.45
15	3A5F	Tirap River	143.36	40.0	-103.36
16	3D4A	Lohit River	462.69	9.42	-453.27
17	3D4B	Tellu / Lohit River	740.81	24.26	-716.55
18	3D4C	Lower Dibang River	860.32	648.66	-211.66
19	3D4D	Upper Dibang River	886.70	1337.03	450.32

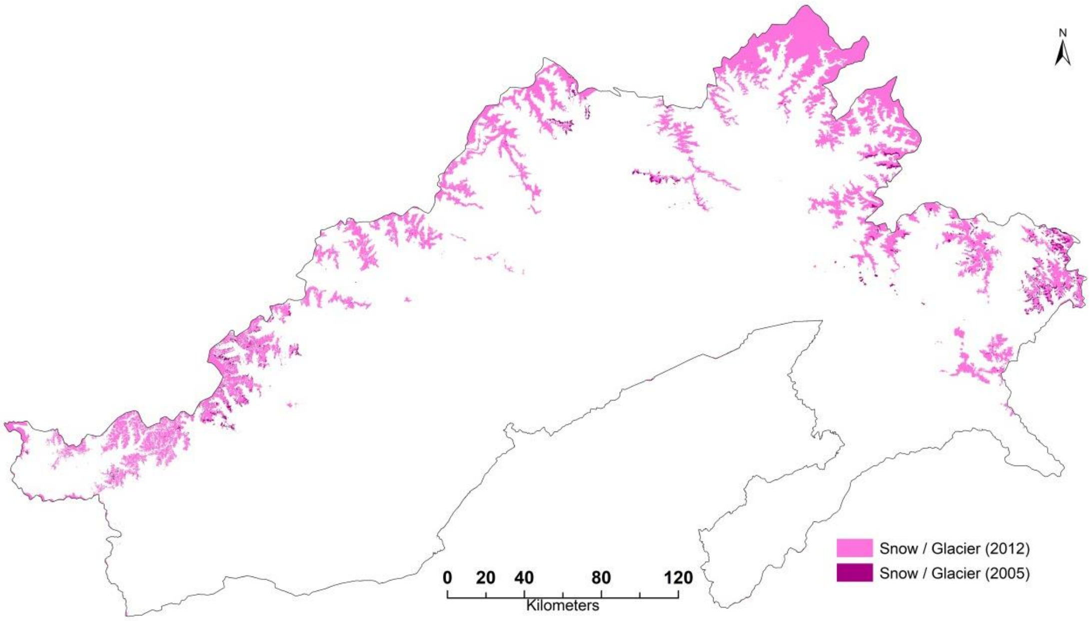

Figure 4-4: Change in Snow and Glacier cover

Lakes:

Ganga Lake, popularly known as Geker Sinying, is surrounded by lush greenery and majestic mountains from all sides in Itanagar. Since the lake has no connection with moving water bodies, therefore, its color is green. Madhuri Lake located in Tawang is a pristine location nestled amidst the picturesque mountains. The lake is supposed to be an outcome of a major earthquake in 1950. There was a grazing ground before the earthquake occurred. Nagula lake in Tawang is usually frozen. Lake of no return, in Chalang district borders on Myanmar, is 1.4 km in length and 0.8 km in width in its widest part.

Ponds:

Ponds are also the natural habitat of many species thus their loss will endanger a lot of flora and fauna as well. They are usually considered as the community property used especially for irrigating agricultural land as also for bathing, washing, cooking purpose and water for their cattle. More importantly, these ponds help in recharging groundwater while a variety of birds survive on small fishes and insects in these ponds. In Arunachal Pradesh, ponds have been constructed but not used for drinking or irrigation purposes. Ita Pukhuri is located at Ithili village about 14 km from Roing in Lower Dibang Valley district of Arunachal Pradesh. During the months of October/November, hundreds of lotus flowers bloom in the pond. The Kampona pond located in Idili village near Roing is an ancient clear water tank. The data shown below confirms the presence of many lakes of different sizes in the state.

Table 4-5 Lakes numbers and area in the state

		100 - 25 ha		<25 ha		<10 ha)		<2.25 ha		Total	
Sl	District	Nu	Area	Nu	Area	Nu	Area	Nu	Area	Nu	Area
1	Anjaw										
2	Changlang	-	-	1	11	2	7	16	16	19	34
3	Dibang Valley	47	1872	103	1660	290	1387	176	176	619	5467
4	East Kameng	1	37	4	55	22	123	7	7	34	222
5	East Siang										
6	Kurung Kumey										
7	Lohit (Including Anjaw)	18	716	74	1130	164	794	90	90	346	2730
8	Lower Dibang Valley										
9	Lower Subansiri	1	54	5	89	25	98	17	17	48	258
10	Papum Pare										
11	Tawang	5	233	13	189	180	662	55	55	253	1139
12	Tirap										
13	Upper Siang	-	-	21	341	46	226	34	34	101	601
14	Upper Subansiri	4	154	16	238	33	185	14	14	67	591
15	West Kameng	-	-	8	123	88	298	10	10	106	431
16	West Siang	1	51	7	101	49	217	22	22	79	391
	Total	77	3117	222	3937	899	3997	441	441	1672	11864

Wetlands:

If we investigate the wetlands of the state, almost all of them have decreased in the area in the past four years. There are around 7 wetlands in the state whose area is larger than 20 Km sq. The wetlands have their own ecosystems and any change in moisture availability to these large areas may affect their viability. There are only 36 man-made wetlands which mainly includes ponds/tanks or reservoirs.

Table 4-6 Numbers of Wetlands under various size

District	<2 km2	2-5 km2	5-10 km2	10-15 km2	15-20 km2	>20 km2	Area (in km2) 2017	Change (in %) (2014-17)
Tawang	1					1	1.43	-2.3
Anjaw	1	1	1				12.19	-0.1
Dibang Valley						3	314.91	-1
East Kameng	1						48.52	-1.18
Kurung Kumey						2	67.52	-1.87
Lower Dibang Valley	1						67.31	-1.52
Upper Siang			1				99.05	0.93
Upper Subansiri	2				1		23.77	0.06
West Kameng						1	23.78	-0.17
Total	6	1	2	0	1	7	658.482	-7.15

Wetland statistics of Arunachal stated that 99.1% of the inland wetland are natural whereas only 0.9% is man-made. The state should take initiative to the develop more man-made wetland for ecosystems services.

Table 4-7 Wetland coverage area

Sl	Wetland category	Num	Total Area	% of area	Open water (ha) Post-monsoon area	Open water (ha) Pre-monsoon Area
Inland Wetlands- Natural (in ha)						
1	Lakes/Ponds	3	18	0.01	16	-
2	Ox-bow lakes/Cut-off Meanders	29	520	0.33	180	39
3	High altitude wetlands	1231	11422	7.33	7946	2984
4	Waterlogged	107	8146	5.23	60	7
5	River/Stream	128	134244	86.2	57811	54354
	Sub-total	1498	154350	99.1	66013	57384
Inland wetlands- Man-made (in ha)						
1	Reservoirs / Barrages	4	164	0.11	162	124
2	Tanks / Ponds	32	95	0.06	47	8
	Sub-Total	1534	154609	99.28	66222	57516
	Wetlands (<2.25 ha), mainly Tanks		1119	0.72	-	-
	Total	2653	155728	100	66222	57516
Area under Aquatic Vegetation					6002	5924
Area under turbidity levels						
1	Low				56471	45810
2	Moderate				7984	9541
3	High				1767	2165

High Altitude Fish Farms:

The High-Altitude Fish Seed Farm, covering an area of 7.4 hectares of land was established at Tarin (near Ziro town) under North Eastern Council (NEC) in 1985-86. The total water area covered is 3.0 hectares and total affected water area covered is 2.75 hectare. The total number of ponds under the farm is 74. Out of which 46 numbers are nursery ponds, 16 are rearing ponds and 12 are stocking ponds. The Apatani tribe practice aquaculture along with rice farming on their plots. Rice-fish culture in the valley is a unique practice in the state, where two crops of rice (Mipya and Emoh) and one crop of fish (Ngihi) are raised together.

Integrating aquaculture with agriculture assures higher productivity and year-round employment opportunities for farmers. Organic inputs are used in the plots utilized for rice cum fish culture. Some of the inputs used are poultry dropping (Paro pai), pig excreta (Alyi ekha), cow dung (Sii ekha) and wastes of plants such as rice husks (Piina), ashes from household stoves (Mubu) and remains of burnt straws (Muyu) and decomposed straw (Liisi), weeds (Tamih) and stalks (Ankho).

Reservoir/Storage:

There are no major or medium water storage reservoirs in the State, except one minor. There are 6 water bodies larger than 50 ha and 64 which, covers an area more than 20ha. These are mainly tanks or ponds. Lower Subansiri and Ranganadi are two reservoirs in the state for hydro-generation

Table 4-8 Reservoir information

Name of Reservoir	District	Length (m)	Max Height above Foundation (m)	Gross Storage Capacity (MCM)	Live Storage Capacity (MCM)
Subansiri Lower	Lower Subansiri	284	130	1365	923.0
Rangaanadi	Papum Pare	340	68	21.28	5.7
Total				1386.28	928.7

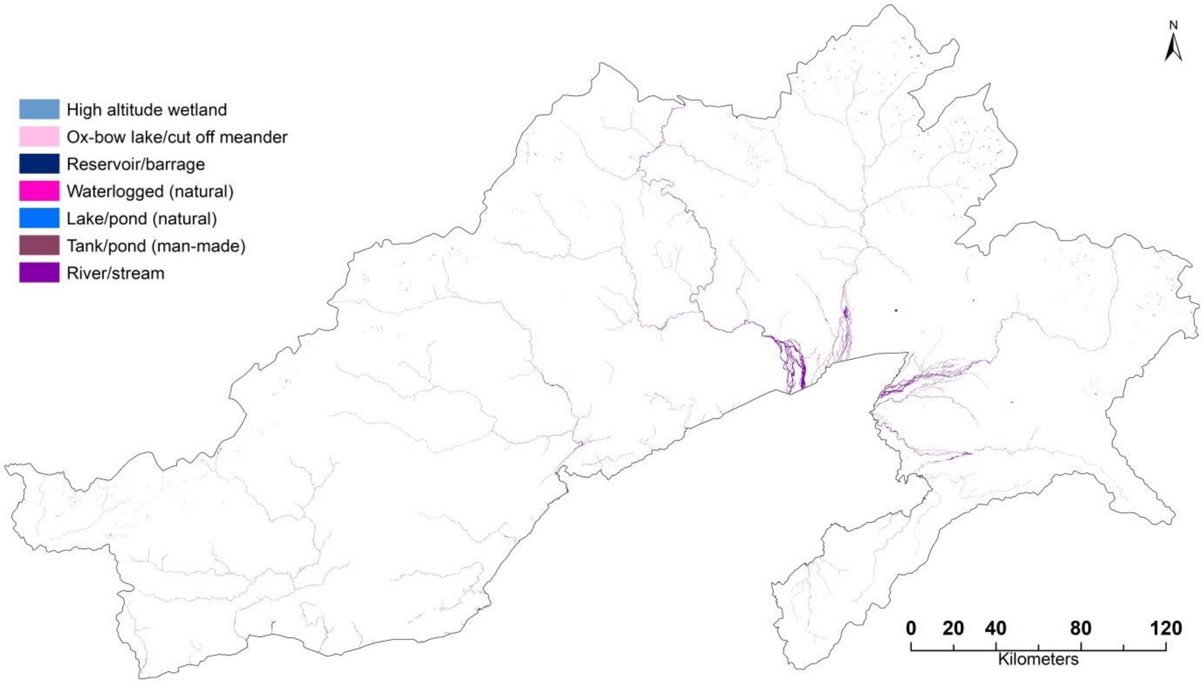

Figure 4-5: Wetland of the State

4.3 Ground Water

Arunachal Pradesh has 2.56 BCM annual replenishable ground water resources and net annual groundwater availability of 2.30 BCM and the annual groundwater draft is 0.0008 BCM. The Stage of Ground Water Development is 0.04 %. In context of Groundwater development and management, there are no blocks or taluks which fall in the category of the over-exploited, critical and semi-critical zone. Therefore, the groundwater potential exploited so far is negligible. With the depletion of surface water resources in the foothill areas of Arunachal Pradesh, especially Changlang, Lohit, Lower Dibang Valley, East Siang, Papum Pare and East Kameng Districts, the need to exploit groundwater potential for meeting the requirements of drinking water and irrigation is increasing day by day.

The CGWB had assessed an irrigational potential about 18,000 hectares through groundwater in the State. An area of more than 87,500 hectares has been irrigated in Arunachal Pradesh. Minor Irrigation Census of the State reveals that about 0.12-million-hectare (about 66.67% of available potential) area is irrigated. Fresh Potential Assessment is being done under GIS environment and ultimate potential is expected to increase to around 0.85 million hectares.

Table 4-9 Groundwater resources

Dynamic Ground Water Resources	
Annual Replenishable Ground water Resource	2.56 BCM
Net Annual Ground Water Availability	2.30 BCM
Annual Ground Water Draft	0.0008 BCM
Stage of Ground Water Development	0.04 %
Ground Water Development & Management	
Over Exploited	NIL
Critical	NIL
Semi- critical	NIL
Ground Water User Maps	8 Districts
Artificial Recharge to Ground Water (AR)	Feasible AR structures: 500 Check Dams, 1000 weirs, 1000 Gabion structures, 300 Development of springs, 600 RTRWH in Urban Areas AR schemes completed during IX Plan: 1

The state has a varying degree of topography, geology and rainfall which result in regional disparities in groundwater potential. Approximately 90% of the total geographical area is covered by hills and forest which results in a very high runoff and this limits the opportunity for groundwater development. Regardless of several barriers in groundwater development such as difficult terrain conditions, impenetrable forest, lack of adequate surface water communication, energy shortage, land holding size and poor coordination between various agencies there exists considerable scope of expansion of groundwater utilization.

Out of all the groundwater draft, approximately 215 MCM is used for agricultural purposes mainly for irrigation. While 707.8 MCM is used for domestic and industrial purposes. Considering the rate of population growth, the total demand for water from ground zones will be 20122 MCM in the year 2025

If the water level for the year 2015 is compared with the last 10 years of mean, out of 9 wells observed, all wells show an increase in monsoon water level. The wells show 0-2 meters of decreased water level as compared to 10 years of the mean for pre-monsoon season, for 5 out of 10 wells observed. This might indicate an increase of GW draft or decrease of recharge during the year. Following tables details the inference.

Out of all the districts, the Lohit has the highest groundwater recharge. Adversely to this, the groundwater development there is much less than other districts. Considering this water availability, the resources can be used for irrigation, which is currently being exercised only of its 5%. East Siang though has the highest consumption of Groundwater of all the districts for agriculture and industrial /domestic use.

Table 4-10 Groundwater utilization District-wise

Sl	District	Annual Replenishable Ground Water Resource					Discharge During Non-Monsoon Period	Net Ground Water Availability	Annual Ground Water Draft			Projected demand for Domestic and Industrial uses up to 2025	Ground Water Availability for Future Irrigation use	Stage of Ground Water Development (%)
		Monsoon Season		Non-Monsoon Season		Total								
		Recharge from Rainfall	Recharge from Other Sources	Recharge from Rainfall	Recharge from Other Sources				Irrigation	Domestic & Industrial Water Supply	Total			
1	Anjaw													
2	Changlang	207.61	0.18	69.07	0.27	277.13	27.71	249.42	0.26	0.99	1.24	2.04	247.12	0.50
3	Dibang Valley													
4	East Kameng	133.64	0.00	30.30	0.00	163.94	16.39	147.55	0.15	0.03	0.18	0.14	147.26	0.12
5	East Siang	603.04	0.08	149.49	0.12	752.73	75.27	677.46	0.71	1.79	2.50	3.66	673.10	0.37
6	Kurung Kumey													
7	Lohit	1428.90	0.00	523.07	0.00	1951.97	195.20	1756.77	0.05	2.53	2.58	10.81	1745.91	0.15
8	Lower Dibang Valley	704.06	0.00	249.47	0.00	953.53	95.35	858.18	0.34	0.48	0.82	1.61	856.24	0.09
9	Lower Subansiri	17.61	0.00	8.03	0.00	25.64	2.56	23.08	0.05	0.00	0.05	0.12	22.91	0.22
10	Pampum Pare	107.27	0.00	25.04	0.27	132.58	13.26	119.32	0.58	0.84	1.41	1.10	117.65	1.19
11	Tawang													
12	Tirap	72.08	0.00	20.44	0.00	92.52	9.25	83.27	0.03	0.18	0.21	0.57	82.67	0.25
13	Upper Siang													
14	Upper Subansiri	2.28	0.00	1.05	0.00	3.33	0.33	3.00	0.00	0.00	0.00	0.00	3.00	0.00
15	West Kameng	14.06	0.00	3.44	0.00	17.51	1.75	15.76	0.00	0.00	0.00	0.07	15.69	0.00
16	West Siang	49.36	0.01	12.86	0.01	62.23	6.22	56.01	0.00	0.25	0.25	0.10	55.91	0.45
	Total (MCM)	3339.91	0.27	1092.26	0.67	4433.10	443.29	3989.82	2.15	7.08	9.23	20.22	3967.45	0.23
	Total (BCM)	3.340	0.000	1.092	0.001	4.433	0.443	3.990	0.002	0.007	0.01	0.02	3.967	0.23

Table 4-11 District wise categorization of water level fluctuation 10 years mean

August 2005- August 2014

District	Number of Stations Analyzed	Range (in m)				Rise						Fall					
		Rise		Fall		0-2 m		2-4 m		>4 m		0-2 m		2-4 m		>4 m	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Changlang	4	0.61	1.59			4	100	0	0	0	0	0	0	0	0	0	0
Lohit	1	0.43	0.43			1	100	0	0	0	0	0	0	0	0	0	0
Papumpare	1	0.25	0.25			1	100	0	0	0	0	0	0	0	0	0	0
Tirap	3	1.41	1.75			3	100	0	0	0	0	0	0	0	0	0	0
Total	9					9	100	0	0	0	0	0	0	0	0	0	0

November 2005- November 2014

State / District	Number of Stations Analyzed	Range (in m)				Rise						Fall					
		Rise		Fall		0-2 m		2-4 m		>4 m		0-2 m		2-4 m		>4 m	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Changlang	4	0.02	0.75	0.07	0.07	3	75	0	0	0	0	1	25	0	0	0	0
Lohit	1	0.31	0.31			1	100	0	0	0	0	0	0	0	0	0	0
Papumpare	2	0.34	0.36			2	100	0	0	0	0	0	0	0	0	0	0
Tirap	3	0.01	0.85			3	100	0	0	0	0	0	0	0	0	0	0
Total	10					9	90	0	0	0	0	1	10	0	0	0	0

January 2006- January 2015

State / District	Number of Stations Analyzed	Range (in m)				Rise						Fall					
		Rise		Fall		0-2 m		2-4 m		>4 m		0-2 m		2-4 m		>4 m	
		Min	Max	Min	Max	No	%	No	%	No	%	No	%	No	%	No	%
Changlang	4	0.28	0.77	0.45	0.82	2	50	0	0	0	0	2	50	0	0	0	0
East Siang	1	0.31	0.31			1	100	0	0	0	0	0	0	0	0	0	0
Lohit	1	0.38	0.38			1	100	0	0	0	0	0	0	0	0	0	0
Papumpare	2	0.74	0.74	0.35	0.35	1	50	0	0	0	0	1	50	0	0	0	0
Tirap	3	0.45	1.67			3	100	0	0	0	0	0	0	0	0	0	0
Total	11					8	72.8	0	0	0	0	3	27.2	0	0	0	0

5 Water resources: Utilizations, Consumption and Future demand

5.1 Agriculture and Horticulture sector

About 54.6% of the population is engaged in agriculture and allied activities and 80% of the population living in the rural area is dependent on agriculture and about 62 % of total working populations are engaged in agriculture. The net area shown increased due to the extension of agriculture and various central and state initiative and a grant provided to the department of agriculture that leads to the requirement of better infrastructure for irrigation in the state.

Table 5-1 Cultivation practices (in ha)

	Net area Sown	Settled	Jhum
1970-1971	115226	28006	87220
1976-1977	111914	40013	71901
1980-1981	118232	52012	66220
1985-1986	149314	76759	72555
1990-1991	165616	92616	73000
1995-1996	164194	80192	84002
2000-2001	200210	116208	84002
2010-2011	216000	131998	84002

Table 5-2 Production of crops

	Kharif Season				Rabi Season			
Food Crops	Irrigated Area (ha)	Total Area (ha)	Production (tonnes)	Productivity (t/ha)	Irrigated Area (ha)	Total Area (ha)	Production (tonnes)	Productivity (t/ha)
Paddy	50401	130505	328845	2.51		495	1155	2.33
Maize		40703	59907	1.47		9595	15543	1.62
Millet		26500	27030	1.02				
Wheat					1315	3910	7700	1.96
Total Cereals		197708	415782	2.10		14000	24398	1.74
Blackgram		1065	919	0.86		1440	1243	0.86
Moong		1225	1262	1.03				
Pea		405	580	1.43		4359	5601	1.28
Arhar		612	554	0.91		161	89	0.55
Rajma		2220	1982	0.89				
Other local Pulses		178	155	0.87		1135	679	0.60
Total Pulses		5705	5452	0.96		7095	7612	1.07
Soyabean		2839	2814	0.99				
Sesamum		1724	765	0.44				

Ground nut	628	653	1.04			
Sun flower	235	129	0.55			
Other local Oilseeds	345	196	0.57			
Mustard				29229	31843	1.09
Total Oil seeds	5771	4557	0.79	29229	31843	1.09
Kharif Season	1130	3093	2.73	2411	6822	2.83
Potato	1748	13146	7.52	4222	31629	7.49
Vegetable	10106	50582	5.01	15866	76681	4.83

The highest productivity is of rice or paddy in the state in both the seasons. It accounts for approximately 2.51 t/ha in Kharif and 2.33 t/ha in Rabi. While even in Kharif season, out of approx. 1.3 lakh ha, it needs irrigation on around 50 thousand ha of area. While the production of paddy goes as low as 1100 tonnes in Rabi from 3 lakh tonnes in Kharif. As rice is an intense water requiring crop, it clearly shows that irrigation facility is not able to support even half of the production of rice in Rabi season. The production of pulses, however, is 20% more in Rabi season.

Table 5-3 Production of spices and fruits

	Total Area (ha)	Production (t)	Productivity (t/ha)
Spices			
Large Cardamom	8300.26	1757.43	0.21
Black Pepper	1473.9	100.91	0.07
Ginger	4080.65	20996.39	5.15
Total spices and condiments	13854.81	22854.73	
Fruit crop			
Citrus (Orange)	42640	217044.1	5.09
Pineapple	6963.6	37331.9	5.36
Apple	4682.3	7280.58	1.55
Banana	5421	31644.08	5.84
Kiwi	3379	6047.34	1.79
Walnut	1108.8	597.2	0.54
Other	20193	6325.02	0.31
Total Fruit crops	66214	306270.2	

Ginger, Citrus, Banana and Pineapple are highly produced fruit crops in the state. However, Apple, kiwi, walnut are other fruit crops which are cultivated.

5.1.1 Irrigated Area

The Command Area Development Water Management (CADWM) programme envisages the utilization of irrigation potential. Available records indicate that a wide utilization gap exists till today. Out of 1.20 lakh, hectare net irrigation potential created, about 0.48 lakh hectare only has been brought underutilization. The utilized area works out to be 40% only leaving 60% potential created unutilized. This is a major consumer side of the water in this State.

Percent of irrigation of the state for agriculture is about 19% of total cultivable crop land whereas the 60374 ha of land is cultivable in horticulture crop. Lohit district shares about 35% of total Horticulture area. Rest all districts ranging from 1 to 10%.

As per the State Government's New Agriculture Policy, status of Agriculture in Arunachal Pradesh (Base Year 1999-2000) is to the tune of 1.10-lakh hectare under Jhum/shifting Cultivation and 0.90 lakh hectare under permanent Cultivation. Rice is of traditional variety and most of the tribes cultivate different varieties of rice. Paddy, millet, maize, oil seeds, potato, ginger are the other major crops cultivated. As per WRD, the total coverage assured under Irrigation is 19% on the net area and 15% to gross area. In terms of expanding irrigation coverage, in 2005-2006 Government of Arunachal Pradesh were able to increase the irrigation coverage to 114659 Ha from 110332 Ha in 2004-2005. There exists immense scope to boost agriculture production by increasing area under irrigation coverage. The statistics shown in table explains that around 75% of Kharif crop and approx. 94% of Rabi crop is under rain-fed. In total around 81% of the agriculture is under rain-fed. This reflects upon the irrigation facility yet to be developed in the state.

Table 5-4 Percentage of Irrigation in Agriculture and Horticulture sector

Sl	District	Kharif			Rabi			Total			% of Irrigated	Horticulture	% of Horticulture
		Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total			
1	Anjaw	1097	7370	8467	53	1194	1247	1150	8564	9714	11.84	1482	2.45
2	Changlang	3642	22067	25709	16	5815	5831	3658	27882	31540	11.60	2085	3.45
3	Dibang Valley	595	3441	4036		1536	1536	595	4977	5572	10.68	2876	4.76
4	East Kameng	1600	11054	12654	162	1764	1926	1762	12818	14580	12.09	342	0.57
5	East Siang	6356	14001	20357	1660	2975	4635	8016	16976	24992	32.07	1000	1.66
6	Kurung Kumey	3034	4950	7984	639	4682	5321	3673	9632	13305	27.61	649	1.07
7	Lohit	6377	14449	20826	0	25980	25980	6377	40429	46806	13.62	21001	34.78
8	Lower Dibang Valley	3319	8307	11626		24179	24179	3319	32486	35805	9.27	3322	5.50
9	Lower Subansiri	6430	10450	16880		60	60	6430	10510	16940	37.96	4024	6.67
10	Papum Pare	5030	8247	13277	133	3809	3942	5163	12056	17219	29.98	3191	5.29
11	Tawang	1122	1390	2512		3197	3197	1122	4587	5709	19.65	3260	5.40
12	Tirap	1094	14171	15265	191	2085	2276	1285	16256	17541	7.33	1573	2.61
13	Upper Siang	1571	7063	8634	284	1274	1558	1855	8337	10192	18.20	1776	2.94
14	Upper Subansiri	1881	5312	7193	394	1450	1844	2275	6762	9037	25.17	4291	7.11
15	West Kameng	2353	2270	4623		3916	3916	2353	6186	8539	27.56	5458	9.04
16	West Siang	4810	15463	20273	1594	3144	4738	6404	18607	25011	25.60	4044	6.70
	Total	50311	150005	200316	5126	87060	92186	55437	237065	292502	18.95	60374	100.00

5.1.2 Per Capita Food Demand

Various studies have shown that increasing income and urbanization leads to a change in the food consumption patterns of its people. It is generally accepted that income and urbanization are two major drivers of changing consumption patterns. People from low-income classes increase their nutrition intake through easily accessible crops, such as cereals and pulses. With economic growth, as income and access to other foods increase, people diversify food habits by consuming more non-grain crops and animal products. Studies have illustrated the emerging shift in food consumption patterns in India from food grains to non-grain food crops and animal products. Consumption expenditure survey carried out by Sample Survey Organization (NSSO) show that the average monthly per capita cereal consumption in the urban areas of India has dropped and the corresponding decline in the rural areas for the specified periods. Within the grain products, there is a shift from coarse cereals to superior cereals such as rice and wheat. Studies have also suggested that the per capita grain consumption will decrease further due to the reduction in the physical labor requirement in rural areas. (Source: Changing Consumption Patterns of India: Implications on Future Food Demand, Upali A. Amarasinghe and Om Prakash Singh)

These studies have also forecasted future food requirement. These are basically done at all India level assuming: These studies have also forecasted future food requirement. These are basically done at all India level assuming

- The total calorie supply would continue to increase in the future. The share of grain in consumption basket will decrease in future.
- The dominance of food grains in the consumption basket is likely to decrease in the future, and the consumption of non-grain crops and animal products would increase to provide a major part of the daily calorie supply.
- Feed demand is expected to increase much faster with increasing animal products in the diet.
- Although, total food grain demand will decrease; the total grain demand is likely to increase with the increasing feed demand for the livestock.

To calculate total food production, we need to estimate the following variables for 2030-31:

- Net Sown Area (NSA)
- Cropping Intensity (CI)
- Yield
- On irrigated land
- On un-irrigated land
- Area under irrigation
- Cropping Mix

Food availability is dependent on various factors which change over time. Therefore, to estimate their values in 2030-31, key assumptions must be made for each of the variables. The calculation matrix below shows the possible future of the agriculture under both scenarios in 2030-31. Key findings are mentioned below in brief.

Table 5-5 Food Availability and Requirement in 2030-31

Variable			Units
Population			
	Low Growth Scenario	1975000	
	High Growth Scenario	2054971	
Per capita food requirement		240	Kg /cap/ Yr
Total food demand			
	Low Growth Scenario	474000	MT
	High Growth Scenario	493193	MT
Net Sown Area under Food Crops		180556	Ha
Cropping Intensity		1.27	
GCA (Food Crops)		229306	Ha
Irrigated Area		68503	Ha
Un- Irrigated Area		160802	Ha
Yield	Irrigated Area	2.6	MT/Ha
	Un-Irrigated Area	1.1	MT/Ha
Total Production		354992	MT
Food Shortage in 2031	Low Growth Scenario	119008	MT
	High Growth Scenario	138201	MT

Firstly, a severe food shortage is estimated under both scenarios. Under the low growth scenario deficit in food supplies is estimated at 119008 MT and under high growth scenario, the deficit goes up to 138201 MT. Secondly, the percentage of the total production of food grains the deficit is estimated at 34% under low growth and 39% under the high growth scenario.

At the present, the figures provided by the Agriculture Department the deficit as a percentage of production is estimated at 35%. Although, there is not a huge rise in the percentage of the deficit, in absolute figures the deficit has increased by 40% under low growth and 60% under high growth scenario. This implies that there will be a very high dependency on food supplies from outside the state. Lastly, growth in crop yields is a slow process and land for agriculture expansion is limited. Moreover, double cropping may also not grow rapidly owing to extreme winters at high altitudes and the mindset of the people.

Therefore, one of the assured ways to achieve self-sufficiency is through the expansion of land under irrigation. To achieve this target, in addition to the present irrigation infrastructure, 80,000 to 90,000 hectares in addition to present figures must be irrigated in next two decades.

As per the Minor Irrigation Census 2000-01, the available irrigation potential in Arunachal Pradesh is estimated as 680534 hectares. The total potential created up to 2000-01 is 124250 hectares, out of which the irrigation potential utilized is merely 44478 hectares (Gross Irrigated Area). This makes up around 36% of the total potential created which is considerably low. Out of the total net irrigated land of approximately 40,000 hectares, around 38300 are through surface water irrigation. The share of groundwater in the total net irrigated land is around 774 hectares which are considerably low given that the total groundwater potential estimated to be 150000.

The study has not been able to find reliable time series data on irrigated land in the state to develop a more extensive multiple regression model and from the interviews with the WRD officials and engineers it was found that the growth in irrigated land solely depends on the funds allotted and the manpower that is with the department.

Therefore, it is assumed that no other variable in the past has influenced the expansion of irrigated land other than available funds and manpower resources. There are wide discrepancies between available data from different sources. Therefore, we have used data from the Agriculture Census conducted every 5 years from 1970-71 to 2000-01 to undertake trend analysis. However, this leaves us with very few data points to accurately project the future land under irrigation. Looking at the past trend of the land under irrigation in Arunachal Pradesh it can be seen the trend is almost linear with very slight variation. Therefore, we have fitted a linear function on the times series data and projected till 2030-31. The R-square for the linear fit is 0.91 reflecting the good fit of the linear nature of the past trends. The projected area for the year 2030-31, under gross irrigation given the past pace of expansion is estimated to be 68,500 hectares.

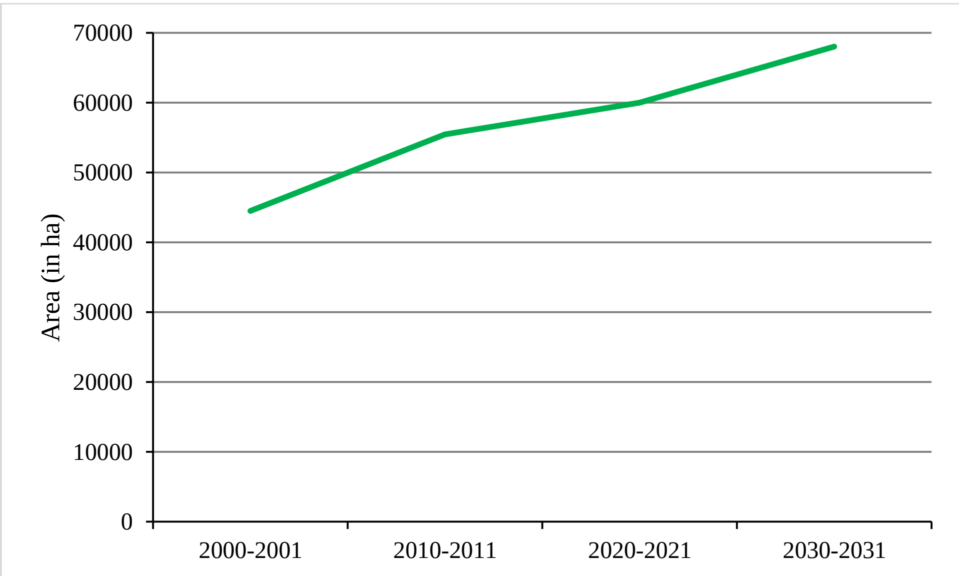

Figure 5-1: Land under irrigation

Table 5-6 Rainfed and Irrigated production and yield

Sl	District	Rainfed Area	Rainfed Prod Q/yr	Rainfed Yield kg/ha	Irrigated Area	Irrigated Prod Q/yr	Irrigated Yield kg/ha	Total Area	Total Prod Q/yr	Total Yield kg/ha	Gross Irrigated (Ha)	Net Irrigated (Ha)	Un-Irrigated (Ha)	Gross Cropped (Ha)
1	Anjaw	8564	96340	1125	1150	15709	1366	9714	112049	1153	1150	1097	10046	11196
2	Changlang	27882	452156	1622	3658	76624	2094	31540	528780	1677	3658	3642	29967	33625
3	Dibang Valley	4977	64383	1294	595	8092	1360	5572	72475	1301	595	595	7853	8448
4	East Kameng	12818	192275	1500	1762	39832	2261	14580	232107	1592	1762	1600	13160	14922
5	East Siang	16976	279265	1645	8016	153510	1915	24992	432776	1732	8016	6356	17976	25992
6	Kurung Kumey	9632	135346	1405	3673	62658	1706	13305	198004	1488	3673	3034	10281	13954
7	Lohit	40429	800247	1892.5	6377	150196	2293	46806	950442	1942.5	6377	5419	61430	67807
8	Lower Dibang Valley	32486	742352	2285	3319	81316	2450	35805	823667	2300	3319	3319	35808	39127
9	Lower Subansiri	10510	128100	1219	6430	108805	1692	16940	236905	1399	6430	6430	14534	20964
10	Pampum Pare	12056	184647	1532	5163	85909	1664	17219	270556	1571	5163	5030	15247	20410
11	Tawang	4587	105867	2308	1122	26599	2371	5709	132446	2320	1122	1122	7847	8969
12	Tirap	16256	266378	1634	1285	21686	1816.5	17541	288064	1648.5	1285	1074	17829	19114
13	Upper Siang	8337	104189	1250	1855	35521	1915	10192	139710	1371	1855	1571	10113	11968
14	Upper Subansiri	6762	86082	1273	2275	31259	1374	9037	117341	1298	2275	1881	11053	13328
15	West Kameng	6186	127456	2060	2353	52968	2251	8539	180279	2111	2353	2353	11644	13997
16	West Siang	18607	220447	1185	6404	101156	1579	25011	321603	1286	6404	4810	22651	29055
	Total	237065	3985530	25229.5	55437	1051840	30107.5	292502	5037204	26190	55437	49333	297439	352876

Moreover, given the minimal exploitation of groundwater potential, it is assumed that most of the irrigation in the state in 2030-31 will be dependent on surface flow irrigation. The detailed summary sheet of irrigated, rainfed and types of cropped area was developed to estimate the crop water reequipment for the future. The table shows the district wise yield under rain-fed and irrigated agriculture lands. The yield is comparatively better by 5000 kg/ha in irrigated lands that the rain-fed.

With growth in government expenditure on state infrastructure, thereby improving connectivity and communication, agriculture sector is expected to perform better than it has in the past few decades. Empirical studies and field survey show that irrigation has a potential to increases crop yields (2-3 times) owing to the increase in availability and reliability with respect to water supply, thereby, directly addressing the issue of food deficit. Cereals and horticultural crops are cultivated on major part of the gross cropped area in the State. The assumptions used are as under: For paddy: 0.03 m per ha, for Maize: 0.045 m per ha, for Millet: 0.15 m per ha, Vegetables: 0.18 m per Ha and for Horticulture crops: 0.015 m per ha. The small portion of area under other crops has been taken in category of vegetables and same assumption has been made for calculation of water requirement of both agriculture and horticulture crops.

Water potential required has been derived from water required by crops cultivated under rainfed conditions. Therefore, the existing water potential represents the water requirement of crops cultivated in irrigated areas. Currently, the total crop water requirement for the State is 16254.75 MCM which is projected to increase to 20073.76 MCM by 2021. The present crop water potential created in the State is 3697.99 MCM. Thus, it can be concluded from the table that a total water potential of 16375.77 MCM is to be created in the State to fulfil the requirement of crops and to provide assured irrigation facilities to farmers of the State

Table 5-7 District-wise Agriculture Water Demand

Sl	District	Gross Crop area (Ha)	Net Irrigated Area (Ha)	Projected Irrigated (Ha)	Existing Water Requirement (MCM)	Existing Water Potential (MCM)	Water Potential Required in 2021 (MCM)	Water Potential to be Created (MCM)
1	Anjaw	11196	1097	10046	556.29	75.56	660.01	584.46
2	Changlang	33625	3642	29967	1815.94	240.34	1968.82	1728.49
3	Dibang Valley	8448	595	7853	248.88	39.07	515.96	476.89
4	East Kameng	14922	1600	13160	792.34	115.77	864.62	748.85
5	East Siang	25992	6356	23466	1285.34	526.62	1541.70	1015.08

6	Kurung Kumey	13954	3034	13365	753.33	241.38	878.09	636.71
7	Lohit	67807	5419	62182	2542.59	418.96	4085.36	3666.40
8	Lower Dibang Valley	39127	3319	35641	2257.16	218.07	2341.64	2123.57
9	Lower Subansiri	20964	6430	13525	825.90	422.49	888.59	466.10
10	Pampum Pare	20410	5030	14142	908.58	339.23	929.11	589.88
11	Tawang	8969	1122	7847	272.53	73.67	504.64	430.97
12	Tirap	19114	1074	17829	1122.24	84.42	1171.34	1086.92
13	Upper Siang	11968	1571	10113	567.24	121.89	664.43	542.54
14	Upper Subansiri	13328	1881	10393	444.34	205.17	682.82	477.65
15	West Kameng	13997	2353	12085	471.46	154.59	793.95	639.36
16	West Siang	29055	4810	24090	1390.58	420.78	1582.67	1161.89
	Total	**352876**	**49333**	**305704**	**16254.75**	**3697.99**	**20073.76**	**16375.77**

Table 5-8 Fish Culture

Year	Govt. Fish Farm (Ha)	People Fish Ponds/Farms (Ha)	Fish Govt. Beels /Lakes (Ha)	Hatcheries (Ha)	Area under Paddy cum-Fish Culture (Ha)	Total area developed for pisciculture (Ha)	Fingerlings Distribution (Lakh)
1993-1994	28	410		9	1082	1681	60
1995-1996	31	635		9	1232	2058	70
1997-1998	31	612		9	872	1622	75
1999-2000	31	807		9	967	1912	80
2000-2002	31	894		11	1071	2103	85
2004-2005	31	1011		11	1171	2388	90
2006-2007	35	1100		11	1200	2465	100
2008-2009	35	6070		6	1325	2700	100
2009-2010	36	6377	107	6	1345	2700	120
2010-2011	36	9200	107	6	1675	3200	150
2011-2012	36	9500	107	6	1675	3200	150
2012-2013	36	10500	104	10	1775	3425	165
2013-2014	33	10650	104	10	1825	3600	169

Table 5-9 Fish Production

Year	Fish Production (Tonnes)	Fish Sheed (Million Nos)	
		Fry	Fingerling
2008-2009	2.7	2.6	10
2009-2010	2.75	2.7	12
2010-2011	2.9	2.7	11
2011-2012	3.01	0	15
2012-2013	3.08	0	18
2013-2014	3.5	0	19.5
2014-2015	4	4.5	0
2015-2016	4.04	5.5	0

5.2 Domestic

The Government of Arunachal Pradesh has been doing the endeavours to ensure adequate potable water and sanitation facilities to the rural people. The responsibility of planning and implementation of drinking water and sanitation programmes is with Public Health Engineering Department (PHED). The department is showing a consistent emphasis on not only rural water supply and sanitation but also on the quality of drinking water and environmental sanitation. Although the amount of rainfall in Arunachal Pradesh is high about the water-holding capacity of the soil in the narrow foothill belt is very low. The torrential rains wash away the top soil on the hill slopes which has further been intensified by continued deforestation and another reason is jhum cultivation. Tanks, ponds etc. are almost negligible in number and the rainwater quickly runs down the slopes and thereafter through innumerable swift-flowing rivers and rivulets to the plains of Assam. The table below shows the number of handpumps, point sources and piped connections in the state. Papum Pare, Kurung Kumey, West Siang, Lohit, tirap, East siang,and Changlang covers 62% of total population. For Lower Dibang Valley, East Siang and Tawang, the no. of piped connections to households is very low in comparison to other districts. East Kameng, Tirap, Kurung Kumey and Lohit have less no. of handpumps in with respect to rural population they accommodate.

Table 5-10 Drinking water supply

Sl	District	Rural Population	Total Houses	No. of habitations	Point Sources (Num.)	Total House Piped Connection	Total hand pumps	Total population Coverage (%)
1	Anjaw	21315	4444	317	1017	252	223	1.71
2	Changlang	138065	25469	482	2833	335	0	11.08
3	Dibang Valley	5620	2830	194	391	140	0	1.14
4	East Kameng	64107	10546	448	783	279	20	5.15
5	East Siang	98718	17537	337	570	185	0	7.92
6	Kurung Kumey	109123	17837	887	1041	398	12	8.76
7	Lohit	120536	20733	352	665	230	14	9.67
8	Lower Dibang Valley	42691	13049	401	289	141	0	5.01
9	Lower Subansiri	73534	11145	666	846	244	87	5.9
10	Papum Pare	102476	17891	626	869	259	0	8.23
11	Tawang	52439	10669	447	181	108	1	4.21
12	Tirap	92314	16073	260	1224	179	17	7.41
13	Upper Siang	28780	8443	212	438	97	0	3.29
14	Upper	72477	12100	741	90	88	0	5.82

	Subansiri							
15	West Kameng	70459	14646	525	767	240	0	5.66
16	West Siang	112629	17360	687	1202	437	223	9.04
	Total	1205283	220772	7582	13206	3612	597	100

Status of access, coverage & slippages (if any) of drinking water supply are provision for the rural population. This includes the water requirement by the households for the purposes such as drinking, cooking, bathing, lawn sprinkling, gardening, sanitary purposes, etc. The amount of domestic water consumption per person shall vary according to the living conditions. The total domestic water demand shall be equal to the total population multiplied by the desirable level of per capita domestic consumption. It has been assumed that per capita daily water requirement of people residing in urban areas of the State is 140 LPCD (litres per capita per day) and for population in rural areas, the daily per capita water requirement is 120 litres. As the last population census was done in 2011, the actual population of the State in 2016 is not readily available. Considering the base population of the State as per the Census 2011, the projected population in 2021 can be assessed by applying the last decadal growth rate of 26.03%. Using the above norms, the annual gross domestic water demand for 2021 for the projected level of population in Arunachal Pradesh would be 78.08 MCM.

Table 5-11 District-wise Domestic Annual water demand

Sl	District	Population (2011)	Population (2016)	Present Water Requirement - 2016 (MCM)	Projected population (2021)	Annual Water Requirement - 2021 (MCM)
1	Anjaw	21167	22972	0.11	24173	0.22
2	Changlang	148226	161700	7.97	173459	8.55
3	Dibang Valley	8004	8407	0.38	9254	0.42
4	East Kameng	78690	90531	4.63	105333	5.38
5	East Siang	99214	104689	4.2	111960	4.49
6	Kurung Kumey	92076	144329	7.11	196582	9.69
7	Lohit	145726	157814	7.16	170904	7.76
8	Lower Dibang Valley	54080	56027	2.54	60285	2.73
9	Lower Subansiri	83030	105466	3.53	133965	4.48
10	Papum Pare	176573	219758	9.79	273505	12.18
11	Tawang	49977	57074	2.57	65178	2.97
12	Tirap	111975	118550	4.5	124658	4.65
13	Upper Siang	35320	36362	1.86	37195	1.9
14	Upper Subansiri	83448	106899	3.23	136941	4.14
15	West Kameng	83947	89206	4.03	94795	4.11
16	West Siang	112274	116861	4.23	138067	4.41
	Total	1383727	1596645	67.84	1856254	78.08

Table above indicates the district-wise projection of water demand in the year 2021 for which the actual decadal growth rate of each district in 2011 Census has been reckoned. In the hilly catchments of the upstream of Arunachal Pradesh plains, natural springs and dug wells are generally the preferred means of fulfilling the needs of freshwater for the present population. In hilly areas, most of the drinking water is harnessed from springs, streams, rivers, ponds and natural water bodies. However, major portion of the domestic water is harnessed from ground water, predominantly through shallow tube wells and dug wells. Although there is abundant surface water in Arunachal Pradesh, ground water continues to play a significant role in meeting the water demands of most communities in the State, especially those in the rural areas, with tube wells and dug wells as the most common means to access water.

5.3 Livestock

The 19th Livestock Census, the last full census exercise, was undertaken in 2012. However, in the year 2016 there were 2759494 numbers of livestock in Arunachal Pradesh. It has been assumed that the existing water potential is equal to present water demand of livestock. Thus, the water potential to be created implies the quantum of water availability to be created to meet the water demand by the livestock in 2021.

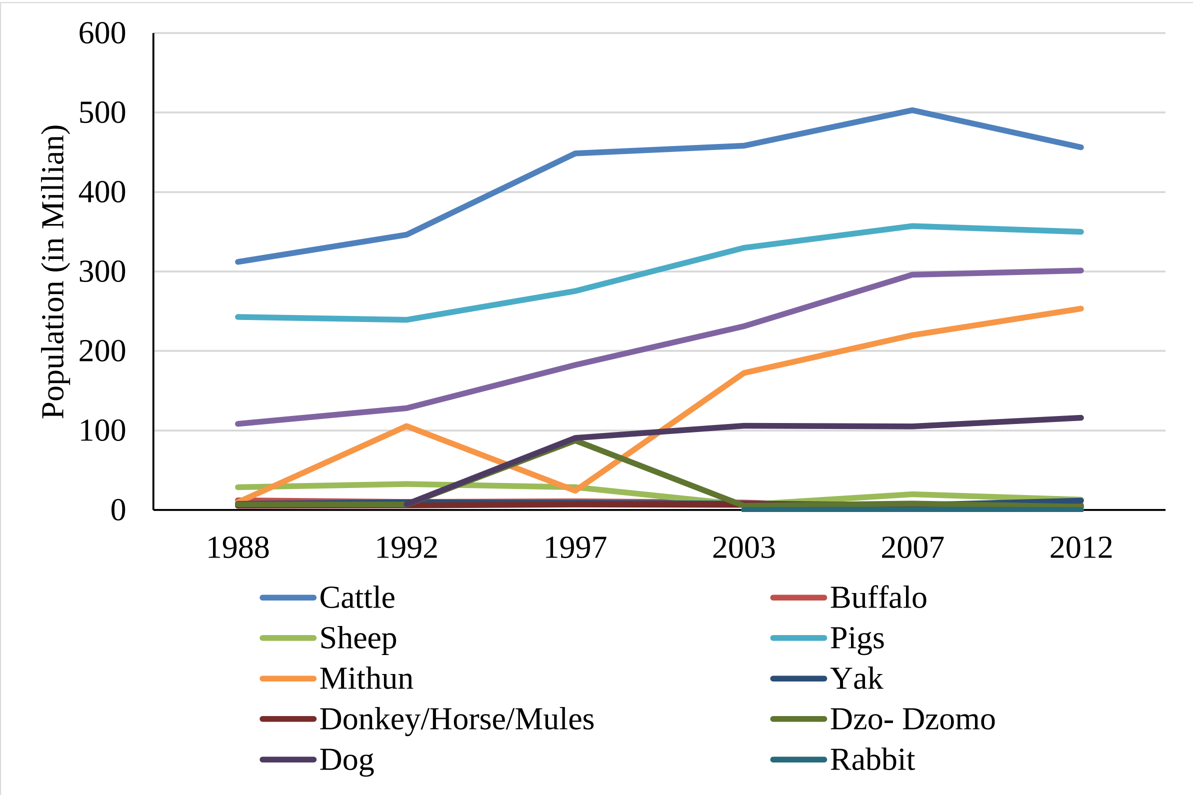

Figure 5-2: Livestock growth

Table 5-12 Livestock population

Species (in Million)	1988	1992	1997	2003	2007	2012
Cattle	312.021	346.535	448.683	458.173	503.124	456.27
Buffalo	12.196	10.241	11.051	9.5	3.189	5.885
Sheep	28.742	32.774	28.472	6.529	19.889	12.877
Goat	108.389	128.134	182.582	231.272	296.196	301.193
Pigs	242.853	239.197	275.372	329.886	357.069	349.89
Mithun	9.83	105.729	24.193	172.504	219.784	253.215
Yak	7.75	9.675	8.921	7.935	5.975	11.899
Donkey/Horse/Mules	5.472	5.814	6.758	6.515	5.754	3.998
Dzo- Dzomo	6.778	6.952	87.502	5.197	8.256	3.865
Dog		7.347	90.598	106.077	105.286	116.105
Rabbit				0.011	0.464	0.208

The species number of different animals in the state observed since 1988 is given above. The number species of buffalo and sheep has greatly reduced since 1988 to 2012. While there is decrease in number of Donkey species, there is high increase in Mithun breed.

In the year 2016 there were 2759494 numbers of livestock in Arunachal Pradesh. It has been assumed that the existing water potential is equal to present water demand of livestock. Thus, the water potential to be created implies the quantum of water availability to be created to meet the water demand by the livestock in 2021.

Table 5-13 District wise information of livestock

		Small Animals						Large Animals					
Sl	District	Poultry	Ducks	Pigs	Goats	Sheep	Total	Indigenous	Hybrid	Buffallo /Mithun	Milch /Meat (any other)	Draft Animal	Total
1	Anjaw	35969	83	15211	5745		57008	5234	457	9758			15449
2	Changlang	137439	14558	29812	35641	581	218031	59609	703	397	3	47	60759
3	Dibang Valley	8340	1049	2000	1526	54	12969	238		28	5565	670	6501
4	East Kameng			31236	22165		53401	28433			20471		48904
5	East Siang	107586	116480	35624	18730		278420	74704	4678	45			79427
6	Kurung Kumey	60690	25100	21400	18976		126166	29672	2542			17069	49283
7	Lohit	132887	7121	16452	33765	0	190225	78232	6945	5560	2061	1871	94669
8	Lower Dibang Valley	68026	8636	15525	22257		114444	26039	3060	2163	17186	3053	51501
9	Lower Subansiri	93818	7957	22526	11612	246	136159	66107	471	10646			77224
10	Papum Pare	133756	21345	36298	44382		235781	100149	4052	398			104599
11	Tawang	12617		5221	8590	8044	34472	24417	1260		2939	9825	38441
12	Tirap	67766	0	19630	16031	0	103427	11728	398	47	5523	0	17696
13	Upper Siang	85789	8969	20891	7690		123339	17336	45			5915	23296
14	Upper Subansiri	36875		22958	19531	406	79770	38063					38063
15	West Kameng	28601	552	5453	11343	3478	49427	16158	145	11	4165	2969	23448
16	West Siang	98713		38632	20032		157377	35285	383			24151	59819
	Total	1108872	211850	338869	298016	12809	1970416	611404	25139	29053	57913	65570	789079

The livestock water requirement of the State has been assessed district wise considering per capita daily water requirement for cows/buffaloes and other large animals as 65 L, goats/pigs 6 L and Poultry 0.25 L. Thus, water demand for livestock of the State during 2021 is expected to be 31.53 MCM as compared to the present demand of 23.41 MCM and, hence, the estimated water potential to be created in the State for its livestock population is 11.75 MCM in addition to the present created potential of 19.78 MCM. The district-wise livestock water demand for the State has been assessed in Table below.

Table 5-14 District-wise Livestock Annual water demand

Sl	District	Livestock - 2016	Current Demand-2016 (MCM)	Projected Livestock - 2021	Water Demand-2021 (MCM)	Existing Potential (MCM)	Potential to be Created (MCM)
1	Anjaw	72457	0.04	79703	0.08	0.03	0.05
2	Changlang	278790	1.18	244332	1.04	1.04	0
3	Dibang Valley	19470	0.16	23169	0.19	0.16	0.03
4	East Kameng	102305	1.65	117806	1.9	1.65	0.25
5	East Siang	357847	1.41	397210	1.72	0.31	1.41
6	Kurung Kumey	175449	2.56	201766	3.07	2.56	0.51
7	Lohit	284894	2.34	376557	3.09	2.18	0.91
8	Lower Dibang Valley	165945	1.29	176234	1.39	1	0.39
9	Lower Subansiri	213383	2.28	717660	3.28	1.85	1.43
10	Papum Pare	340380	3.61	783519	6.76	2.4	4.36
11	Tawang	72912	0.97	80204	1.05	0.97	0.08
12	Tirap	121123	0.44	126357	0.49	0.44	0.05
13	Upper Siang	146635	2.14	190626	3.64	2.14	1.5
14	Upper Subansiri	117833	0.87	128801	0.95	0.86	0.09
15	West Kameng	72875	0.63	78414	0.65	0.63	0.02
16	West Siang	217196	1.83	499963	2.23	1.56	0.67
	Total	2759494	23.41	4222321	31.53	19.78	11.75

The livestock water requirement of the State has been assessed district wise considering per capita daily water requirement for cows/buffaloes and other large animals as 65 L, goats/pigs 6 L and Poultry 0.25 L. Thus, water demand for livestock of the State during 2021 is expected to be 31.53 MCM as compared to the present demand of 23.41 MCM and, hence, the estimated water potential to be created in the State for its livestock population is 11.75 MCM in addition to the present created potential of 19.78 MCM. The district-wise livestock water demand for the State has been assessed.

5.4 Industrial

Arunachal Pradesh is rich in natural resources but due to difficult terrain, inadequate infrastructural facilities and varying climatic conditions, the state could not develop much in the industrial sector of its economy. However, the resources, policy incentives & climate in state support investments in mining & mineral products (including cement), tissue culture & floriculture, plantation crops (tea, rubber, etc.) & agro-based industries. Based on the available information collected from DIPs in each of the 18 districts in Arunachal Pradesh, the total requirement of water by the industries has been assessed and shown, district-wise.

Table 5-15 District-wise Industrial Annual water demand

Sl	District	Present Water demand (MCM)	Water demand - 2021 (MCM)	Existing potential (MCM)	Potential to be created (MCM)
1	Anjaw		4.27	0	4.27
2	Changlang	0.02	0.03	0.02	0.01
3	Dibang Valley				
4	East Kameng				
5	East Siang	0.57	0.62	0.57	0.05
6	Kurung Kumey				
7	Lohit	0.33	0.38	0.33	0.06
8	Lower Dibang Valley	0.03	0.06	0.03	0.06
9	Lower Subansiri				
10	Papum Pare				
11	Tawang	0.12	0.13	0.12	0.02
12	Tirap	0.0015	0.0015	0.0015	0.0001
13	Upper Siang				
14	Upper Subansiri				
15	West Kameng				
16	West Siang				
	Total	1.07	5.49	1.03	4.46

The total assessed water potential to be created for industries is 4.46 MCM. This data is obtained from PMKSY state irrigation Report. Power or electricity is the most convenient and versatile form of energy. It plays a key role in the industrial, agricultural and commercial sectors of the economy and is also the most crucial source of supplying domestic energy requirements. The demand has, therefore, been growing at a rate faster than other forms of energy. The demand of power met mainly from Grid Power, diesel and hydro generation. As of June 2016, Arunachal Pradesh had a total installed power generation capacity of 257.86 MW. Hydro energy (97.57 MW) accounted for around 37.84% of Arunachal Pradesh installed power generation capacity. Though power plays a vital role in the development of the state, Arunachal Pradesh is facing the problem of power shortage. The state continues to be deficit in electric energy. Water demand for power generation is zero in the state as there are no thermal power plants in the state

5.5 Institutional

Medical Institutions

Inhospitable terrain and low population density make redering of health services rather difficult in Arunachal Pradesh. The inventory of medical institutions is taken from different sources like state profile, website and documents available on website of government departments in Arunachal. The medical institutions are categorized under various categories including government, family welfare clinics, medical colleges etc. The number of beds in each category of medical institution is taken from state department web-portals/documents. The water demand for each bed is taken from government norms and according to population

Table 5-16 Water Demand -Medical Institutions

Sl	Districts	State Govt	Private Aided	Total Allopathic	Ayurvedic	Homeopathic	Total	Family Welfare
1	Anjaw					8	8	16
2	Changlang	45		45	1	7	98	30
3	Dibang Valley	14		14		8	36	4
4	East Kameng	61		61		4	126	23
5	East Siang	66		66	1	7	140	50
6	Kurung Kumey	86		86	1	5	178	18
7	Lohit	62		62		4	128	29
8	Lower Dibang Valley	36		36	1	3	76	22
9	Lower Subansiri	66		66	1	9	142	25
10	Papum Pare	73	1	74	5	9	162	32
11	Tawang	24		24		4	52	18
12	Tirap	50		50		6	106	22
13	Upper Siang	20		20		2	42	16
14	Upper Subansiri	57		57	1	7	122	29
15	West Kameng	45		45	2	8	100	27
16	West Siang	69		69	1	5	144	44
	Total	774	1	775	14	96	1660	405

Table 5-17 District-wise Medical Institutions Annual water demand

Sl	Districts	General Hospital	District Hospital	CHC/PHC/HSC	Total	Total Bed	Water Demand
1	Anjaw			(Average estimation)			0.14
2	Changlang		65	70	135	405	0.07
3	Dibang Valley		22	108	130	390	0.07
4	East Kameng		62	78	140	420	0.08
5	East Siang	120		101	221	663	0.12
6	Kurung Kumey			(Average estimation)			0.09
7	Lohit		94	161	255	765	0.14
8	Lower Dibang Valley			(Average estimation)			0.09
9	Lower Subansiri		100	62	162	486	0.09
10	Papum Pare	300		62	362	1086	0.20
11	Tawang		30	24	54	162	0.03
12	Tirap		60	127	187	561	0.10
13	Upper Siang		30	48	78	234	0.04
14	Upper Subansiri		84	30	114	342	0.06
15	West Kameng		75	68	143	429	0.08
16	West Siang		66	171	237	711	0.13
	Total	420	688	1110	2218	6654	1.53

Educational

Arunachal Pradesh is lagging behind in the field of higher education in comparison with the country and the north-eastern region. Non-availability if proper infrastructure facilities in colleges and university due to shortage of fund are the main problems for achieving the goal of higher education. The directorate of higher and technical oversee the establishment and maintenance of collegiate education consisting of eleven colleges and technical education in the state. Due to paucity of funds even the basic minimum infrastructure viz., academic buildings, lecture halls, hostels, residential buildings, water supply, road, sports facility and health care are yet to develop. Any such development needs constant water supply. Dedicated allocation water is required for utilities, canteens, gardening, sports complex and activities. According to the 2001 census, the literacy rate is 68.4%; there are however, concerns over the quality of education, as the relatively high literacy level has not translated into high rate of employment or productivity. Table below depicts no. of different types of educational institutions in the state. The table also lists the number of students in each type of institution. There is only 1 university in state and 25 colleges. The water consumption for each educational institution is calculated based on per student water consumption rates in L/day/student taken from government norms and research publication.

Table 5-18 Water Demand-Education Sector

Sl	Districts	University		Colleges		Higher Secondary		Secondary		Middle		Primary		Pre - Primary
		No.	Students	No.	Students	No.	Students	No.	Students	No.	Students	No.	Students	Students
1	Anjaw				473	2	2811	3	5061	29	9604	48	18884	3744
2	Changlang					1	1988	1	2838	7	6799	18	17260	1539
3	Dibang Valley					10	104	19	104	93	422	178	790	258
4	East Kameng				357	6	1694	10	2399	62	4465	205	13110	1471
5	East Siang			5	3959	12	2841	23	4979	78	9499	144	16616	413
6	Kurung Kumey				59	5	455	8	895	82	5249	164	17354	674
7	Lohit				1639	6	2710	10	4698	27	9109	67	20564	2788
8	Lower Dibang Valley					9	1248	24	1843	67	3890	178	9131	51
9	Lower Subansiri			3	777	7	2186	21	2705	100	6033	162	17043	496
10	Papum Pare	1	1310	6	6978	21	6341	35	9138	98	16804	204	33828	1122
11	Tawang					4	780	11	1034	37	2097	80	4680	1759
12	Tirap				242	8	231	14	512	61	1298	164	3037	214
13	Upper Siang					5	681	4	1221	27	3027	76	5897	1430
14	Upper Subansiri				299	4	1976	13	2735	62	7021	131	17406	854
15	West Kameng			2	877	8	1259	15	2234	57	4574	137	10691	3098
16	West Siang			4	1080	14	3559	18	5842	83	8840	220	19476	1793
	Total			25	16740	122	30864	229	48238	970	98731	2176	225767	21704

Accordingly, the water demand as per existing educational infrastructure comes out to be 7.13 MCM for entre state. The Papum pare, Anjaw and Lohit shows maximum water demand. Dibang Valley, Tirap, Tawang, Upper Siang, Lower Dibang Valley and West Kameng. It is to be noticed that consumption rate for each student gradually decreases from pre-primary to higher education institutions. While in some districts, the number of institutions is more, it is the strength of students which dictates its water demand.

Table 5-19 District-wise Educational Annual water demand

Sl	Districts	University	Colleges	Higher Secondary	Secondary	Middle	Primary	Pre - Primary	Demand (MCM)
1	Anjaw		473	2811	5061	9604	18884	3744	0.66
2	Changlang			1988	2838	6799	17260	1539	0.51
3	Dibang Valley			104	104	422	790	258	0.03
4	East Kameng		357	1694	2399	4465	13110	1471	0.39
5	East Siang		3959	2841	4979	9499	16616	413	0.58
6	Kurung Kumey		59	455	895	5249	17354	674	0.42
7	Lohit		1639	2710	4698	9109	20564	2788	0.67
8	Lower Dibang Valley			1248	1843	3890	9131	51	0.26
9	Lower Subansiri		777	2186	2705	6033	17043	496	0.48
10	Papum Pare	1310	6978	6341	9138	16804	33828	1122	1.15
11	Tawang			780	1034	2097	4680	1759	0.17
12	Tirap		242	231	512	1298	3037	214	0.09
13	Upper Siang			681	1221	3027	5897	1430	0.20
14	Upper Subansiri		299	1976	2735	7021	17406	854	0.50
15	West Kameng		877	1259	2234	4574	10691	3098	0.37
16	West Siang		1080	3559	5842	8840	19476	1793	0.65
	Total	1310	16740	30864	48238	98731	225767	21704	7.13
	Total Demand (MCM)	0.01	0.12	0.34	0.70	1.44	4.12	0.40	
	Consumption (L/day/Student)	20	20	30	40	40	50	50	

5.6 Water uses by Forestry

Forest is the most important resource in Arunachal Pradesh with the predominantly large tribal population living in close association with forests and highly dependent on it. Carbon sequestration of forests of Arunachal Pradesh is very significant in India. Apart from projected vulnerability due to climate change, the forests in Arunachal Pradesh also face several threats and biotic pressures in the form of shifting cultivation, grazing, forest fires, encroachment, commercial plantations, human-wildlife conflicts and illegal extraction of forest products along interstate borders. According to SAPCC Arunachal Pradesh 2030, the rainfall is projected to decrease which makes role of forest in water resources availability more important. Forest affects hydrological regimes through evapotranspiration and holding under the soil. In this study, SWAT model is used to calculate ET for two landuse classes, namely 2005 & 2012 and Future climate projection 2030. Forest area in each district is taken from state forest department. The area under Anjaw and Lohit is not available due to division of two districts. The total forest area in a district is fractioned out using total district area, and then ET is calculated as water use.

The table shows total ET and water consumption under forest category in each district. The water consumption is calculated for two periods, 2005 and 2012 respectively. The change between two is reported. The state reflects positive value of ET overall, and shows increased ET in 2012, in comparison to 2005. The water consumption for different districts shows negative and positive values, both. The change in consumption might be a function of various happenings, 1) decrease of dense forest; 2) conversion of dense forest into open forest or degraded forest; 3) the degraded forest converted into open forest 4) Open forest converted into dense forest and 5) Forest plantation. The negative values show decrease in water consumption, due to dense forest converted into either open or degraded whereas increase in consumption due to either degraded forest converted into open forest or forest plantation. The under the same land use practice (2012) future water consumption was increased in 2030 which function of future rainfall and temperature.

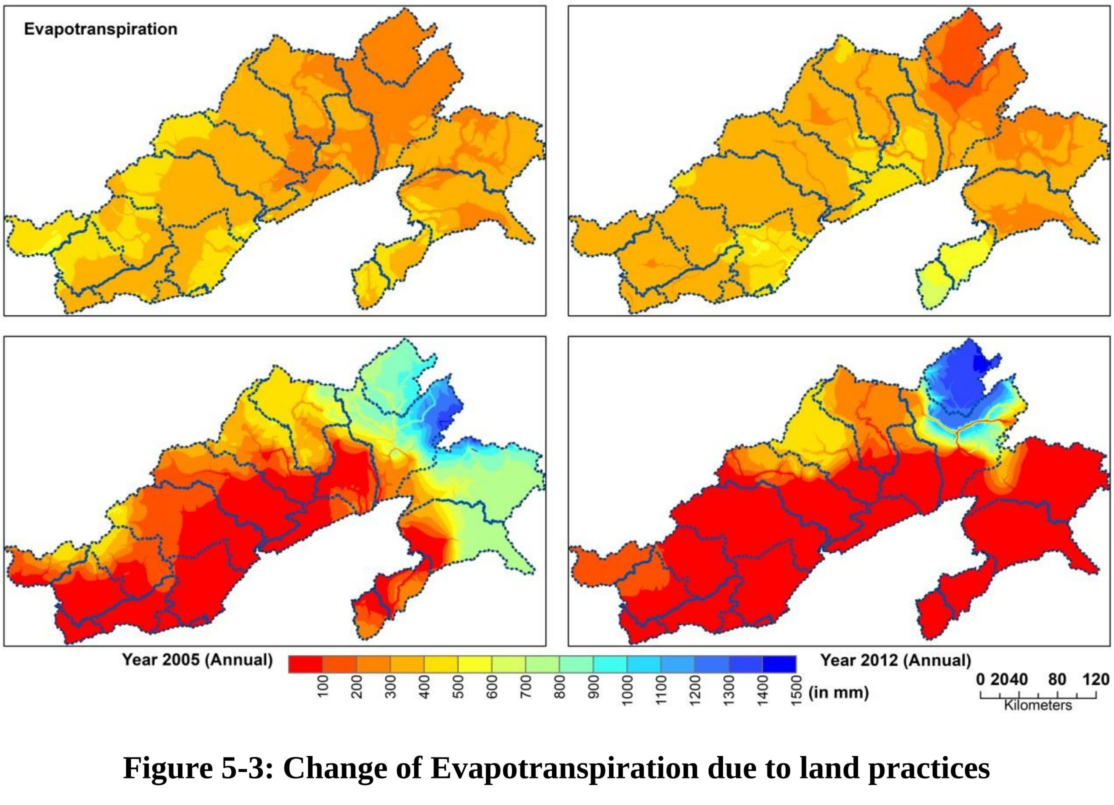

Figure 5-3: Change of Evapotranspiration due to land practices

Table 5-20 Water Demand by Forestry

Sl	District	2005			2012			Land Practice Impact		2030			Climate Change Effects	
		Area (Km^2)	ET (mm)	Water Uses (MCM)	Area (Km^2)	ET (mm)	Water Uses (MCM)	Change	Change (%)	Area (Km^2)	ET (mm)	Water Uses (MCM)	Change	Change (%)
1	Anjaw	4562.50	310.38	1416.10	4412.00	307.21	1355.40	-60.70	-0.28	4412.00	468.00	2064.82	709.42	3.27
2	Changlang	4168.02	336.33	1401.84	4072.12	336.80	1371.51	-30.33	-0.14	4072.12	456.21	1857.75	486.25	2.24
3	Dibang Valley	4181.07	251.97	1053.52	4162.23	226.24	941.66	-111.85	-0.52	4162.23	518.54	2158.26	1216.60	5.60
4	East Kameng	3596.11	399.04	1435.01	3591.26	352.11	1264.54	-170.47	-0.79	3591.26	453.48	1628.57	364.04	1.68
5	East Siang	3419.27	304.06	1039.65	3419.27	407.80	1394.38	354.72	1.64	3419.27	466.13	1593.84	199.46	0.92
6	Kurung Kumey	5620.02	381.69	2145.08	5620.02	349.83	1966.04	-179.04	-0.83	5620.02	423.01	2377.34	411.29	1.89
7	Lohit	2610.92	318.89	832.59	2565.77	340.15	872.76	40.17	0.19	2565.77	440.55	1130.36	257.60	1.19
8	Lower Dibang Valley	2847.72	307.21	874.84	2847.72	343.79	979.00	104.17	0.48	2847.72	551.34	1570.07	591.07	2.72
9	Lower Subansiri	2387.30	379.73	906.53	2684.07	380.99	1022.61	116.08	0.54	2684.07	463.95	1245.28	222.67	1.03
10	Papum Pare	2563.85	401.62	1029.69	2539.60	466.49	1184.70	155.01	0.72	2539.60	540.60	1372.90	188.20	0.87
11	Tawang	861.38	475.34	409.45	861.38	330.61	284.78	-124.67	-0.58	861.38	464.18	399.84	115.06	0.53
12	Tirap	1547.12	443.47	686.10	1324.95	584.32	774.20	88.10	0.41	1324.95	557.01	738.01	-36.19	-0.17
13	Upper Siang	4584.59	332.58	1524.74	4545.08	358.51	1629.44	104.70	0.48	4545.08	432.14	1964.11	334.67	1.54
14	Upper Subansiri	5431.65	372.85	2025.17	5431.65	342.42	1859.91	-165.26	-0.76	5431.65	450.94	2449.36	589.45	2.72
15	West Kameng	5584.19	390.76	2182.05	5584.19	321.10	1793.07	-388.99	-1.80	5584.19	477.00	2663.64	870.58	4.01
16	West Siang	6247.72	338.47	2114.66	6247.72	349.66	2184.60	69.94	0.32	6247.72	474.87	2966.83	782.23	3.60
	Total	60213.44	359.02	21618.04	59909.03	362.38	21709.68	91.64		59909.03	477.37	28598.93	6889.25	

5.7 Sectorwise banchmark from the state average

The resources which requires water as consumption and future demand of each districts was summarized with state average. The standards scores of each consumer sectors was calculated from the state average value. All the districts have assigned the standards score for each resource variables. These water consumers further dived into five groups:

1) Land and population: In this group district wise population, rural population, total district area and agriculture area was compared with state average.
2) Domestic and livestock: In this group district wise house cover with pipe connection, population covered with drinking water, ground water availability for domestic uses and total number of livestock were considered.
3) Agriculture sector: This groups data was summarised with net sown area, total agriculture area, rain fed area, horticulture area and production of agriculture.
4) Irrigation status: All districts was scored with respect to state average in the various component of irrigation supports like Surface irrigation, Groundwater irrigation, Net irrigated area, Canal irrigated area, Pond irrigated area, Net groundwater availability for irrigation and Gross irrigated area.
5) Medical and Educational sector: Four parameters was evaluated consideting the water accounting for this sector. These four parameters was total number of medical institution, numbers of beds, Total numbers of Educational institutes and numbers of students.

These are demand sides variables which contributes the regional variation of resource distribution, utilization, current demands and supply.

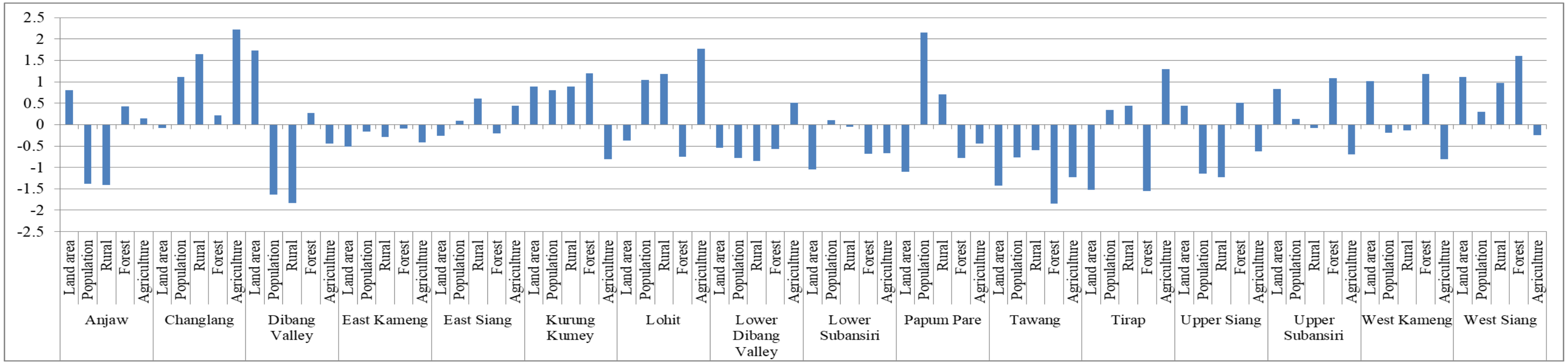

Figure 5-4: Benchmarking land and population

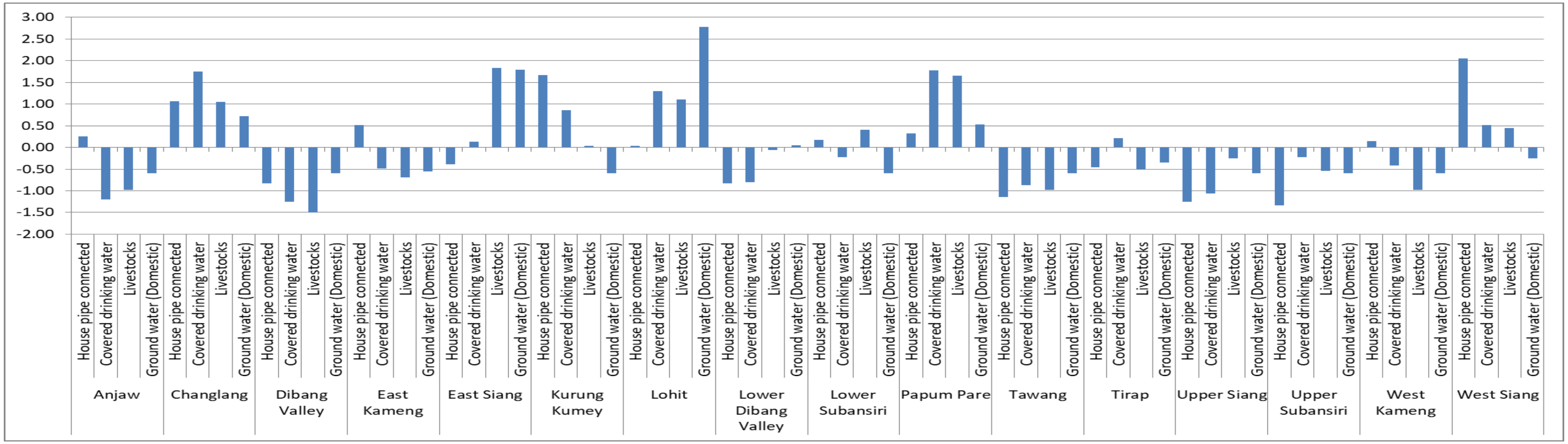

Figure 5-5: Benchmarking Domestic and Livestock

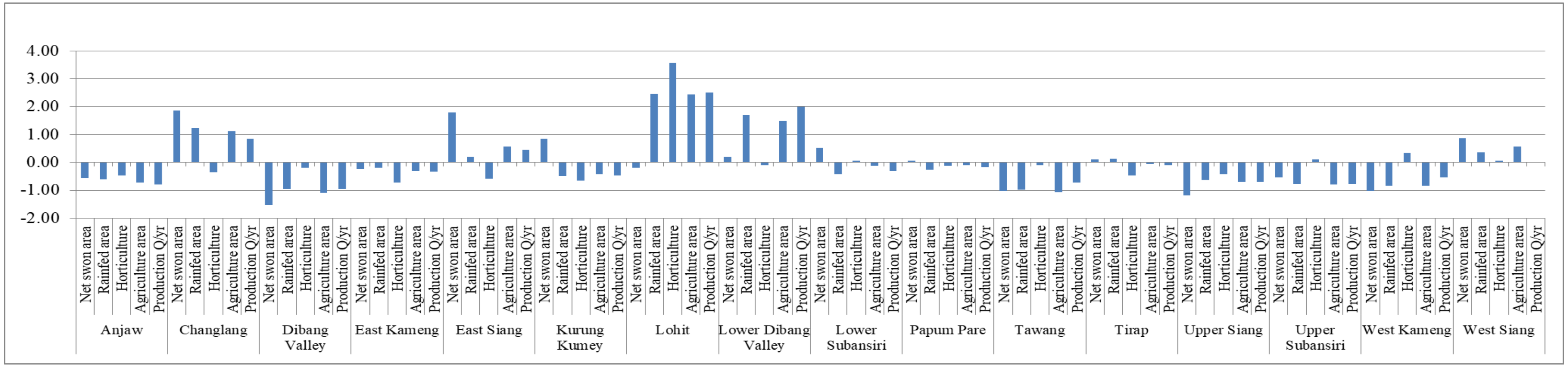

Figure 5-6: Benchmarking Agriculture sector

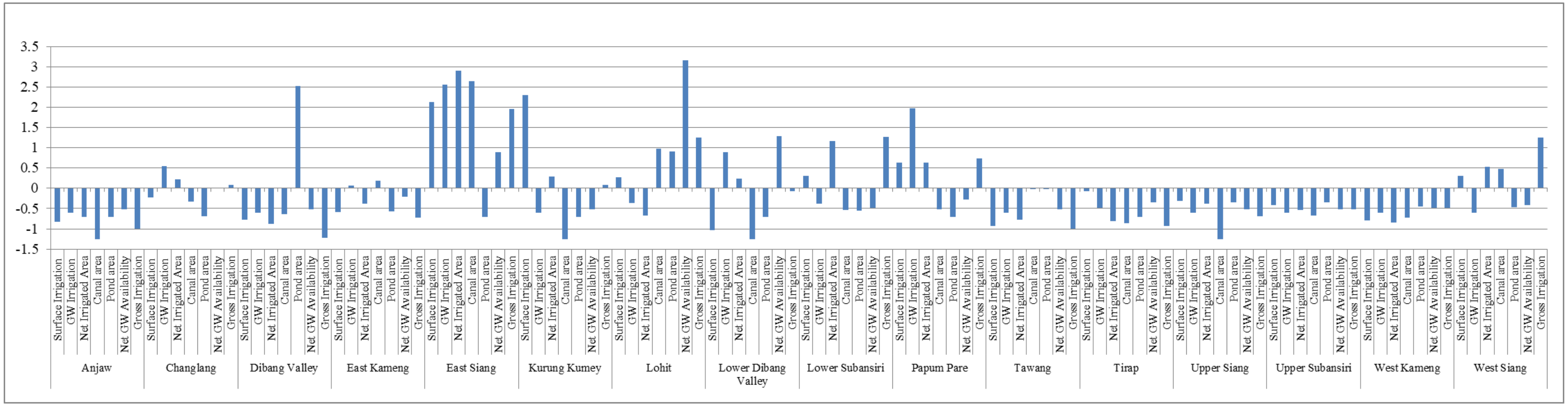

Figure 5-7: Benchmarking Irrigation sector

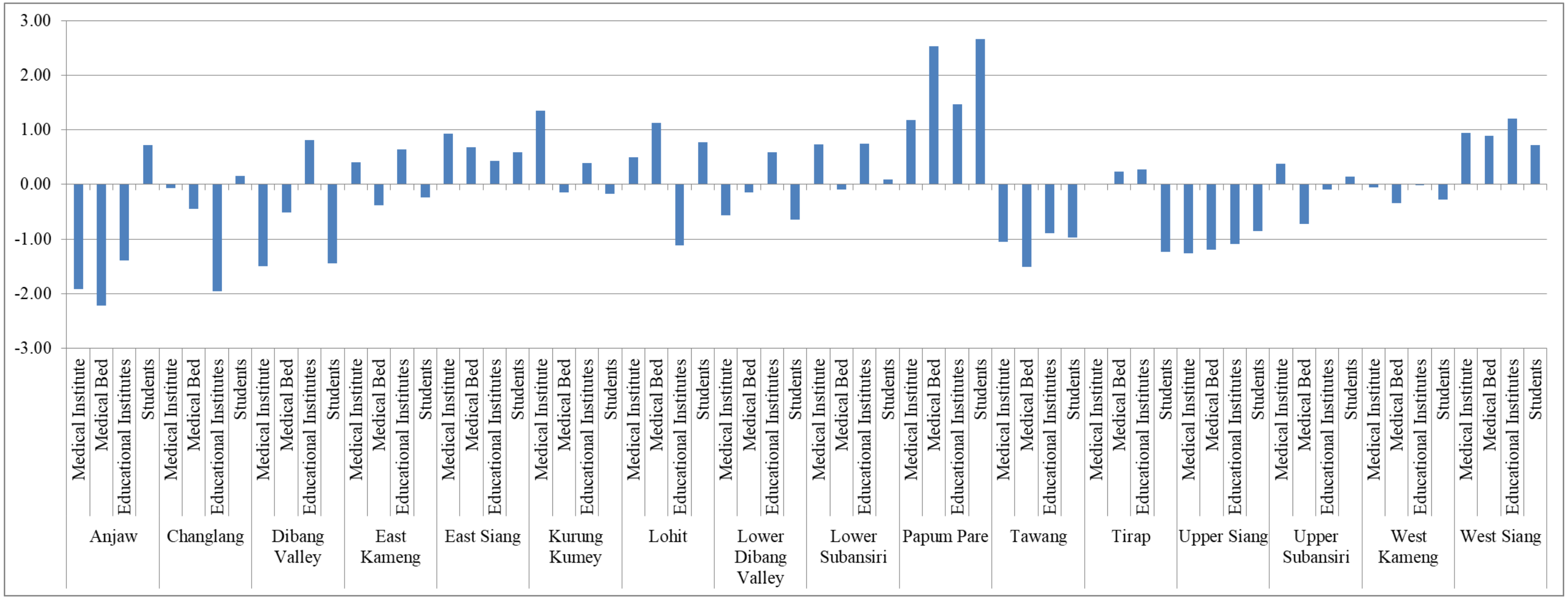

Figure 5-8: Benchmarking of Institutional sectors

6 Sectoral Water Budget: Potential created and utilized

6.1 Present Water demand

The present water demand corresponds to total water delivered to a sector for specific use. There are not many big water consuming industries in many districts, while the total water allocated or delivered to industries sums up to 1.07 MCM. While the largest industrial demand is in East Siang district, it is very less compared to the water demand in other sectors. In health sector and education sector the demand is 1.53 and 7.13 MCM respectively.

Table 6-1 Present water demand of various sector

District	Industries	Medical	Education	Livestock	Domestic	Agriculture	Forestry
Anjaw		0.14	0.66	0.04	0.11	556.29	1355.40
Changlang	0.02	0.07	0.51	1.18	7.97	1815.94	1371.51
Dibang Valley		0.07	0.03	0.16	0.38	248.88	941.66
East Kameng		0.08	0.39	1.65	4.63	792.34	1264.54
East Siang	0.57	0.12	0.58	1.41	4.20	1285.34	1394.38
Kurung Kumey		0.09	0.42	2.56	7.11	753.33	1966.04
Lohit	0.33	0.14	0.67	2.34	7.16	2542.59	872.76
Lower Dibang Valley	0.03	0.09	0.26	1.29	2.54	2257.16	979.00
Lower Subansiri		0.09	0.48	2.28	3.53	825.9	1022.61
Pampum Pare		0.20	1.15	3.61	9.79	908.58	1184.70
Tawang	0.12	0.03	0.17	0.97	2.57	272.53	284.78
Tirap	0.0015	0.10	0.09	0.44	4.50	1122.24	774.20
Upper Siang		0.04	0.20	2.14	1.86	567.24	1629.44
Upper Subansiri		0.06	0.50	0.87	3.23	444.34	1859.91
West Kameng		0.08	0.37	0.63	4.03	471.46	1793.07
West Siang		0.13	0.65	1.83	4.23	1390.58	2184.60
Total	1.07	1.53	7.13	23.41	67.84	16254.75	21709.68

The water demand is obtained from water resource department documents, and is calculated based on no. of beds in different medical institutions. There educational facilities in Arunachal lacks at level of universities, and existing water demand is calculated based on per student per year. Agriculture and forest has demands 16254.75 and 21709.68 MCM respectively, as more than 60% of state is covered in forest. The highest demand in agriculture is posed by Lower Dibang valley and Lohit district. The column graph shows a steady pattern of water demand across the sectors, while in every district, livestock demand is highest next to forest and agricultures, In Anjaw district, third highest demand is in sector of education instead of livestock.

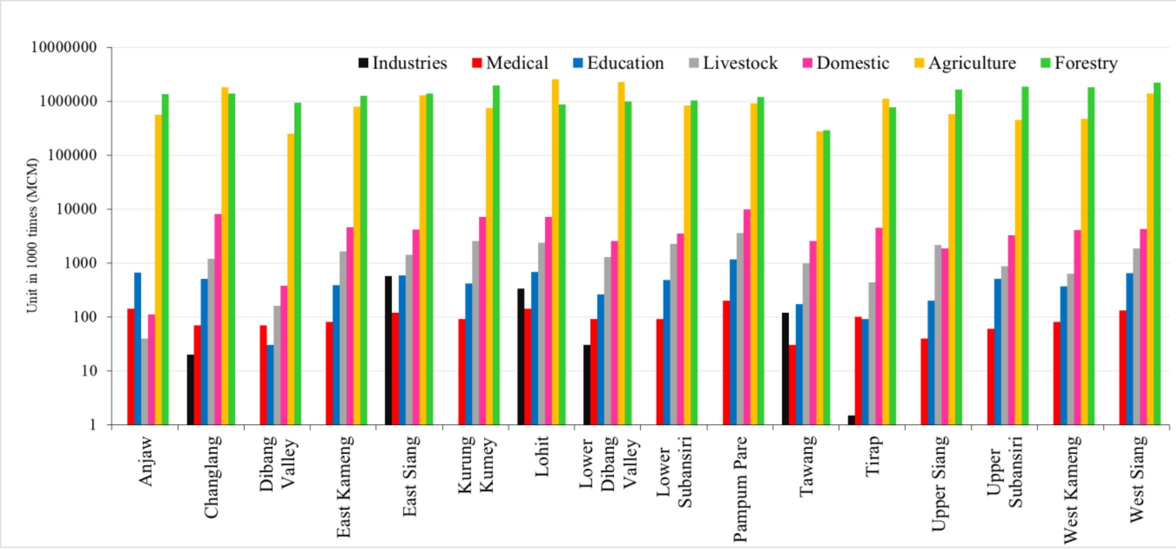

Figure 6-1: Present water demand (in MCM)

6.2 Exiting Potential

Existing water potential here refers to the amount of maximum water which can be tapped for particular use or consumption by creating or already existing infrastructures. For example, districts where few industrial setup is already there, it can harness up to 5.49 MCM of water, while in section 6.1 if you may see, the total present demand is only 1.07 MCM. But that is not the case with agriculture, as the present demand is much higher than the existing potential.

Table 6-2 Existing potential of various sector

District	Industry	Livestock	Domestic	Agriculture
Anjaw	4.27	0.03	0.11	75.56
Changlang	0.03	1.04	7.97	240.34
Dibang Valley		0.16	0.38	39.07
East Kameng		1.65	4.63	115.77
East Siang	0.62	0.31	4.20	526.62
Kurung Kumey		2.56	7.11	241.38
Lohit	0.38	2.18	7.16	418.96
Lower Dibang Valley	0.06	1.00	2.54	218.07
Lower Subansiri		1.85	3.53	422.49
Pampum Pare		2.40	9.79	339.23
Tawang	0.13	0.97	2.57	73.67
Tirap	0.0015	0.44	4.50	84.42
Upper Siang		2.14	1.86	121.89
Upper Subansiri		0.86	3.23	205.17
West Kameng		0.63	4.03	154.59
West Siang		1.56	4.23	420.78
Total	5.49	19.78	67.84	3697.99

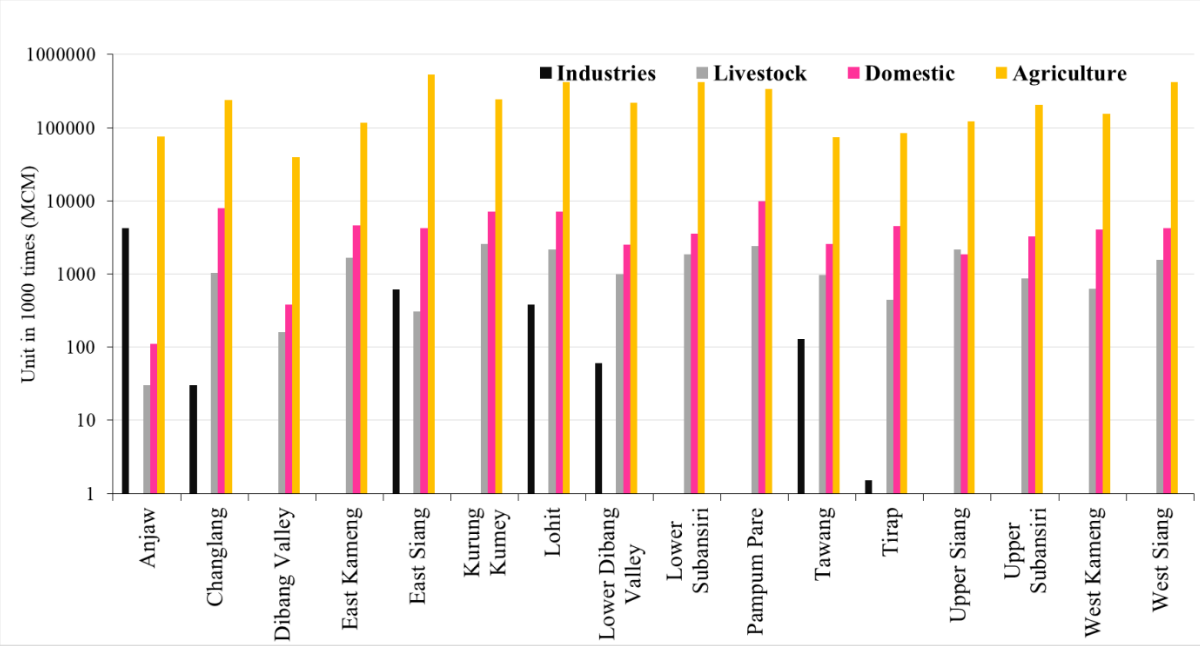

Figure 6-2: Existing potential in various sectors (in MCM)

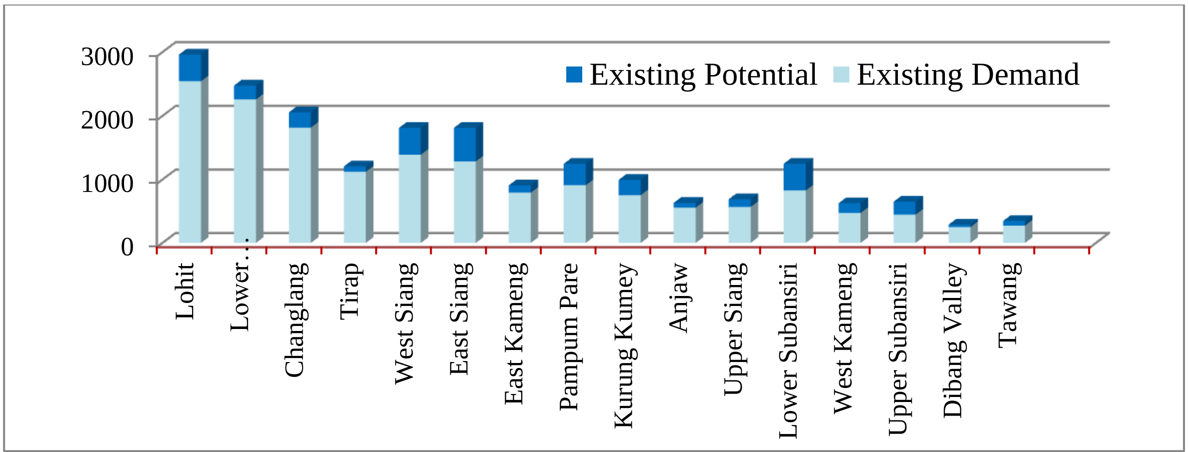

Figure 6-3: Differences between existing potential and current demand (in MCM)

The graph above shows the difference between existing potential and current demand in Agriculture sector. The largest gap is found in Lohit, Lower Dibang Valley, Changlang and Tirap. This gives a possibility of more infrastructures development and technological innovations in agriculture.

6.3 Future demand

The future scenarios can only be predicted. It is difficult to trace exact patterns of growth in different sectors, but based on historical datasets the future possibilities are explored. While calculating future water demand for livestock, previous livestock census is studied for growth rate, and that factor is then used to calculate future possible growth statistics, assuming business as usual scenario. For agriculture sector, Major medium irrigation plans under proposal are considered to get the value of agricultural expansion, also, crops which are currently sown, their water requirement is known and multiplied times its expected growth. For forest it was assumed that no forest degradation and deforestation activities in future.

Table 6-3 Existing potential of various sector

District	Industries	Medical	Education	Livestock	Domestic	Agriculture	Forestry
Anjaw	0			0.08	0.22	660.01	2064.82
Changlang	0.02			1.04	8.55	1968.82	1857.75
Dibang Valley				0.19	0.42	515.96	2158.26
East Kameng				1.9	5.38	864.62	1628.57
East Siang	0.57			1.72	4.49	1541.7	1593.84
Kurung Kumey				3.07	9.69	878.09	2377.34
Lohit	0.33	NA	NA	3.09	7.76	4085.36	1130.36
Lower Dibang Valley	0.03			1.39	2.73	2341.64	1570.07
Lower Subansiri				3.28	4.48	888.59	1245.28
Pampum Pare				6.76	12.18	929.11	1372.9
Tawang	0.12			1.05	2.97	504.64	399.84
Tirap	0.0015			0.49	4.65	1171.34	738.01
Upper Siang				3.64	1.9	664.43	1964.11
Upper Subansiri				0.95	4.14	682.82	2449.36
West Kameng				0.65	4.11	793.95	2663.64
West Siang				2.23	4.41	1582.67	2966.83
Total	1.03			31.53	78.08	20073.76	28598.93

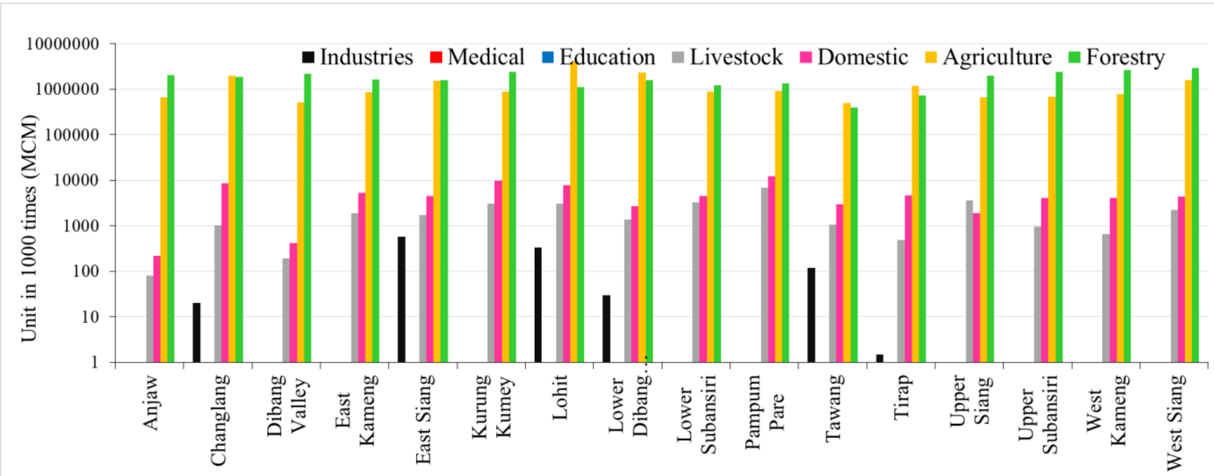

Figure 6-4: Future demand in various sectors (in MCM)

6.4 Potential to be Created

The potential to be created is simply a difference between existing water demand and future water demand in respective sectors. The graph shown above reflects upon the gaps in existing resources and future requirement which needs infrastructure development, technological advancement to wisely tap natural water for fulfilling future requirements. For domestic, industries and livestock, the water requirement will rise with population and development growth, and piped connections availability, freshwater availability, rainwater harvesting, water pollution treatment plants etc can be addressed to fill the potential gap. While for forest, with changing climate and altering rainfall pattern, it is crucial to have studies on environmental flow, and optimum flow in streams so as to support forest ecosystems. West Siang, Changlang, Lower Dibang Valley and Lohit district needs more attention for covering the largest gap in agriculture sector. While in domestic it is Upper Subansiri, Lower Subansiri and Papum Pare districts which shows highest gap and insecurity of water demand fulfilment of future.

Table 6-4 Potential to be created of various sector

District	Industries	Medical	Education	Livestock	Domestic	Agriculture
Anjaw	4.27			0.05	0.11	584.46
Changlang	0.01			0.01	0.58	1728.49
Dibang Valley				0.03	0.04	476.89
East Kameng				0.25	0.75	748.85
East Siang	0.05			1.41	0.29	1015.08
Kurung Kumey				0.51	2.58	636.71
Lohit	0.06			0.91	0.60	3666.40
Lower Dibang Valley	0.03			0.39	0.19	2123.57
Lower Subansiri				1.43	0.95	466.10
Pampum Pare				4.36	2.39	589.88
Tawang	0.02			0.08	0.40	430.97
Tirap	0.0001			0.05	0.15	1086.92
Upper Siang				1.50	0.04	542.54
Upper Subansiri				0.09	0.91	477.65
West Kameng				0.02	0.08	639.36
West Siang				0.67	0.18	1161.89
Total	4.46			11.75	10.24	16375.77

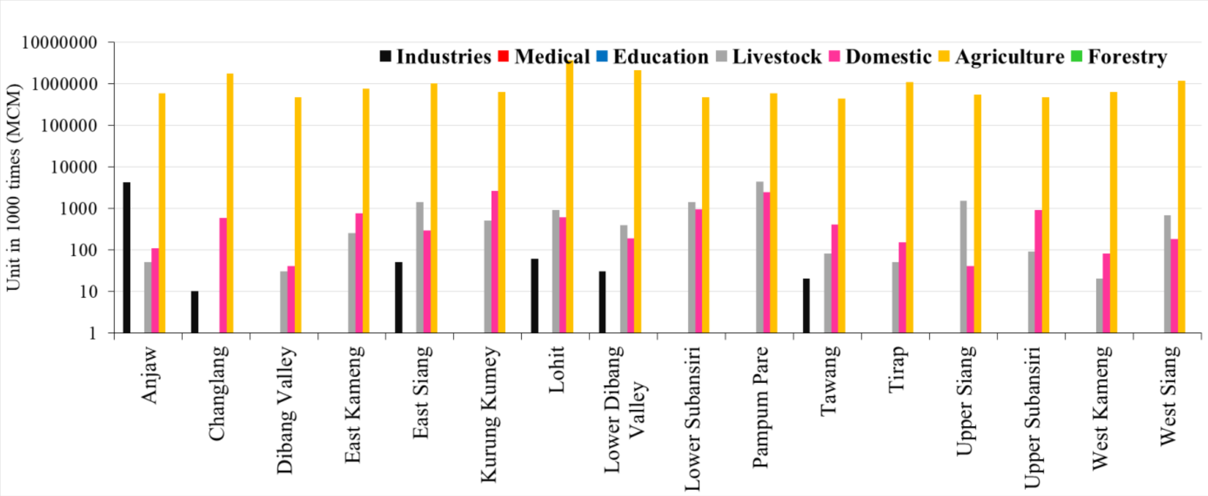

Figure 6-5: Future potential to be created in various sectors (in MCM)

Table 6-5 Sectoral wise water status of Arunachal

	District	Anjaw	Changlang	Dibang Valley	East Kameng	East Siang	Kurung Kumey	Lohit	Lower Dibang Valley	Lower Subans	Pampum Pare	Tawang	Tirap	Upper Siang	Upper Subans	West Kameng	West Siang	Total
Availability	Present availability	10982.67	10237.11	27968.77	9246.95	14046.25	23038.09	10207.98	10685.38	9368.93	8948.70	3457.98	5046.01	20909.93	21980.00	12244.17	23981.20	218652.97
	Future availability	19729.33	15570.80	31292.37	10837.98	9966.17	18459.64	8083.21	13078.37	12297.96	7789.08	6766.51	5659.89	18612.80	20903.26	19326.53	28498.70	246872.61
Agriculture	Present demand	556.29	1815.94	248.88	792.34	1285.34	753.33	2542.59	2257.16	825.9	908.58	272.53	1122.24	567.24	444.34	471.46	1390.58	16254.75
	Existing Potential	75.56	240.34	39.07	115.77	526.62	241.38	418.96	218.07	422.49	339.23	73.67	84.42	121.89	205.17	154.59	420.78	3697.99
	Future Demand	660.01	1968.82	515.96	864.62	1541.7	878.09	4085.36	2341.64	888.59	929.11	504.64	1171.34	664.43	682.82	793.95	1582.67	20073.76
	Potential to be Created	584.46	1728.49	476.89	748.85	1015.08	636.71	3666.4	2123.57	466.1	589.88	430.97	1086.92	542.54	477.65	639.36	1161.89	16375.77
Domestic	Present demand	0.11	7.97	0.38	4.63	4.2	7.11	7.16	2.54	3.53	9.79	2.57	4.5	1.86	3.23	4.03	4.23	67.84
	Existing Potential	0.11	7.97	0.38	4.63	4.2	7.11	7.16	2.54	3.53	9.79	2.57	4.5	1.86	3.23	4.03	4.23	67.84
	Future Demand	0.22	8.55	0.42	5.38	4.49	9.69	7.76	2.73	4.48	12.18	2.97	4.65	1.9	4.14	4.11	4.41	78.08
	Potential to be Created	0.11	0.58	0.04	0.75	0.29	2.58	0.6	0.19	0.95	2.39	0.4	0.15	0.04	0.91	0.08	0.18	10.24
Livestock	Present demand	0.04	1.18	0.16	1.65	1.41	2.56	2.34	1.29	2.28	3.61	0.97	0.44	2.14	0.87	0.63	1.83	23.41
	Existing Potential	0.03	1.04	0.16	1.65	0.31	2.56	2.18	1	1.85	2.4	0.97	0.44	2.14	0.86	0.63	1.56	19.78
	Future Demand	0.08	1.04	0.19	1.9	1.72	3.07	3.09	1.39	3.28	6.76	1.05	0.49	3.64	0.95	0.65	2.23	31.53
	Potential to be Created	0.05	0	0.03	0.25	1.41	0.51	0.91	0.39	1.43	4.36	0.08	0.05	1.5	0.09	0.02	0.67	11.75
Industries	Present demand		0.02			0.57		0.33	0.03			0.12	0.0015					1.07
	Existing Potential	4.27	0.03			0.62		0.38	0.06			0.13	0.0015					5.49
	Future Demand	0	0.02			0.57		0.33	0.03			0.12	0.0015					1.03
	Potential to be Created	4.27	0.01			0.05		0.06	0.03			0.02	0.0001					4.46

Sector	District	Anjaw	Changlang	Dibang Valley	East Kameng	East Siang	Kurung Kumey	Lohit	Lower Dibang Valley	Lower Subans	Pampum Pare	Tawang	Tirap	Upper Siang	Upper Subans	West Kameng	West Siang	Total
Medical	Present demand	0.14	0.07	0.07	0.08	0.12	0.09	0.14	0.09	0.09	0.2	0.03	0.1	0.04	0.06	0.08	0.13	1.53
	Existing Potential																	
	Future Demand																	
	Potential to be Created																	
Education	Present demand	0.66	0.51	0.03	0.39	0.58	0.42	0.67	0.26	0.48	1.15	0.17	0.09	0.2	0.5	0.37	0.65	7.13
	Existing Potential																	
	Future Demand																	
	Potential to be Created																	
Forestry	Present Uses	1355.4	1371.51	941.66	1264.54	1394.38	1966.04	872.76	979	1022.61	1184.7	284.78	774.2	1629.44	1859.91	1793.07	2184.6	21709.68
	Existing potential																	
	Future Uses	2064.82	1857.75	2158.26	1628.57	1593.84	2377.34	1130.36	1570.07	1245.28	1372.9	399.84	738.01	1964.11	2449.36	2663.64	2966.83	28598.93
	Potential to be created																	

7 Climate Change and future

The objective of producing high-resolution datasets that allow for generating quality information on the changes in the climate in high altitudinal reaches of the study areas. TERI has generated scenario information for selected 4.5 RCP and assessed the changes in the near future climate. The dynamic downscaling of climate data is being carried out for two time periods, one in the past and the other for a future time period, 1996-2005 and 2020-2029 respectively. Ten years baseline (1996-2005) of control simulations and 10 years of future simulations (2020-2029) of future simulation has been completed using CCSM4. The Community Climate System Model (CCSM) version 4 is a coupled climate model for simulating the earth's climate system (http://www.cesm.ucar.edu/models/ccsm4.0/) with initial and boundary conditions. The Weather Research and Forecasting model (WRF) has been used for the dynamic downscaling of climate projections from CCSM4. The advantages of the WRF model over other RCMs (Regional Climate Model) is its portability to different computing architectures, efficient use of large parameter space (such as different cumulus schemes, micro-physics schemes, radiation schemes, planetary boundary layer schemes etc.), it was found that there are 10224 combinations of WRF that can be used for both climate and weather research.

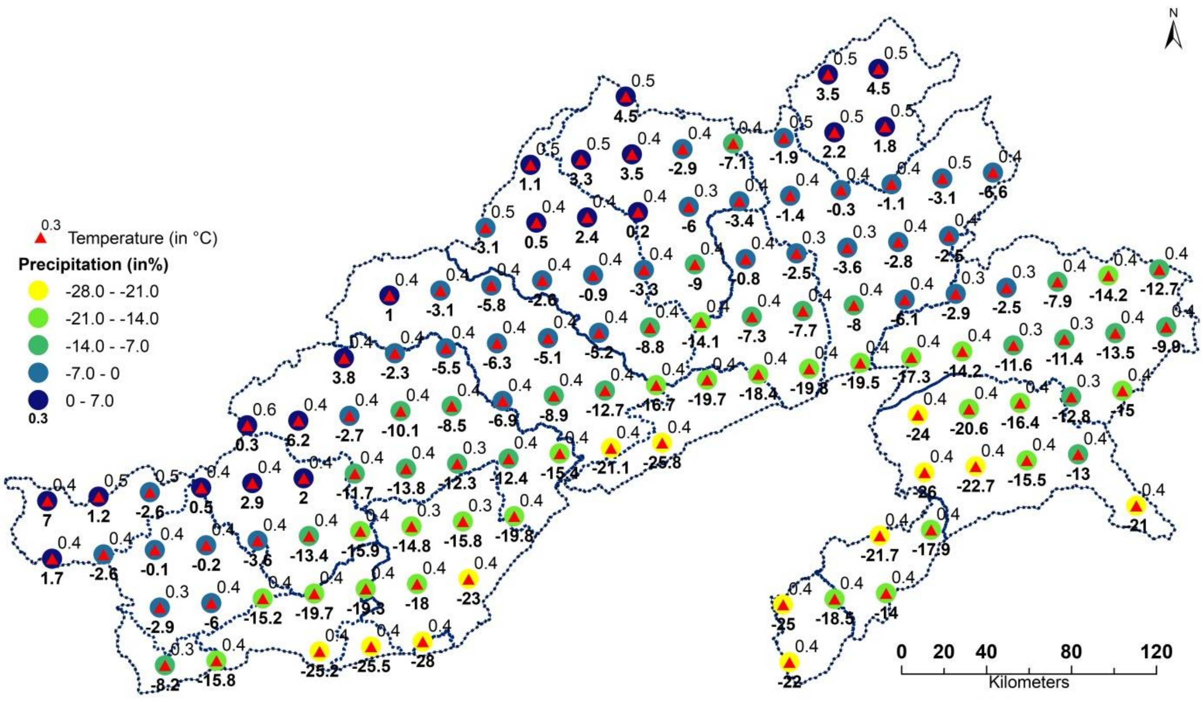

Figure 7-1: Temperature Difference (in °C) and Precipitation differences (in%) from baseline (1996-2005) to future simulations (2020-2029)

Model scenarios have been generated over the South Asian region with 30km resolution (like CORDEX domain) to understand the near future climate change (rainfall, temperature changes etc.). The horizontal resolution is much finer than the CORDEX simulations.

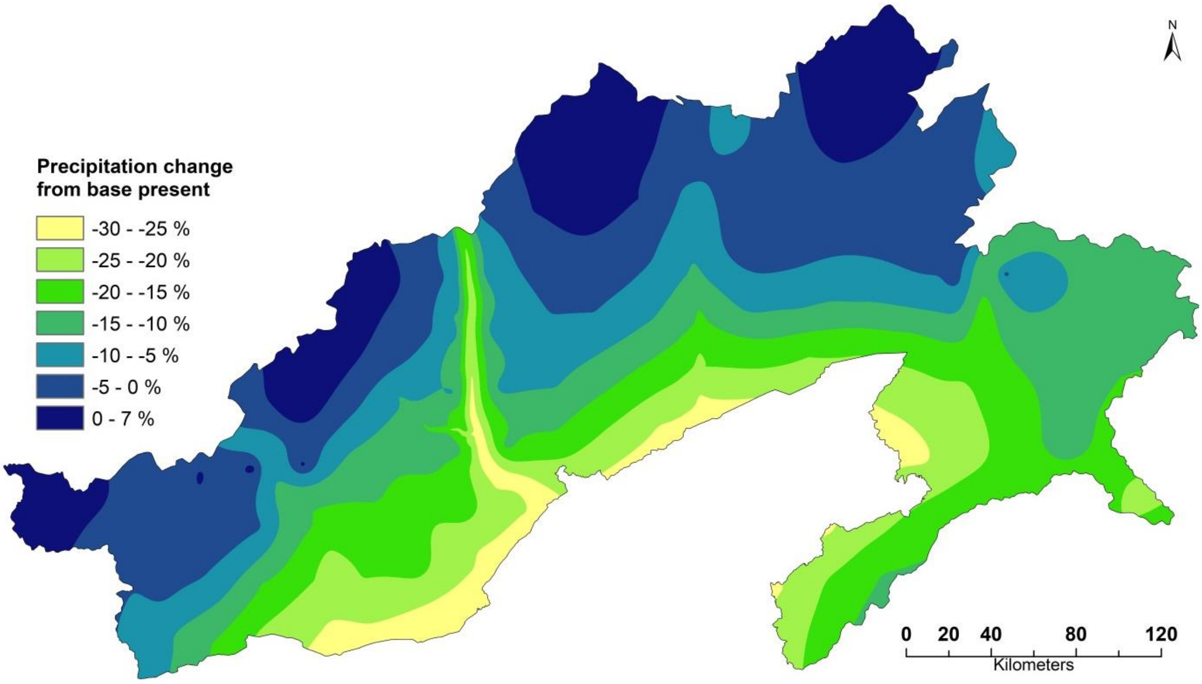

Figure 7-2: Future Precipitation differences (in %) from baseline (1996-2005)

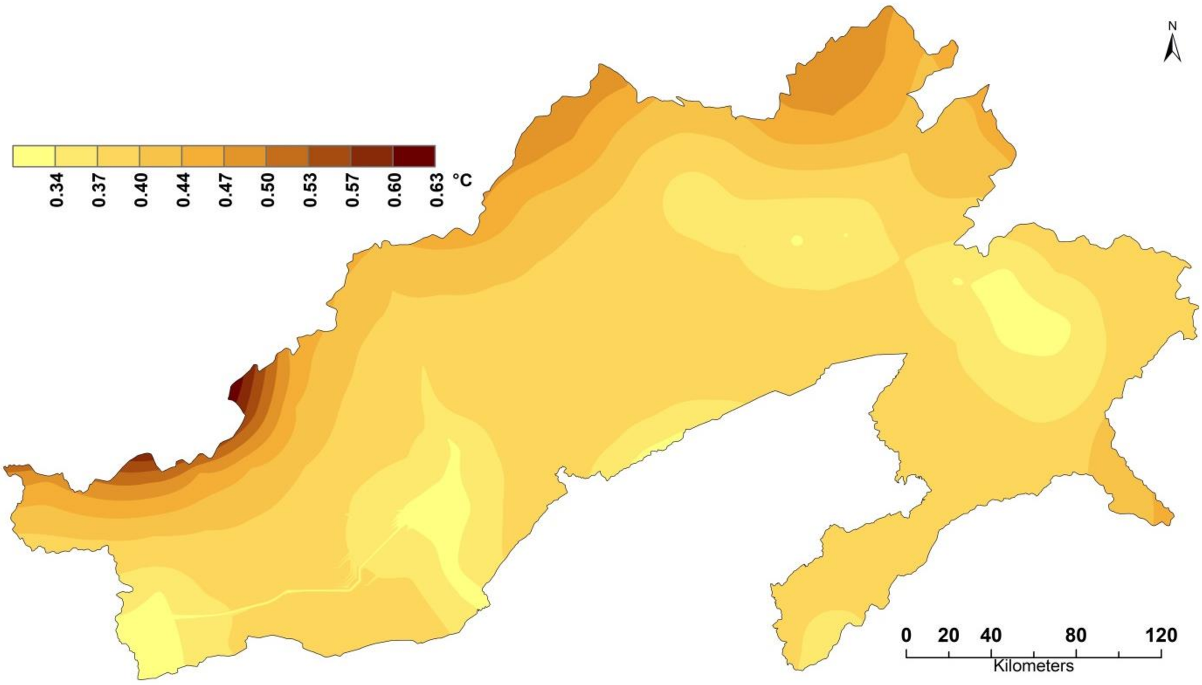

Figure 7-3: Future Temperature increase (in °C) baseline (1996-2005)

Further basic variables (Rainfall, maximum and minimum temperature, wind speed humidity and solar radiation) have extracted from the future scenario to provide input into the hydrological model SWAT to estimate the future surface water changes with respect to climate change.

The % of runoff calculated in two scenario, **First land practice change**: change in land practices during 2005 and 2012 to see the impact of land practices over the runoff and **second Climate parameters change**: the change of future climatic parameters extracted from climate model over 2012 land practices to see the change of runoff due to climate change.

Table 7-1 Change of runoff in Catchment due to land practices and climate change

ID	Code	Catchment	% of Runoff				
			2005	2012	Change in Land Practice	2030	Climate Change
1	3A2C	Dhansiri River	6.33	1.84	-4.48	4.92	3.07
2	3A2D	Twang Chu	26.97	20.38	-6.60	35.18	14.81
3	3A3A	Bhareli River	3.57	3.04	-0.53	2.05	-0.99
4	3A3B	Bishom River	6.59	1.97	-4.62	5.64	3.67
5	3A3C	Kameng River	10.54	5.78	-4.76	14.80	9.02
6	3A3D	Brahmaputra River	21.03	25.05	4.01	0.90	-24.15
7	3A3E	Disang River	15.38	28.28	12.90	29.25	0.97
8	3A4A	Dikrang (Subansiri) River	4.20	5.35	1.16	6.69	1.34
9	3A4B	R B Subansiri River	9.65	9.28	-0.37	9.36	0.08
10	3A4C	L B Subansiri River	10.78	12.18	1.40	7.34	-4.84
11	3A5A	Brahmaputra River	26.28	26.51	0.23	18.09	-8.42
12	3A5B	Dihang River	23.65	30.17	6.51	29.95	-0.22
13	3A5C	Siang River	34.58	35.74	1.16	33.67	-2.07
14	3A5D	Siyom River	11.01	12.53	1.52	8.84	-3.69
15	3A5F	Tirap River	9.14	10.28	1.15	14.95	4.67
16	3D4A	Lohit River	18.98	16.35	-2.63	15.74	-0.61
17	3D4B	Tellu / Lohit River	37.72	26.53	-11.19	34.26	7.74
18	3D4C	Lower Dibang River	45.88	50.34	4.46	48.62	-1.72
19	3D4D	Upper Dibang River	59.52	69.98	10.46	55.72	-14.26
		Over All	20.10	20.61	0.51	19.79	-0.82

Runoff of Brahmaputra, Upper Dibang and L B Subansari river catchment will decreased due to climate change while Lohit, Twang chu, Kameng, Dhansiri and Bishom River decreased their runoff due to land practices. Runoff will increased due to climate change in the catchment of Twang chu, Kemeng Bishom and Dhansiri rivers.

Table 7-2 Change of runoff in districts due to land practices and climate change

Code	Districts	% of Runoff				
		2005	2012	Change in Land Practice	2030	Climate Change
1	Anjaw	41.89	29.41	-12.48	37.11	7.69
2	Changlang	17.68	12.77	-4.90	15.53	2.76
3	Dibang Valley	53.10	60.07	6.97	52.28	-7.79
4	East Kameng	9.45	5.37	-4.09	13.37	8.00
5	East Siang	28.62	29.13	0.52	25.53	-3.61
6	Kurung Kumey	11.06	10.45	-0.61	11.08	0.62
7	Lohit	19.51	18.78	-0.72	15.82	-2.97
8	Lower Dibang Valley	31.96	36.96	5.00	40.14	3.18
9	Lower Subansiri	4.46	5.27	0.80	6.39	1.12
10	Papum Pare	3.67	4.95	1.28	5.41	0.46
11	Tawang	26.97	20.38	-6.60	35.18	14.81
12	Tirap	12.35	23.28	10.93	23.90	0.62
13	Upper Siang	32.63	36.03	3.40	34.10	-1.93
14	Upper Subansiri	12.50	14.50	2.00	8.24	-6.26
15	West Kameng	6.39	2.14	-4.25	5.15	3.01
16	West Siang	7.67	8.48	0.80	6.97	-1.51
	Over All	19.99	19.87	-0.12	21.01	1.14

Similar to catchment runoff of various districts was affected by land practices. Low runoff due to change in practices observed in Anjaw, Changlang, East and west Kameng and Tawang districts where as due to climate change low runoff was observed in Dibang valley and Upper Subansiri. High runoff due to climate change was observed in Tawang, Anjaw, East and west Kemang districts.

7.1 Impact of Land Practices

Two time land use and land cover practices 2005 and 2012 was simulated under present climatic condition (1985-2014). The annual water balance under 2005 land practice and 2012 land practices was calculated. It was observed that over all water volume increased by 11389.05 MCM. The effect of land practices not uniformly increased the water volume in all districts and catchments. Water volume decreased in Lohit, Tawang chu, Bishom, Kameng, Dhansiri and Bhareli catchements. Similarly Anjaw, Changlang, East and West Kameng and Tawang district associated with above catchment decreased annual water volume due to land practices change between two years 2005 and 2012. This need to formulated with best and optimum land practices to control the water balance as per the state requirement and its association with neighbouring state.

Table 7-3 Water balance difference due to Land practices in the catchments

ID	Catchment	Precipitation (in mm)			Snow melt (in mm)			Water Yield (in mm)			Volume (in MCM)		
		2005	2012	Change	2005	2012	Change	2005	2012	Change	2005	2012	Change
1	Dhansiri River	3464.70	2189.90	-1274.80	60.10	0.00	-60.10	3081.97	1892.94	-1189.03	2809.93	1725.85	-1084.08
2	Twang Chu	2955.08	1931.10	-1023.97	248.45	186.68	-61.77	2456.22	1592.07	-864.14	5757.93	3732.18	-2025.75
3	Bhareli River	3061.50	2701.74	-359.76	30.29	0.00	-30.29	2673.27	2337.81	-335.46	6192.44	5415.38	-777.06
4	Bishom River	3616.08	1890.93	-1725.14	70.48	80.67	10.19	3191.08	1573.07	-1618.01	11139.53	5491.32	-5648.21
5	Kameng River	3376.27	2483.86	-892.41	148.64	8.37	-140.27	2966.25	2133.19	-833.06	11946.74	8591.54	-3355.20
6	Brahmaputra River	2451.13	3194.1	742.98	0.00	0.00	0.00	1122.71	2786.09	1663.38	678.97	1684.91	1005.94
7	Disang River	2402.02	3242.66	840.64	135.78	0.00	-135.78	1956.87	2622.06	665.20	2648.32	3548.57	900.25
8	Dikrang (Subansiri) River	2936.56	3804.78	868.22	11.64	0.31	-11.33	2526.50	3316.07	789.57	11344.15	14889.36	3545.21
9	R B Subansiri River	3147.38	3491.24	343.86	123.57	4.70	-118.86	2781.77	3138.56	356.79	23020.56	25973.14	2952.58
10	L B Subansiri River	2897.86	3442.03	544.18	115.57	113.19	-2.38	2529.95	3083.29	553.33	18411.54	22438.36	4026.82
11	Brahmaputra River	3150.00	3287.63	137.63	81.89	0.00	-81.89	2840.35	2860.63	20.28	6520.87	6567.44	46.57
12	Dihang River	2778.71	3377.39	598.68	115.35	52.24	-63.11	2466.09	2945.54	479.45	9662.66	11541.24	1878.59
13	Siang River	3004.82	3852.02	847.20	437.21	233.33	-203.87	2654.95	3419.34	764.39	16135.11	20780.59	4645.48
14	Siyom River	3003.75	3611.66	607.91	228.82	282.28	53.45	2644.74	3226.16	581.42	15601.69	19031.56	3429.88
15	Tirap River	2629.18	3030.01	400.83	143.36	0.00	-143.36	2214.61	2415.94	201.32	4368.08	4765.17	397.09
16	Lohit River	2504.84	2446.98	-57.86	462.69	9.42	-453.27	2175.84	2109.28	-66.56	13659.08	13241.22	-417.86
17	Tellu / Lohit River	2432.27	2070.26	-362.01	740.81	24.26	-716.55	2144.43	1707.37	-437.06	20335.84	16191.16	-4144.68
18	Lower Dibang River	2527.41	3083.54	556.13	860.32	648.66	-211.66	2245.04	2799.95	554.92	19049.97	23758.64	4708.67
19	Upper Dibang River	2487.38	3836.89	1349.51	886.70	1337.03	450.32	2209.22	3628.83	1419.61	9371.72	15393.83	6022.11
	Total										207263.93	218652.97	11389.05

Table 7-4 Water balance difference due to Land practices in the districts

ID	District	Precipitation (in mm)			Snow melt (in mm)			Water Yield (in mm)			Total water availability (in MCM)		
		2005	2012	Change	2005	2012	Change	2005	2012	Change	2005	2012	Change
1	Anjaw	2419.87	1939.06	-480.80	815.36	29.89	-785.48	2134.20	1573.00	-561.20	14900.95	10982.67	-3918.28
2	Changlang	2507.66	2383.56	-124.11	489.66	7.48	-482.18	2172.71	2019.55	-153.16	11013.48	10237.11	-776.37
3	Dibang Valley	2518.49	3362.17	843.68	974.10	998.60	24.50	2244.11	3121.86	877.75	20104.98	27968.77	7863.80
4	East Kameng	3289.55	2592.03	-697.52	136.88	7.28	-129.61	2884.37	2236.80	-647.56	11923.97	9246.95	-2677.02
5	East Siang	3050.95	3440.54	389.60	167.84	7.71	-160.13	2737.90	2996.85	258.95	12832.55	14046.25	1213.70
6	Kurung Kumey	3242.30	3584.56	342.26	148.52	6.10	-142.42	2871.24	3226.17	354.93	20503.53	23038.09	2534.56
7	Lohit	2525.28	2669.02	143.74	386.25	6.39	-379.86	2210.89	2309.50	98.61	9772.13	10207.98	435.85
8	Lower Dibang Valley	2541.69	2988.32	446.62	405.51	133.48	-272.03	2234.98	2625.40	390.42	9096.37	10685.38	1589.01
9	Lower Subansiri	2955.61	3524.34	568.73	28.66	0.00	-28.66	2579.40	3129.24	549.83	7722.73	9368.93	1646.20
10	Papum Pare	2765.90	3598.79	832.89	11.82	0.56	-11.27	2364.89	3112.59	747.70	6799.06	8948.70	2149.64
11	Tawang	2955.08	1931.10	-1023.97	248.45	186.68	-61.77	2456.22	1592.07	-864.14	5334.90	3457.98	-1876.92
12	Tirap	2437.36	3195.61	758.26	96.99	0.00	-96.99	1977.60	2581.08	603.47	3866.22	5046.01	1179.79
13	Upper Siang	2918.96	3806.24	887.28	383.61	244.41	-139.19	2567.00	3379.11	812.11	15884.57	20909.93	5025.36
14	Upper Subansiri	2899.88	3482.35	582.48	127.33	125.55	-1.78	2529.77	3125.71	595.94	17789.33	21980.00	4190.67
15	West Kameng	3553.25	1972.26	-1580.98	58.30	61.47	3.16	3135.08	1649.71	-1485.37	23268.58	12244.17	-11024.41
16	West Siang	2975.00	3523.80	548.80	211.79	262.91	51.12	2623.71	3137.67	513.96	20053.04	23981.20	3928.16
	Total										207263.93	218652.97	11389.05

7.2 Imapct of climate change

To calculate the impact of future climate on water balance of the area, the future climate parameter was simulated over present land use practices and the water balance for the year 2030 was calculated in SWAT. The input of all climatic parameters was obtained from RCM model under RCP 4.7scenario.

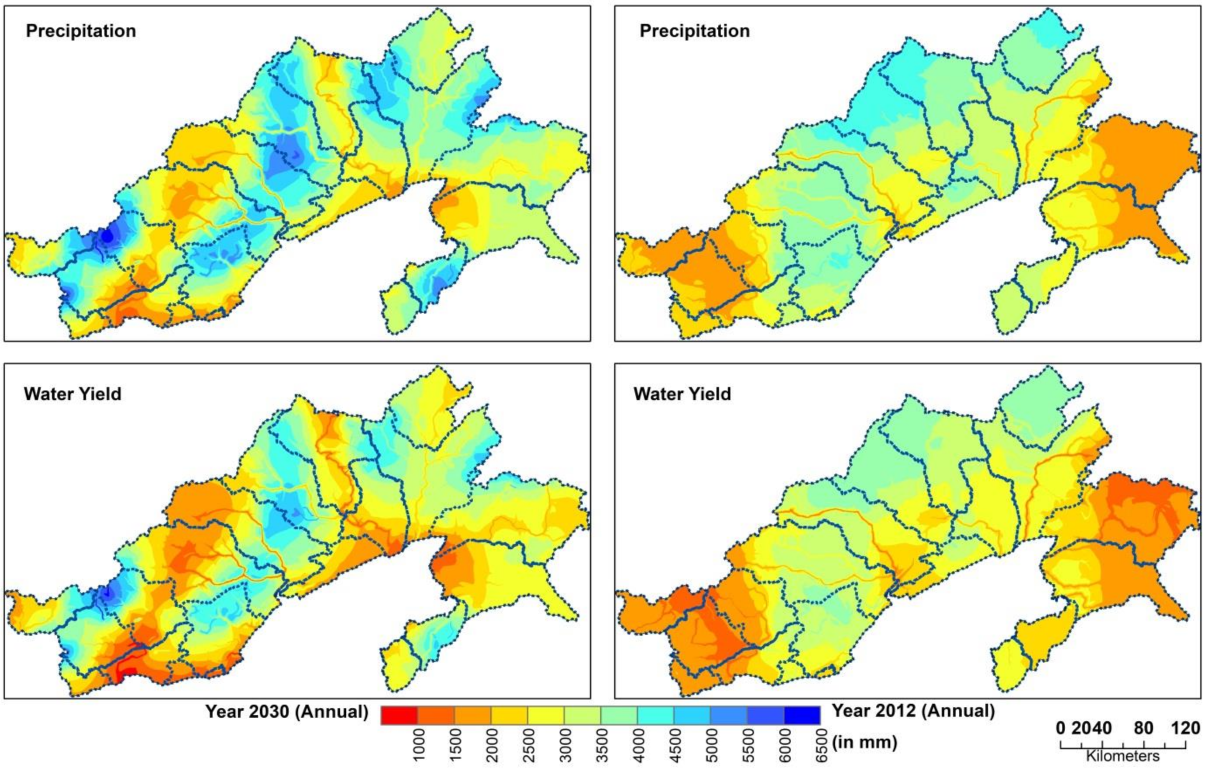

Figure 7-4: Precipitation and water yield during 2012 and 2030

It is observed that overall 22217.37 MCM water volumes will increase due to change in climatic variables. Some catchment and associated districts will also produce low water volume compared to present climatic condition. The water volume will decreased in future in the catchment of - Bhareli river, Brahmaputra river, R B Subansiri river, Dihang river, Siang river and upper Dihang associated with following districts- East siang, Kurung Kumey, Lohit, Papum pare, Upper Siang and Upper Subansiri.

The change in volume either increases or decreases situation requires a better land practices measures to mitigate future climatic condition of water resources.

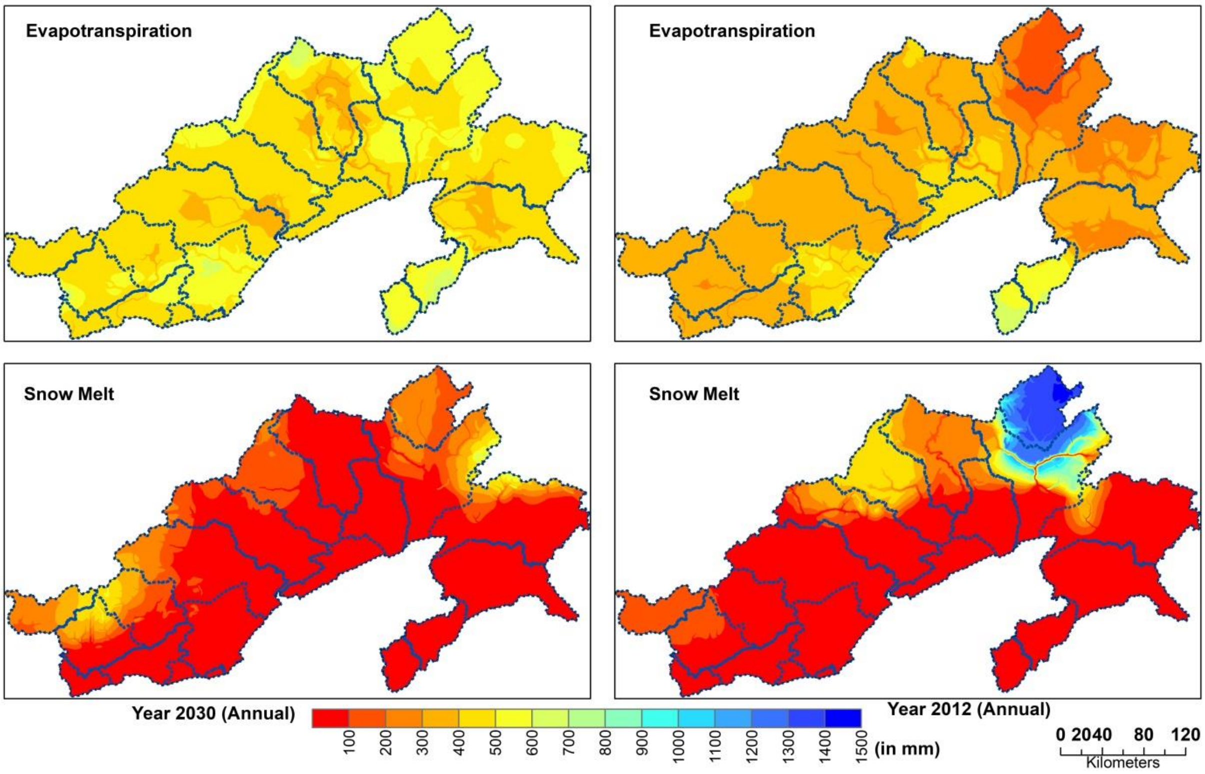

Figure 7-5: ET and Snow melt during 2012 and 2030

Table 7-5 Water balance difference due to Climate Change in the catchments

ID	Name	Precipitation (in mm)			Snow melt (in mm)			Water Yield (in mm)			Volume (in MCM)		
		2012	2030	Change	2012	2030	Change	2012	2030	Change	2012	2030	Change
1	Dhansiri River	2189.90	3287.75	1097.85	0.00	0.00	0.00	1892.94	2880.19	987.25	1725.85	2625.85	899.99
2	Twang Chu	1931.10	3568.70	1637.59	186.68	297.04	110.36	1592.07	3115.33	1523.26	3732.18	7303.13	3570.95
3	Bhareli River	2701.74	2192.99	-508.76	0.00	0.00	0.00	2337.81	1697.46	-640.36	5415.38	4269.58	-1145.79
4	Bishom River	1890.93	3369.38	1478.44	80.67	170.67	89.99	1573.07	2912.61	1339.54	5491.32	9906.13	4414.81
5	Kameng River	2483.86	3103.10	619.24	8.37	164.19	155.82	2133.19	2680.86	547.68	8591.54	11097.32	2505.78
6	Brahmaputra River	3194.1	1597.90	-1596.20	0	0.00	0.00	2786.09	1145.33	-1640.75	1684.91	616.67	-1068.24
7	Disang River	3242.66	3287.50	44.84	0.00	0.00	0.00	2622.06	2731.87	109.81	3548.57	3509.29	-39.28
8	Dikrang (Subansiri) River	3804.78	3971.43	166.64	0.31	6.30	5.99	3316.07	3416.03	99.95	14889.36	14842.63	-46.73
9	R B Subansiri River	3491.24	3318.10	-173.14	4.70	79.90	75.20	3138.56	2902.26	-236.30	25973.14	24793.32	-1179.82
10	L B Subansiri River	3442.03	3463.61	21.58	113.19	54.64	-58.55	3083.29	3010.71	-72.58	22438.36	23488.73	1050.37
11	Brahmaputra River	3287.63	2743.73	-543.90	0.00	0.00	0.00	2860.63	2271.93	-588.71	6567.44	4833.82	-1733.63
12	Dihang River	3377.39	3014.70	-362.68	52.24	0.00	-52.24	2945.54	2518.88	-426.66	11541.24	9553.88	-1987.36
13	Siang River	3852.02	3353.46	-498.56	233.33	14.95	-218.39	3419.34	2881.79	-537.56	20780.59	16877.26	-3903.32
14	Siyom River	3611.66	4174.81	563.14	282.28	95.11	-187.17	3226.16	3697.44	471.28	19031.56	24478.68	5447.12
15	Tirap River	3030.01	4593.30	1563.29	0.00	0.00	0.00	2415.94	3988.05	1572.12	4765.17	7444.00	2678.83
16	Lohit River	2446.98	2902.23	455.24	9.42	0.00	-9.42	2109.28	2444.90	335.62	13241.22	15952.63	2711.41
17	Tellu / Lohit River	2070.26	3145.98	1075.73	24.26	85.47	61.21	1707.37	2672.79	965.42	16191.16	24474.74	8283.58
18	Lower Dibang River	3083.54	4067.55	984.01	648.66	175.79	-472.87	2799.95	3539.13	739.18	23758.64	27758.18	3999.54
19	Upper Dibang River	3836.89	3596.28	-240.61	1337.03	230.26	-1106.77	3628.83	3091.26	-537.57	15393.83	12765.51	-2628.31
	Total										218652.97	240870.35	22217.37

Table 7-6 Water balance difference due to Climate Change in the districts

ID	District	Precipitation (in mm)			Snow melt (in mm)			Water Yeild (in mm)			Total water availability (in MCM)		
		2012	2030	Change	2012	2030	Change	2012	2030	Change	2012	2030	Change
1	Anjaw	1939.06	3302.17	1363.11	29.89	105.29	75.40	1573.00	2825.74	1252.74	10982.67	19729.33	8746.66
2	Changlang	2383.56	3557.23	1173.67	7.48	0.00	-7.48	2019.55	3071.77	1052.22	10237.11	15570.80	5333.70
3	Dibang Valley	3362.17	4007.71	645.54	998.60	221.79	-776.82	3121.86	3492.84	370.98	27968.77	31292.37	3323.60
4	East Kameng	2592.03	3053.77	461.73	7.28	142.77	135.49	2236.80	2621.67	384.87	9246.95	10837.98	1591.04
5	East Siang	3440.54	2626.48	-814.07	7.71	0.00	-7.71	2996.85	2126.34	-870.51	14046.25	9966.17	-4080.07
6	Kurung Kumey	3584.56	3004.32	-580.25	6.10	103.65	97.55	3226.17	2585.02	-641.15	23038.09	18459.64	-4578.44
7	Lohit	2669.02	2274.20	-394.81	6.39	0.00	-6.39	2309.50	1828.78	-480.72	10207.98	8083.21	-2124.77
8	Lower Dibang Valley	2988.32	3776.12	787.81	133.48	57.34	-76.15	2625.40	3213.36	587.96	10685.38	13078.37	2392.99
9	Lower Subansiri	3524.34	4578.82	1054.47	0.00	0.00	0.00	3129.24	4107.53	978.30	9368.93	12297.96	2929.03
10	Papum Pare	3598.79	3248.13	-350.66	0.56	11.20	10.64	3112.59	2709.24	-403.35	8948.70	7789.08	-1159.62
11	Tawang	1931.10	3568.70	1637.59	186.68	297.04	110.36	1592.07	3115.33	1523.26	3457.98	6766.51	3308.53
12	Tirap	3195.61	3457.30	261.69	0.00	0.00	0.00	2581.08	2895.09	314.01	5046.01	5659.89	613.89
13	Upper Siang	3806.24	3473.09	-333.15	244.41	19.19	-225.22	3379.11	3007.89	-371.22	20909.93	18612.80	-2297.13
14	Upper Subansiri	3482.35	3424.49	-57.86	125.55	58.60	-66.95	3125.71	2972.59	-153.12	21980.00	20903.26	-1076.74
15	West Kameng	1972.26	3065.43	1093.16	61.47	130.03	68.57	1649.71	2603.95	954.24	12244.17	19326.53	7082.36
16	West Siang	3523.80	4204.19	680.39	262.91	87.35	-175.56	3137.67	3728.73	591.06	23981.20	28498.70	4517.50
	Total										218652.97	240870.36	22217.39

7.3 Benchmark from the state climate change

The detailed table for existing resources (Agriculture, forest and snow / glacier), present and future climate based water budget was contracted for each district and catchment. Further a standard scores was calculated from model outputs giving values for future as well as current climatic conditions of each catchment and district to benchmark from the state condition. For this analysis, the landuse is not changed, and only climatic parameters are used as a variable. To know present situation of climate, historic climatic parameters from IMD is used to run model. The values obtained across different sub-catchments shows amount of precipitation, snowmelt, Evapotranspiration and water yield. If looked carefully, it is observed that the largest catchment Lohit with high forest and agricultural landuse, shows least present precipitation and water yield. The Disang river catchment shows decrease ET in future. While Tirap river catchment shows increased precipitation, while there is very little change in ET. It is interesting to note that catchments with highest forest area shows high future present and future water yield irrespective of precipitation. In fact the largest catchment shows least present precipitation in current scenario.

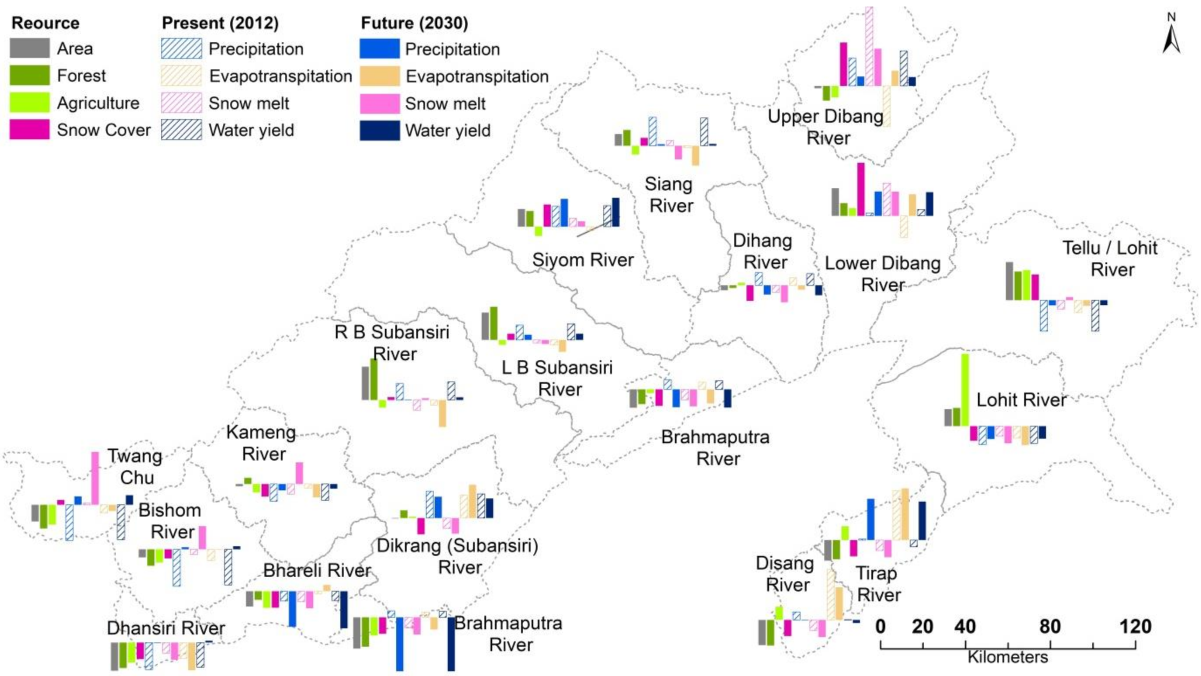

Figure 7-6: Resources and water balance benchmark of each catchment from the state

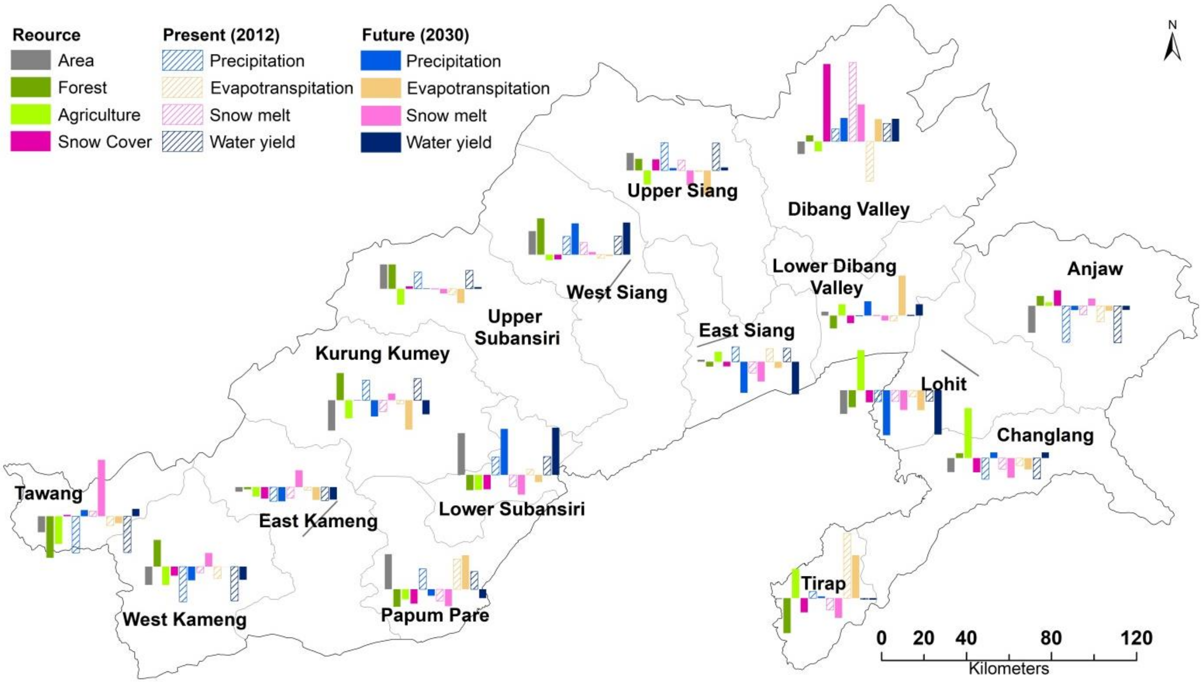

Figure 7-7: Resources and water balance benchmark of each district from the state

Table 7-7 Resources and Water balances of each catchments

Catchment Name	Catchment area	Forest	Agriculture	Snow /Glacial	Water balance present 2012 (in mm)					Water balance future 2030 (in mm)				
					Precipitation	Snow Melt	ET	Water Yield	Volume (MCM)	Precipitation	Snow Melt	ET	Water Yield	Volume (MCM)
Dhansiri River	911.69	852.34	10.56	0.00	2189.90	0.00	296.52	1892.94	1725.85	3287.75	0.00	415.26	2880.19	2625.85
Twang Chu	2344.25	1020.07	13.66	548.17	1931.10	186.68	330.61	1592.07	3732.18	3568.70	297.04	464.18	3115.33	7303.13
Bhareli River	2515.29	2380.63	48.28	0.00	2701.74	0.00	355.32	2337.81	5415.38	2192.99	0.00	492.61	1697.46	4269.58
Bishom River	3401.12	1664.36	87.20	190.65	1890.93	80.67	317.29	1573.07	5491.32	3369.38	170.67	476.78	2912.61	9906.13
Kameng River	4139.45	3715.82	141.88	102.14	2483.86	8.37	349.06	2133.19	8591.54	3103.10	164.19	447.75	2680.86	11097.32
Brahmaputra River	538.42	491.51	31.24	0.00	3194.1	0	390.32825	2786.09	1684.91	1597.90	0.00	450.30	1145.33	616.67
Disang River	1284.57	842.99	390.77	9.50	3242.66	0.00	590.47	2622.06	3548.57	3287.50	0.00	552.49	2731.87	3509.29
Dikrang (Subansiri) River	4345.00	3848.43	254.27	4.21	3804.78	0.31	469.11	3316.07	14889.36	3971.43	6.30	553.89	3416.03	14842.63
R B Subansiri River	8542.78	6911.38	151.68	496.29	3491.24	4.70	343.63	3138.56	25973.14	3318.10	79.90	416.78	2902.26	24793.32
L B Subansiri River	7801.73	6150.51	181.24	584.56	3442.03	113.19	344.55	3083.29	22438.36	3463.61	54.64	450.57	3010.71	23488.73
Brahmaputra River	2127.63	1818.92	196.17	0.02	3287.63	0.00	399.04	2860.63	6567.44	2743.73	0.00	446.15	2271.93	4833.82
Dihang River	3792.90	2913.00	268.98	22.05	3377.39	52.24	398.84	2945.54	11541.24	3014.70	0.00	468.05	2518.88	9553.88
Siang River	5856.52	4595.46	138.91	626.28	3852.02	233.33	358.45	3419.34	20780.59	3353.46	14.95	432.98	2881.79	16877.26
Siyom River	6620.44	4572.15	133.19	996.50	3611.66	282.28	348.43	3226.16	19031.56	4174.81	95.11	478.77	3697.44	24478.68
Tirap River	1866.58	1421.25	398.29	7.99	3030.01	0.00	584.85	2415.94	4765.17	4593.30	0.00	595.56	3988.05	7444.00
Lohit River	6524.85	4809.49	1069.61	48.95	2446.98	9.42	313.85	2109.28	13241.22	2902.23	0.00	435.00	2444.90	15952.63
Tellu / Lohit River	9157.00	5762.14	584.97	1089.13	2070.26	24.26	311.63	1707.37	16191.16	3145.98	85.47	465.22	2672.79	24474.74
Lower Dibang River	7843.22	4306.53	328.97	1791.86	3083.54	648.66	270.41	2799.95	23758.64	4067.55	175.79	527.27	3539.13	27758.18
Upper Dibang River	4129.55	1831.52	108.02	1542.75	3836.89	1337.03	187.18	3628.83	15393.83	3596.28	230.26	512.84	3091.26	12765.51

Table 7-8 Resources and Water balances of each districts

District	District area	Forest	Agriculture	Snow /Glacial	Water balance present 2012 (in mm)					Water balance future 2030 (in mm)				
					Precipitation	Snow Melt	ET	Water Yield	Volume (MCM)	Precipitation	Snow Melt	ET	Water Yield	Volume (MCM)
Anjaw	911.69	4412.00	316.63	1037.37	1939.06	29.89	307.21	1573.00	10982.67	3302.17	105.29	468.00	2825.74	19729.33
Changlang	2344.25	4072.12	771.58	7.12	2383.56	7.48	336.80	2019.55	10237.11	3557.23	0.00	456.21	3071.77	15570.80
Dibang Valley	2515.29	4162.23	185.96	3187.21	3362.17	998.60	226.24	3121.86	27968.77	4007.71	221.79	518.54	3492.84	31292.37
East Kameng	3401.12	3591.26	192.02	102.14	2592.03	7.28	352.11	2236.80	9246.95	3053.77	142.77	453.48	2621.67	10837.98
East Siang	4139.45	3419.27	381.24	346.64	3440.54	7.71	407.80	2996.85	14046.25	2626.48	0.00	466.13	2126.34	9966.17
Kurung Kumey	538.42	5620.02	106.80	496.29	3584.56	6.10	349.83	3226.17	23038.09	3004.32	103.65	423.01	2585.02	18459.64
Lohit	1284.57	2565.77	674.30	83.21	2669.02	6.39	340.15	2309.50	10207.98	2274.20	0.00	440.55	1828.78	8083.21
Lower Dibang Valley	4345.00	2847.72	394.71	239.03	2988.32	133.48	343.79	2625.40	10685.38	3776.12	57.34	551.34	3213.36	13078.37
Lower Subansiri	8542.78	2684.07	137.06	0.14	3524.34	0.00	380.99	3129.24	9368.93	4578.82	0.00	463.95	4107.53	12297.96
Papum Pare	7801.73	2539.60	184.80	5.77	3598.79	0.56	466.49	3112.59	8948.70	3248.13	11.20	540.60	2709.24	7789.08
Tawang	2127.63	861.38	13.66	548.17	1931.10	186.68	330.61	1592.07	3457.98	3568.70	297.04	464.18	3115.33	6766.51
Tirap	3792.90	1324.95	569.65	7.20	3195.61	0.00	584.32	2581.08	5046.01	3457.30	0.00	557.01	2895.09	5659.89
Upper Siang	5856.52	4545.08	145.18	886.28	3806.24	244.41	358.51	3379.11	20909.93	3473.09	19.19	432.14	3007.89	18612.80
Upper Subansiri	6620.44	5431.65	129.73	584.55	3482.35	125.55	342.42	3125.71	21980.00	3424.49	58.60	450.94	2972.59	20903.26
West Kameng	1866.58	5584.19	104.43	190.65	1972.26	61.47	321.10	1649.71	12244.17	3065.43	130.03	477.00	2603.95	19326.53
West Siang	6524.85	6247.72	230.13	339.21	3523.80	262.91	349.66	3137.67	23981.20	4204.19	87.35	474.87	3728.73	28498.70

8 Alternative interventions required with respect to Climate change

8.1 Flood Control

Flood is a recurring phenomenon in the State due to high annual rainfall and geological fragility of the region and renders many people homeless, devastate agriculture and disrupt road communication and other public assets. The magnitude of floods and river bank erosion problems are increasing every year in the State. An estimated 8155 sq km area of the state is flood prone. To tackle the flood problems, construction of embankment, spurs and guide bunds etc. are utmost necessary. Presently, protection and restoration works have been taken up.

8.2 Forestry

1. Forest fragmentation/ Thinning of dense forest
2. Forest fires
3. Loss of biodiversity
4. Human intervention
5. Sustainable Harvesting of timber and non-timber products
6. Protective Areas management

Preventive measure or intervention in terms of Climate and Water resources

1. The primary cause for forest fragmentation/ thinning of dense forest is shifting cultivation, grazing and other human intervention. To combat this, other options for agriculture should be explored by introducing high yield varieties, increasing water use efficiency and reliable irrigation infrastructure. This needs an analysis of consumption by irrigation for future population food requirements.
2. To prevent forest fires, unauthorized human intervention should be regulated, also, fire control measures should be taken.
3. Loss of biodiversity can be protected in two ways, one is to restrict human interference, and fragmenting the forest, other is to ensure, enough environmental flow or stream flow across the channels flowing through forests to support the species survival. Also, Small water bodies, which might have dried up or lost or are vulnerable to future climatic variability, should be mapped and reserved and rejuvenated by the forests department under maintenance.
4. As many local tribal are thriving within the green dense forests of Arunachal Pradesh.

It is the urban and advanced people interference which causes the disturbance. Protected areas should be linked for keeping a large patch undisturbed. Unauthorized actions within these forest lands should be restricted and regulated accordingly.

5. Forests are primary suppliers of timbers, but in many parts, this happens in a non-enforced and irregular manner. The Harvesting of timbers and non-timber plants should be compensated by planting more trees, and water supply to them are to be ensured.
6. Forest is the most important resource in Arunachal Pradesh with the predominantly large tribal population. Apart from projected vulnerability due to climate change, the forests in Arunachal Pradesh also face several threats and biotic pressures in the form of shifting cultivation, grazing, forest fires, encroachment, commercial plantations, human-wildlife conflicts and illegal extraction of forest products along interstate borders with Assam and Nagaland. Identification of priority vulnerable areas and reduction measurements is a necessity for the state. Fragmented forests should be taken up for defragmentation measures implementation and rehabilitating the shifting cultivation. Linking and expanding protected areas should be promoted, this also requires the type of water sources covered in the region and if they have sufficient natural flow to suffice the blooming biodiversity and maintain the forest ecosystem in its best manner.

8.3 Agriculture

1. Shifting cultivation
2. Old crop varieties
3. Poor knowledge of advanced agricultural practices and technologies
4. Irrigation infrastructure reliability

Preventive measure or intervention in terms of Climate and Water resources

1. The yield of shifting cultivation is very low. The main reason forshifting cultivation is that farmers are here not very equipped with soil, water and crop enhanced varieties and supported technologies. To avoid loss of nutrients and save crop loss from repetitive farming over one land they choose jhum cultivation. The farmers should have supported by government and research institutions by capacity building and making them understand the use of new agri-tools. This includes introduction of high yield varieties, which should be distributed on subsidized rates, micro or sprinkler

irrigation techniques, ensuring continuous water supply in low rain season, also strengthening water-carrying infrastructure to avoid any water losses. Agriculture is the main occupation for about 35 percent of the population of Arunachal Pradesh. Jhum cultivation (Shifting Cultivation) and Terrace farming (Wetland Rice Cultivation (WRC) are the two major patterns that farmers employ. Jhum is a way of life in the high-altitude areas. Jhum area productivity is very low (0.7 to 0.8 tonnes/ha of organic rice against average of 3 tonnes/ha). Jhum/shifting cultivation accounts for 0.11 million hectares and permanent cultivation is about 0.09 million hectares. 17% of the total cultivated area is under irrigation. Jhum cultivation contributes only about 14% as compared to Terrace farming contribution of 86% of total grain production in the state. An area of more than 87,500 hectares has been irrigated in Arunachal Pradesh. Minor Irrigation Census of the State reveals that about 0.12 million-hectare (about 66.67% of available potential) area is irrigated. The net irrigation area underutilization is around 51,700 hectares with cropping intensity at the level of 130.56%. Fresh Potential Assessment being done under GIS environment and ultimate potential are expected to increase to around 0.85 million hectares.

The Command Area Development Water Management (CADWM) programme envisages the utilization of irrigation potential. Available records indicate that a wide utilization gap exists till today, it is estimated that about 55% of created potential is utilized and 45% remains unutilized due to poor resource support. Any shift in rainfall and temperature over a long period of time may affect agriculture directly. This must be identified with variabilities in climate projected and accordingly, climate resistant variety need to be promoted. Also, new varieties which are pest resistant and consumes less water with high yield suitable for this climate needs to be selected. Terraced rice cultivation should be supported to lessen dependency on shifting cultivation. Enhancement of livestock production by introduction of climate change adaptation measures should be done.

8.4 Horticulture

The climate resilient oriented cultivation practices and implementation of resource conservation technology like micro-irrigation and rainwater harvesting system needs to be strengthened with financial and institutional support. The climate-related information, projections, vulnerable areas and relevant data should be disseminated at the institutional level to all the researchers and stakeholders in water and climate sector for better preparation for future. The financial and research assistance is sought for in-situ / ex-situ conservation of germplasm of agricultural and horticultural importance/ conservation of wild relative of agricultural and horticultural crops found in Arunachal Pradesh and investigation on the use of existing wild germplasm for developing more climate change tolerant varieties.

Energy: replacement of old technology with new energy efficient technologies

Urban Development: urban transport (3500 million rupees) and urban mapping… building sewerage line and stormwater drainage in twenty-six urban settlements…. connecting all the unconnected 2741 habitations

8.5 Water Resources

Focus is on Rooftop rainwater harvesting schemes, source protection, gully plugging, check dam, catchment area protection, contour trenching, impounding reservoirs and artificial recharge. Advocacy and communication strategy on optimum water use, re-use of water, wise water use programs and water pricing has been proposed

8.6 Health

Controlling vector-borne disease research, mosquito Control measures, an improvement of access to and use of services.

Table 8-1 Interventions and Impact for Supply and Demand sectors

Sectors		Interventions	Impact
Supply		Source protection, gully plugging, check dam, Catchment area protection, Contour trenching Impounding reservoirs and artificial recharge	Enhancing sustainable sharing of natural resources and protection from wear and tear due to human intervention and natural causes
		Policy intervention of putting cost to above mentioned involvements to bear costs from MGNREGS and IWMP	Regulating and implementing conduct of natural resources management works under government policy initiative
		Spring rejuvenation inventorying, measurement of discharge and rejuvenation of old dying springs	Natural resource protection and availability for local usage, sub-surface water fluctuation assessment
		Temporal study on glaciers extent and Glacial lake changes	Support in measuring impact of climate change assisting vulnerability reduction measures
		WRH to tap the surface run off by rain water and for artificial recharge of ground water.	Rainwater harvesting and increased recharge for dry periods
Demand	Forest	Enhancing afforestation and plantations activities.	Helps in Deforestation combating, biodiversity protection
		Effective fire prevention and fire management.	Avoiding loss of natural and economic resources
		Sustainable harvesting of timber and non-timber products.	Reduction in imbalance in forest products production and consumption
		Expansion of protected area network.	Conservation, protection and development of Biodiversity and Wild Life
		Rehabilitation of shifting cultivation areas.	Reduction in degraded forest patches
		Eco-restoration of degraded open forests.	Enhancement in forest land quantity and quality
	Agriculture & horticulture	Rehabilitation of Shifting Cultivation areas by Terraced Rice Cultivation. Also hand over the rehabilitated irrigation system to the farmers and make them responsible for its maintenance	Reduced dependency of the farmers on WRD for overall maintenance of the system
		Micro Irrigation and Rain Water Harvesting System (MI & RWH)	Increased irrigation efficiency
		Introduction of new advanced technologies in irrigation and climate resilient, high yield, less water demanding crop variety.	Increased resilience towards changing climatic conditions, high yield, less water consumption, high productivity
		Integrated crop management, Creation of assured irrigation in settled cultivation areas	
	Energy	Replacement of defective energy meters system and providing meter to unmetered consumers.	Reduced energy consumption, Less energy wastage
		Regular energy auditing, finding loads and supply gaps	
		Implementing energy efficiency demonstrated projects in different institutional levels	

Sectors	Interventions	Impact
	Assessment of energy required specifically for each sector, agriculture, domestic etc. and policy making for distribution	An assured adequate distribution of energy and power for different sectors
Domestic / Livestock	Infrastructure improvement for Piped water provisions to every household in urban	Assured and clean water supply to each household, less struggle for fetching water for daily purposes
	Identification of groundwater potential in different catchments and accordingly provisions for water usage to different sectors.	Increased water availability apart from surface water resources, and selective crop cultivation as per water availability
	Roof top rain water harvesting schemes	Extra water availability for daily purposes at household level.
	Water Quality monitoring stations establishments	Control over water quality levels and declarations for fit/unfit of water for different purposes.
	Solid Waste Management	
Industrial	Setup of sewage treatment Plans	Ethical dumping of industrial sewages Decreased chances of natural resources pollution
	Quantification provisions of water consumptions in large, medium and small-scale industries	Proper water budgeting of water requirements and polluted water expulsion from industries
	Sewage generation estimates for different industries	
	Identifying non-point and point source pollution of surface/groundwater	Targeted policy and frameworks for tackling groundwater /surface water pollution
Institutional	Infrastructure support for R&D activities on climate change effect on water resources	
	Awareness, capacity building on Participatory Irrigation management	Increase the coverage area under government programmes
	Proper blending of MIP, CAD and watershed schemes are required	
	Coordination between line departments	Greater interdepartmental cooperation between WRD and other line departments
	Creation of River Basin Agencies and empowering them	
	Massive stake-holder engagement	

8.7 Policies in respect to water utilisation

Managing water resources in Arunachal Pradesh in effect implies ensuring sustainable utilization of the immense water resources of the State. In terms of utilization of water resources, it is estimated that Arunachal Pradesh has more than one-third of the country's proven hydropower potential. Several projects, large and small are been planned to tap this enormous hydro power potential. Apart from the planned large power projects, State's Small Hydro Power Policy 2007 envisages that these eco-friendly and renewable- micro/mini/small hydro projects that are low in gestation period will be ideal for viable investment for State's domestic power requirement. The policy calls for formulation and notification of an Action Plan for Small Hydro Power Generation.

In terms of utilisation of water for State's agriculture, the Agriculture Policy 2001 provides rapid expansion of area under agriculture through the innovative use of technology, expand irrigation facilities and build supporting infrastructure. The new Industrial Policy formulated in 2001 provides for a range of fiscal incentives, streamlined administrative processes and development of infrastructure facilities such as industrial parks, Industrial Estates, Industrial Growth Centers, Integrated Infrastructure Development Centers etc.