INTEGRATED ECOLOGICAL CARRYING CAPACITY OF UTTARA KANNADA DISTRICT, KARNATAKA

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The conservation and sustainable management of ecosystems are the vital components in the pursuit of development goals that are ecologically, economically and socially sustainable. This requires an understanding of the complex functioning of ecosystems, and recognition of the full range and diversity of resources, values and ecological services that they represent. In this regard, the current research envisions the beginning of an on-going process to integrate ecological and environmental considerations into administration in the biodiversity rich district of Karnataka. This is a major step towards an ecological audit that eventually should result in the conservation and sustainable use of biodiversity. This process in due course will create an integrated database on biodiversity for the district and also furnish analyzed data, advice and management prescriptions to beneficiaries at every level from the village communities to the Government. Integrated Ecological carrying capacity study provides the regional planner in evolving appropriate conservation strategies for sustainable management particularly on a defined geographical area. Decision making on developmental activities, entail planning that depends upon the availability of reliable and accurate data. Data required for natural resource planning include spatial data such as, information of physiography of the area, land use, assets, etc. Geographic information system (GIS) with a capability of handling spatial data helps in the analysis and visualisation of results effectively, and aids decision making process [1-35].

The district is in need for ecologically sound development plans for sustainable productivity. For preparation of such a plan, the basic need is to have a fresh appraisal of the carrying capacity of the district, which has never been done before. The carrying capacity study, which involves detailed study on every aspect of ecology and human life in the region, will be the best guide and tool for both policy makers to choose appropriate developmental and other income generating projects which are in tune with the ecology of the district. The carrying capacity studies, if adapted to the village panchayat levels, can transform lives of people at grass-root level through better understanding of their surroundings, by adopting lifestyles having greater harmony with their environment, so as to reap maximum sustainable benefits [33].

Ecosystem carrying capacity can be defined as 'the maximum number of a species that can be supported indefinitely by a particular habitat, allowing for seasonal and random changes, without degradation of the environment and without diminishing carrying capacity in the future. Carrying capacity thus refers to the maximum number of activities (biological, developmental, agricultural, and industrial, population) that can be supported over a period of time in the habitat without damaging the existing quality of life, balance of resources, ecology and productivity of the ecosystem. Ecological Carrying Capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economic development in the region. The aim of Environmental Carrying capacity is to adjust/increase the ability of the natural environment [1]. Carrying capacity depends on

1) Resources (Biological or Non Biological) that influences on the number of species in the habitat based on the current condition.
2) Interaction (Physical, Chemical, Biological) between the resources and the processes involved in conversion/production of resource to a desired output with residuals and wastes in the environment
3) Habitat (Region), Human Choices, Living Standards, Time, technology
4) Economic Conditions, Growth Strategies and Policies;
5) Social-Cultural and Political Aspects

Carrying capacity research began, through inventorying, mapping and monitoring of the vegetation. Eventually this process was strengthened to cover the rest of the organisms, including the biodiversity of cultivated plants. Such a dynamic documentation process enabled the district to keep proper stock of its biological and ecosystem diversities and to supervise their judicious use for sustainable progress. Data required for natural resource planning included spatial data such as, information of physiography of the area, land use, assets, etc. The scope of a carrying capacity study has been extended to the analysis of supportive capacity in the region with respect to resource availability/utilisation, supply/demand, infrastructure/congestion and assimilative capacity/residuals. Hence, the carrying capacity is assessed as the ability to produce desired outputs (i.e., goods and services) from a limited resource base (i.e., inputs or resources) while at the same time maintaining desired quality levels in this resource base [1]. The four dimensions that are relevant to the estimation of carrying capacity are:

(i) The stock of available resources to sustain rates of resource use in production.
(ii) The capacity of the environmental media to assimilate wastes and residuals from production and consumption.
(iii) The capacity of infrastructure resources (e.g., distribution and delivery systems) to handle the flow of goods and services and resources used in production.
(iv) The effect of both resource use and production outputs on quality of life.

Planning for development within the limits of carrying capacity recognises that humankind is dependent on the productive capacity of ecosystems, and therefore, a minimal level of ecosystem integrity is essential for human survival. Planning for sustainable development calls for trade-offs between the desired production-consumption levels through the exploitation of *supportive capacity* within its regenerative capacity and environmental quality within the *assimilative capacity* of regional ecosystem. The utilisation of carrying capacity, thus, requires a series of adjustments to reconcile competing operations in the developmental process through participation of various stakeholders.

Ecological carrying capacity provides physical limits as the maximum rate of resource usage and discharge of waste that can be sustained for economic development in the region. Due to the increased scale of human activities, exploitation, demand of resources led to

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production of larger amount of goods and services with byproducts and wastes damaging the environment and the ecosystem at local, regional and global scales, effecting sustainable development in the region. Through carrying capacity investigations, it is possible to identify locations for conservation (ecologically sensitive) as well as development in the region as carrying capacity allows us to divide the region into various classes based on the different resource availability.

Realising the importance and necessity, the Government of Karnataka through Karnataka Biodiversity Board, vide letter KBB/Misc/Western Ghats study/15/09-10/1314 dated. 29-06-2009, as per the advice of Western Ghats Task Force, Government of Karnataka invited us to undertake a study on **'INTEGRATED ECOLOGICAL CARRYING CAPACITY OF UTTARA KANNADA'** (Ref: Letter No.FEE 49 ENV 2009, dated 22-05-2009 of the Secretary to the Government, Forest, Ecology & Environment, Bangalore).

1.0 STUDY AREA - UTTARA KANNADA DISTRICT, KARNATAKA STATE, INDIA

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Uttara Kannada (Figure 1) district is bounded between 13.769° to 15.732° north and 74.124° to 75.169° east. It encompasses an area of 10,291 sq km, which is 5.37% of the total area of the State. The district extends to about 328 km north south and 160 km east west. Most of the district is hilly and thickly wooded. The area of the district is 10,222.3 sq km. For administrative purpose, the district has 11 taluks. Supa taluk is the largest with an area of 1890.3 sq km and Bhatkal taluk the smallest in district with 348.9 sq km. The district is surrounded by state of Goa and Belgaum district in the north, Dharward and Haveri in the east; southern neighbours are Udipi and Shimoga districts, the Arabian Sea on the other side. This district takes away maximum portion of the shoreline, i.e., 120 km of 300 km of the total costal belt of Karnataka [1].

The west flowing rivers break the shoreline of Uttara Kannada by deep and wide mouthed estuaries. Kalinadi, Bedthi, Aganashini, Sharavathi, Venkatapur, Bhatkal, Belambar, Navgadde halla, Hattikeri halla and Belambar are west flowing rivers (Figure 1). Of these major rivers are Kalinadi, Bedthi, Aganashini, and Sharavathi River. The two east flowing rivers are Dharma and Varada. The rivers give raise to magnificent waterfalls in the district. The Jog fall in Sharavathi, Lushington falls, where the river Aghanashini drops 116 meters, Magod falls, where the Bedti river plunges 180 meters in two leaps, Shivganga falls, where the river Souda drops 74 meters, and Lalguli and Mailmane falls on the river Kali. The Kali river origins in Joida taluk flows through Karwar taluk, the Gangavali (Bedthi) origins in Dharwad District flows through Yellapur and Ankola taluks. The Aghanashini river origins in Sirsi flows through Siddapur and Kumta taluks. Sharavati origins in Shimoga district, which forms the famous Jog Falls flows through Honnavar. The other rivers of the District are the Venktapur (origins in Bhatkal) and the Varada (origins in Sirsi). All the rivers flow from East to West, whereas Varada River flows eastwards. Uttara Kannada district has five reservoirs such as Supa reservoir, Tattihalla reservoir, Bommanahalli reservoir, Kodsalli reservoir and Kadra reservoir across Kali River and Gersoppa reservoir across Sharavathi river. Also, where these rivers meet the sea, there form some of the finest estuaries of the west coast. The district has varied Geographical features with thick forest, perennial rivers and abundant flora and fauna and a long coastal line of about 140 KM in length [1,2,6,19].

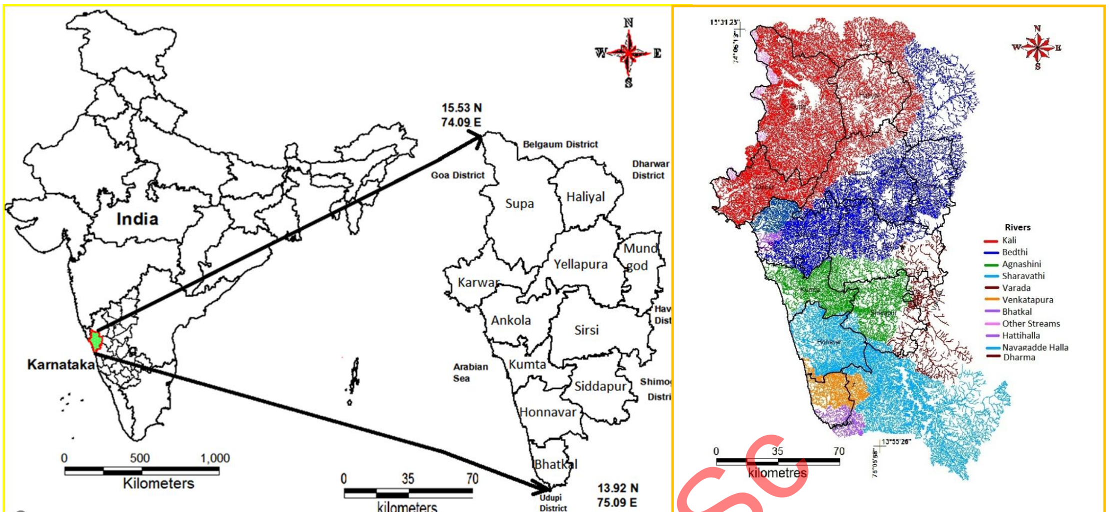

Figure 1: Uttara Kannada district, Karnataka State, India and stream network

2.0 LAND-USE CHANGES:

Land use (LU) dynamics is a major concern, as the abrupt changes have a negative impact on ecology, climate, regional hydrology, and also people's livelihood in the region. LU dynamics are specific to a region and vary from region to region. Land use refers to use of the land surface through modifications by humans and natural phenomena. Land use can be classified into various classes such as water bodies, built up, forests, agriculture, open lands, sand, soil, *etc*. Land use modifications alter the structure of the landscape and hence the functional ability of the landscape. The modification includes conversion of forest lands, scrublands to agricultural fields, and cultivation lands to built-up, construction of storage structures for water bodies leading to submergence of land features that may vary from small scale to large scale. . Main objective of the current study is to assess the spatial pattern of LU changes in Uttara Kannada district, Central western Ghats in Karnataka. Land use patterns and their changes over time for Uttara Kannada district, Karnataka are quantified with the spatial data acquired through space borne sensors. Remote sensing data with synoptic repetitive coverage aids in understanding the landscape dynamics. The spatial data have been analysed using Geographic Information System (GIS). Changes in land use (LU) have been analysed using temporal remote Sensing data with collateral data (field data, the Survey of India topographic maps, Google Earth data) through GIS. Vegetation cover (land cover) assessment was done by computing Normalised Difference Vegetation Index (NDVI) show the decline of vegetation cover from 92.87% (1973) to 83.44% (in 2013). Land use analysis reveal distressing trend of deforestation in the district, evident from the reduction of evergreen-semi evergreen forest cover from 67.73% (1973) to 32.08% (2013). Taluk-wise analysis reveal similar trend for evergreen - semi evergreen forest cover during 1973 to 2013; Ankola (75.66 to 55.33%), Bhatkal (61.37 to 30.38%), Honnavar (70.63 to 35.71%), Karwar (72.26 to 59.70%), Kumta

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(62.89 to 29.38%), Siddapur (71.42 to 23.68), Sirsi (64.89 to 16.78), Supa (93.56 to 58.55%), Yellapur (75.28 to 18.98%), Haliyal (35.45 to 2.59%), Mundgod (20.63 to 1.52) [11,13,14,29]

Forest tree cover has declined from 81.75 (1973) to 60.98% (2013) in the coastal zone, 91.45 (1973) to 59.14% (2013) in the Sahyadrian interior, and 69.26 (1973) to 16.76% (2013) in plains zone. Changes in the landscape structure (through large scale land use changes) have altered functional abilities of an ecosystem evident from lowered hydrological yield, disappearing perennial streams, higher instances of human–animal conflicts, declined ecosystem goods, etc. This necessitates the restoration of native forests in the region to ensure water and food security apart from livelihood of the local people [11,13,14]. Table 1 lists land use details during 1973 to 2013. Figure 2 depicts land uses during 1973 and 2013. Comparative assessment of land use categories reveals the decline of vegetation cover in the district during 1973 to 2013. The reduction of area under evergreen forests from **67.73**% (1973) to **32.09**% (2013) due to anthropogenic activities involving the conversion of forest land to agricultural and horticultural activities, monoculture plantations and land releases for developmental projects [14].

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Figure 2: Land use changes in Uttara Kannada district from 1973 to 2013

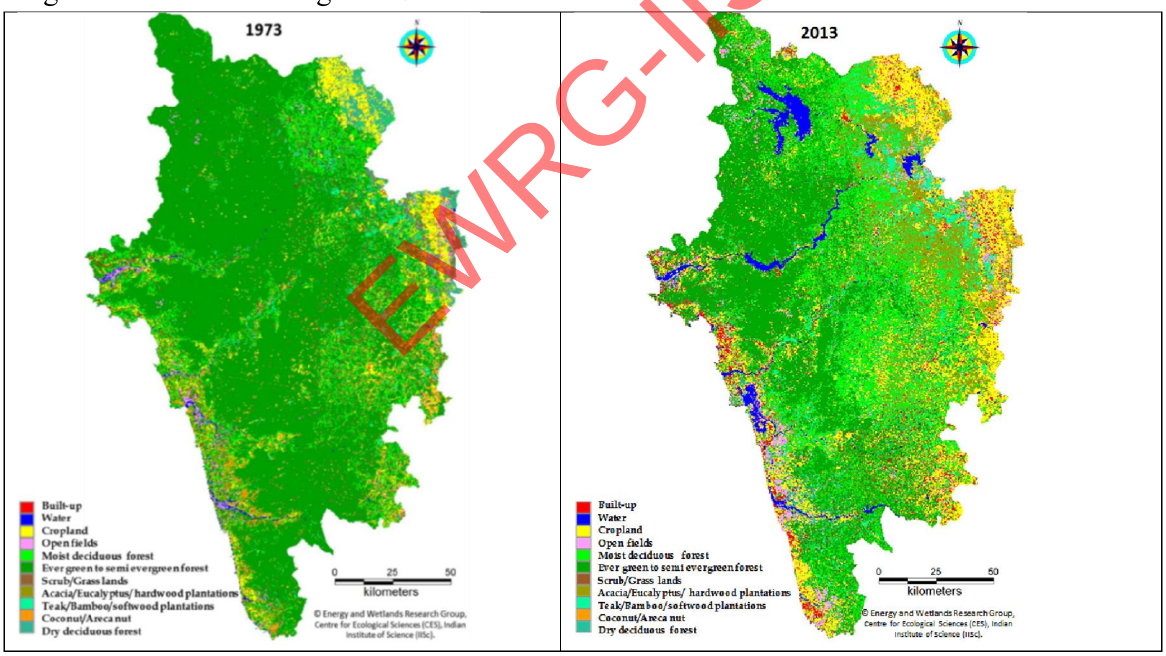

Table 1: land use variation from 1973 to 2013

Year / Category	1973	1979	1989	1999	2010	2013	Loss / Gain in area (1973-2013)

	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	(Ha)
Built-up	3886	**0.38**	9738	0.95	12,982	1.26	21,635	2.10	28,491	2.77	31589	**3.07**	27703
Water	7,681	0.75	18527	1.80	16,604	1.61	32,983	3.21	26,119	2.54	28113	2.73	20432
Crop land	71,990	**7.00**	103163	10.02	121,167	11.77	138,458	13.45	148,187	14.40	145395	14.13	**73405**
Open fields	14071	1.37	15988	1.55	34,783	3.38	21,945	2.13	30,812	2.99	37660	3.66	23589
Moist deciduous forest	**95,357**	**9.27**	**102967**	**10.01**	**143,849**	**13.98**	**179,075**	**17.40**	**166,266**	**16.15**	**161,996**	**15.74**	66639
Evergreen to semi evergreen	**696,978**	**67.73**	**589762**	**57.31**	**531,872**	**51.68**	**423,062**	**41.11**	**367,064**	**35.66**	**330,204**	**32.08**	**-366774**
Scrub/grass	38,109	3.70	58936	5.73	44,123	4.29	47,366	4.60	35,158	3.42	40402	3.93	2293
Acacia/Eucalyptus/ hardwood plantations	40,905	**3.97**	50321	4.89	55,694	5.41	73,977	7.19	119,717	11.63	122927	**11.94**	82022
Teak/ Bamboo/ softwood plantations	13997	**1.36**	20896	2.03	21,937	2.13	38,588	3.75	44,794	4.35	67111	**6.52**	53114
Horticulture plantations	20,702	**2.01**	29675	2.88	32,227	3.13	43,623	4.24	53,646	5.21	53,993	**5.25**	**33291**
Dry deciduous forest	25,410	2.47	29113	2.83	13,848	1.35	8374	0.81	9008	0.88	9873	0.96	-15537
Total	1029086												

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3.0 ASSESSMENT OF RENEWABLE ENERGY POTENTIAL:

Energy is essential for economic and social development of a region. Dependence on fossil fuels has posed a serious threat due to greenhouse gas (GHG) emissions, dwindling stock of the fuel resource base. Among daily activities, about 80% of the mechanical work requires electrical energy. Dependence on the conventional energy resources for electricity generation is eroding the resources at faster rate. The process of electricity generation causes significant adverse effect on ecology by producing enormous quantity of by-products including nuclear waste and carbon dioxide. Improving energy efficiency, switch over to renewable sources of energy and de-linking economic development from energy consumption (particularly of fossil fuels) is essential for sustainable development of a region. Green energy technologies have gained importance so that they are reliable and environmental friendly. Electrical energy harvesting from solar radiations is one such promising technology which uses photoelectric effect. Solar photovoltaic (SPV) modules directly convert solar radiations to direct current (DC) electrical power which can be used for various applications (or stored in battery) or can be sent to the existing grid. Uttara Kannada is located in the west coast of Karnataka, India, receives an average solar insolation of 5.42 $kWh/m^2/day$ annually and has more than 300 clear sunny days. This solar potential can be utilized to meet the domestic and irrigation electricity demand. Domestic demand of the household in rural region is about 50 to 100 kWh per month and that in urban region is less than 150 kWh/month in Uttara Kannada. The solar potential assessment reveals that, domestic demand can be supplied by installing rooftop SPV modules, since less the 5% of the rooftop is required in majority of the houses and irrigation demand can be met by installing PV modules in wasteland where less than 3% of available wasteland area is sufficient. To estimate the fraction of rooftop required to generate sufficient electricity, rooftop area of a household in selected villages (chosen randomly, representative of agro-climatic zones) is digitized using Google earth image (http://googleearth.com). Electricity demand in households is estimated based on the sample household survey of 1700 households, which indicate the requirement of 50-100 units (kWh) per month per household. Computed rooftop area per household is used to extrapolate for all the villages in the district. Rooftop area required to install the PV module to meet the respective household's electricity demand is computed. The roof area required is less than 5% to meet the domestic demand of the respective household using rooftop PV system. In the similar manner the area required to generate electrical energy to meet the irrigation demand in the village is determined. In most of the villages in the district, less than 0.5% of the available wasteland is sufficient to meet the irrigation demand. The supply side includes assessment of regional solar energy availability, spatial extent of rooftop (individual households) and waste land (in the respective villages). The demand side includes estimation of domestic electricity consumption in households and irrigation as well as the extent of rooftop/land area required for installing PV based systems to meet the decentralised demand [16].

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3.1 Solar energy potential (Seasonal variations of solar insolation) assessment:

The monthly average GHI (Global Horizontal Irradiance) datasets from NASA and NREL were compared and validated with surface data based model. Figure 3 illustrates the monthly variability of solar radiation. The values indicate that adequate solar energy is available in the region. Higher resolution NREL GHI data were used to study the solar energy potential in Uttara Kannada. Solar maps generated for monsoon, winter and summer seasons, show seasonal availability and regional variability of GHI (Figure 4). The seasonal average GHI is highest in summer (6.65 – 6.95 kWh/m^2/day), moderate in winter (5.70 – 5.85 kWh/m^2/day) and lowest in monsoon (4.50 – 5.20 kWh/m^2/day). Annual average GHI values were considered for assessing the technical potential of solar energy in Uttara Kannada. Figure 4 illustrates the seasonal variations of solar insolation in Uttara Kannada. Solar insolation ranges from 4.5 to 6.95 kWh/m^2/day in the districts throughout the year. During Monsoon season, district gets the insolation ranges from 4.5 to 5.2 kWh/m^2/day. Coastal and the eastern part of the central (moist deciduous) region receives insolation of 4.8-5 kWh/m^2/day. The central region (Evergreen) gets the lowest insolation ranges from 4.5 to 4.8 kWh/m^2/day during monsoon. Eastern most part (dry deciduous) receives higher insolation of 4.89-5.2 kWh/m^2/day. In winter, insolation in the district ranges from 5.70 to 5.85 kWh/m^2/day. Most of the parts in the district receive insolation of 5.80-5.85 kWh/m^2/day. Eastern region of the district (dry deciduous) gets insolation ranges from 5.75 to 5.80 kWh/m^2/day. Some parts in this region receive insolation of 5.70-5.75 kWh/m^2/day also.

Uttara Kannada gets higher insolation ranges from 6.65 to 6.95 kWh/m^2/day in summer. Western part of the district receives insolation of 6.65-6.85 kWh/m^2/day. Most of the eastern part (central) gets insolation of 6.85-6.90

KWh/m²/day. In summer, some parts of the district get higher insolation of 6.90-6.95 kWh/m²/day.

Figure 3: Comparison of different available solar data for Uttara Kannada

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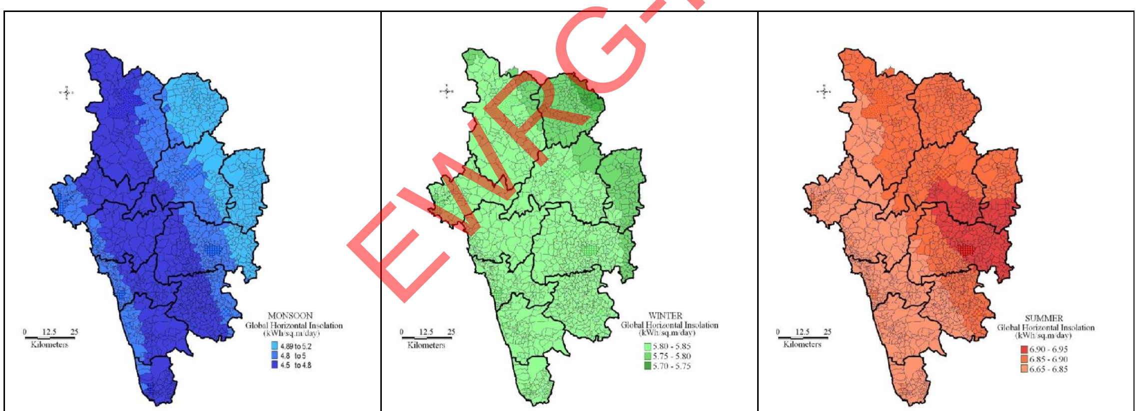

Figure 4: Seasonal variations of solar radiation in Uttara Kannada

Uttara Kannada has a good solar potential and can meet the energy demand in the domestic sector. Energy harvesting through PV based solar system mounted on rooftops of individual houses would help in meeting the respective house's energy demand while bringing down the dependency on the State's grid.

Average monthly energy consumption of electricity for domestic purposes is about 34±8 kWh per month per household and irrigation requirement is about 3218±2412 kWh/hectare/year. Monthly domestic electricity consumption ranges from 23 (for Haliyal) to 44 (Honnavar) kWh. These values were used for calculating the region wise electricity demand for domestic and irrigation. Coastal taluks (Ankola, Kumta, Karwar, Bhatkal and Honnavar) have higher household electricity consumption. Siddapur and Sirsi taluks with vast extent of horticulture crops lead in the per hectare consumption of electricity for irrigation. A large part of Uttara Kannada except the coast is rainfed and hence do not rely on irrigation for agriculture. The electricity consumption ranges from 1,000 - 5,000 kWh/month. There are about

80 villages, which have the domestic consumption of 10,000 to 1,00,000 KWh of electricity in a month. The monthly average electric energy consumption per household is about 50 to 100 kWh in Uttara Kannada. This electricity demand can be met through solar rooftop PV system, which ensures continuous supply of electricity compared to the current system of depending on grid with uncertainties. The rooftop area required to generate the electric energy using PV which will meet the domestic electricity demand in respective villages. Majority of the villages require rooftop area less than 250 m^2 to meet the electric energy demand using solar PV system. Around 26% (350) of the villages in the district require rooftop area less than 100 m^2 and about 27% (363) places need rooftop area ranges from 100 to 250 m^2. Hence more than 54% of the villages require rooftop area less than 250 m^2 to meet the current domestic electricity demand. In very few places total rooftop area required is 10,000 to 1,00,000 m^2 which are normally the city or town municipal corporations or census towns.

3.2 Opportunities for decentralized wind applications:

Wind is one of the promising renewable sources which can substitute fast depleting fossil fuels sources. Windmills have been used for centuries to grind grain and pump water in rural areas. It has the advantage of being harnessed on a local basis for applications in rural areas and remote areas. Water pumping for agriculture and plantations is probably the most important application that contributes to the rural development through multiple cropping. Wind resource assessment is the primary step towards understanding the local wind dynamics of a region. Climatic average datasets of meteorological variables containing wind speed data for the period of 1961~1990 compiled from different sources I were used for the potential assessment of wind speed in the district. These were validated with the data of meteorological observatories at Karwar, Honnavar and Shirali obtained from the Indian Meteorological Department, Government of India, Pune. Analysis showed the seasonal variation of wind speed in the region. Wind speed varies from 1.9 m/s (6.84 km/hr.) to 3.93 m/s (14.15 km/hr.) throughout the year with minimum in October and maximum in June and July. District experiences annual average wind of 2.5 m/s to 3.0 m/s in all taluks indicating the prospects for WECS installation. Hybridizing wind energy systems with other locally available resources (solar, bioenergy) would assure the reliable energy supply to meet the energy demand at decentralized levels. Wind speed is seasonal dependent which is normally at its maximum during monsoon season. Wind speed varies from 1.9 m/s (6.84 km/hr.) to 3.93 m/s (14.15 km/hr.) throughout the year resulting minimum in October and maximum in June and July. Annual average wind sped in the district ranges from 2.54 ± 0.04 m/s (9.144±0.144 km/hr.) in Haliyal taluk to 2.70 ± 0.05 m/s (9.72±0.18 km/hr.) in Karwar taluk [16].

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3.3 Bioenergy:

Rural population of India mostly depends on bio energy for cooking, space and water heating. Though most of the energy need is harvested from fossil fuels, majority of the rural population depends on the bio energy for their domestic usage in the country. About 70% of the Indian population lives in rural area where 75% of the primary energy need is supplied by bio energy resources. Also, about 22% of the urban households depend on firewood, 22% on kerosene and 44% on LPG for cooking in the country. Bio energy resources are renewable in nature and combustion would not produce poisonous gases and ash with sufficient oxygen supply. A village level study on the present scenario of domestic energy consumption will help to assess the demand and supply of bio energy in the country. Uttara Kannada district in Karnataka state, India is chosen for bio energy assessment which has evergreen as well as moist and dry deciduous forest. In the district majority of the people live in rural area or in semi urban area, mostly dependent on forest, agricultural and livestock residues for domestic energy need [16].

Bioresource availability is computed based on the compilation of data on the area and productivity of agriculture and horticulture crops, forests and plantations. Sector-wise energy demand is computed based on the National Sample Survey Organisation (NSSO study) data, primary survey data and from the literature. Using the data of bioresource availability and demand, bioresource status is computed for all the agroclimatic zones. The ratio of bioresource availability to demand gives the bioresource status. The ratio greater than one indicates bioresource surplus zones, while a ratio less than one indicates scarcity. The supply/demand ratio in the district ranges from less than 0.5 to more the 2. If the ratio is less than 1 (demand > supply) then that place is fuel wood deficit place and where the ratio is more than 1 (supply > demand) then that place is referred as fuel wood surplus region. In Uttara Kannada, most of the Taluks with ever green forest cover (Sirsi, Siddapur, Yellapur, Supa and estern hilly ares of Kumta, Honnavar and Ankola) are fuel wood surplus regions where the supply/demand ratio is currently > 2 (compared to 8-9 in early 1990's). Dwindling resource base could be attributed to the decline in forest cover in the district.

A village level study on the present scenario of domestic energy consumption will help to assess the demand and supply of bio energy in the country. For bio energy assessment Uttara Kannada district in Karnataka state, India is chosen which has evergreen as well as moist and dry deciduous forest. In the district majority of the people live in rural area or in semi urban area, mostly dependent on forest, agricultural and livestock residues for domestic energy need. The primary objective of the study is to assess the bio energy status in Uttara Kannada district across the agroclimatic zones. This includes identification of the bioenergy surplus and deficit places in the district.

Bio resources from various sources (forests, agriculture, horticulture) is used for domestic applications (cooking, water heating) in the district. Fuel wood is mainly used for domestic cooking and water heating supplemented by horticultural and agricultural residues, forest biomass and biogas production from livestock. Majority of the fuel requirement for cooking, water and space heating is supplied by agricultural residues, animal matter or by forest in the district. More than 80% of the people are dependent on bio energy for their requirements such as food, fuel wood for traditional stoves, timber for houses and cattle sheds, poles for fencing and shelter construction, leaves to prepare manure and covering to control weed, wood to prepare all housing structures, ropes, herbal medicines and decorative articles. Study gives the village level details of supply and demand trend of bio energy in the district.

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3.4 Fuel wood:

Fuel wood is one of the prominent forest by-products collected (normally by women and children) which is used for cooking and water heating through burning. Major domestic energy need is shared by fuel wood in the rural regions where the people collect it from nearby forest. The availability of the fuel wood for the consumers is depends on the closeness of the forest, type of the forest and methods of extraction. Figure 5 gives the availability of fuel wood in the districts annually. Since fuel wood is the cheapest primary energy source hence the demand will be high depending upon the availability. If the demand for the fuel wood increases then it may lead to deforestation or consumers may switch over to some other fuels such as LPG, electricity or kerosene due to the lack of availability. In majority of the villages of Sirsi, Siddapur, Kumta and Honnavar Taluks, availability of fuel food ranges from 1,000 to 5,000 tonnes per annum. In northern villages of Haliyal and Supa Taluks availability of forest bio mass per annum is less than 1,000 tonnes to 5,000 tonnes. Availability of fuel wood is high in the central region of the district. In eastern part of Karwar and Ankola and southern part of Supa fuel wood availableness is 10,000 to 25,000 tonnes per annum [16].

Figure 6 gives the supply to demand ratio of available forest bio mass (fuel wood) in the district. The supply/demand ratio in the district ranges from less than 0.5 to more the 2. If the ratio is less than 1 (supply < demand) then that place is fuel wood deficit place and where the ratio is more than 1 (supply > demand) then that place is fuel wood surplus region. In Uttara Kannada, most of the Taluks with ever green forest cover (Sirsi, Siddapur, Yellapur, Supa and estern hilly ares of Kumta, Honnavar and Ankola) are fuel wood surplus regions where the supply/demand ratio is more than 2. The villages with semi and moist deciduous forests (Western parts of Mundgod and Haliyal, Eastern parts of Bhatkal and Karwar) are also forest bio mass surplus places where the availability ratio is more than 1. The coastal and the extreme eastern part of the district (coastal villages of Karwar, Ankola, Kumta, Honnavar and Bhatkal with eastern part of Mundgod and Haliyal) are the fuel wood deficit places. The bioresource supply is dwindling in the district evident from the reduced bioresource supply to demand ratio from 8-9 to 2. This necessitates sustainable management approaches with augmentation of forest resources [16].

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3.5 Biogas resource status:

Livestock a vital component of agrarian ecosystem, provides milk and manure. Other uses of livestock are for wool, for meat, transportation and for ploughing (or sowing). Animal residue from livestock aid in recharging the essential nutrients of soil. It also boosts the quality of the organic manure which increases the soil fertility. Farmers in Uttara Kannada are very much dependent on livestock for their agriculture and horticulture practices. Animal residue is the main feedstock for the production of biogas as well as manure. There are about 3,66,949 cattle, 1,18,669 Buffaloes, 2,702 Sheep, 11,994 Goats in Uttara Kannada. Other members of livestock are Pigs (900), Dogs (93,403) and Rabbits (277). Total livestock population in the district is about 5,94,929 and poultry population is 3,61,351. Dung available from each cattle varies from 3-4 kg to 8-10 kg (from coastal to hilly region). Similarly average dung produced from a buffalo is 12-15 kg and from a hybrid one is 15-18 kg. By considering 3 kg dung production from a cattle in coastal area and 8 kg in hilly area, total dung production from cattle is about 6,32,058.46 tonnes per year. Similarly by considering the dung production per buffalo as 12 kg/day, total dung obtained is 5,19,770.22 tonnes per year. Assuming gas production of 0.036 m^3 per kg of dung, total biogas generated will be 41,465 thousand m^3 per year. National per capita natural gas consumption is about 54 m^3 per annum; then the biogas produced from livestock residue could meet the 50% of the gas demand in Uttara Kannada district. (100% dung produced is considered to generate biogas). Figure 7 gives the availability to demand ratio of biogas resource in the district. In more than 50% of the villages (625 villages) the availability is less than demand; which are called biogas energy deficit regions. In 334 villages of Siddapur, Yellapur and Supa taluks supply to demand ratio is between 1 and 2. There are 275 villages in Ankola, Mundgod and eastern Yellapur taluk, availability is more than twice of biogas demand. About 40% of the villages have adequate biogas potential to meet the domestic needs. These villages are to be considered for dissemination of biogas technology in the district [16. 1].

In Uttara Kannada district, bio energy meets the household energy demand. The supply/demand ratio of bioresources in the district ranges from less than 0.5 (Bioresource deficit) to more than 2. The coastal and the extreme eastern part of the district (coastal villages of Karwar, Ankola, Kumta, Honnavar and Bhatkal with eastern part of Mundgod and Haliyal) are the fuel wood deficit places. The bioresource supply is dwindling in the district evident from the reduced bioresource supply to demand ratio from 8-9 (in 1990's) to 2 (2010-13). This necessitates sustainable management approaches with augmentation of forest resources. In coastal regions (Kumta, Honnavar, Ankola, Bhatkal, Karwar), availability of agro-horticultural residues is more than the current demand which has the potential to meet the rural household energy demand. Similarly in Sirsi, Siddapur and Yellapur taluks, forest biomass potential could meet the energy demand. In Mundagod, Haliyal and in coastal villages, availability of animal residues provides the scope for biogas production. About 40% of the villages have adequate biogas potential to meet the domestic needs. These villages are to be considered for dissemination of biogas technology in the district. Biogas can also be used for electricity generation and the by-product, i.e. slurry is used for organic manure production which is a very good fertilizer.

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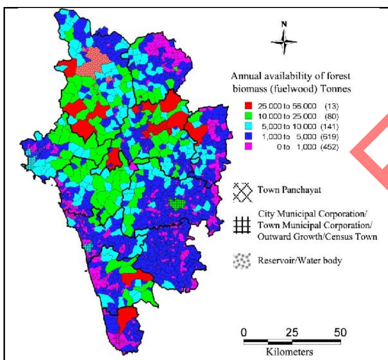

Figure 5: Availability of forest biomass (fuel wood) in tonnes/annum

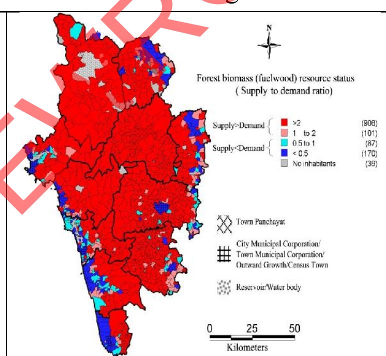

Figure 6: Fuel wood resource status (Supply to demand ratio)

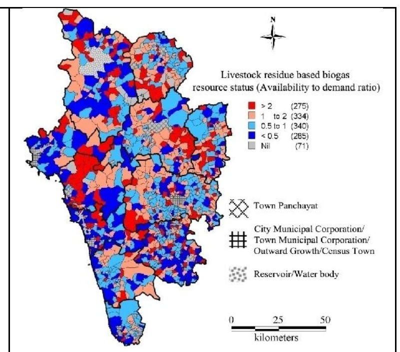

Figure 7: Biogas resource status (supply to demand ratio)

4.0 FLORISTIC DIVERSITY IN UTTARA KANNADA DISTRICT

Forests of all major kinds were studied using transect cum quadrat methods (altogether 116 transects, each transect with five quadrats of 400 sq.m each for tree vegetation, 10 sub-quadrats each of 25 sq.m for shrubs and tree saplings and 20 sub-quadrats of one sq.m for herb layer diversity. Out of 116 transects 8 were studied using point-centre quarter method). Altogether for tree vegetation 540 quadrats, each of 400 sq.m were studied. Necessary permission was, however, not granted for forest studies within the Dandeli-Anshi Tiger Reserve areas. Altogether 1068 species of flowering plants were inventorised during the study period, through sample surveys and opportunistic surveys outside the transect zones. These species represented 138 families. Of these 278 were trees species (from 59 families), 285 shrubs species (73 families) and 505 herb species (55 families). Moraceae, the family of figs (*Ficus* spp.), keystone resources for animals, had maximum tree sp (18), followed by Euphorbiaceae (16 sp.), Leguminosae (15 sp.), Lauraceae (14 sp.), Anacardiaceae (13 sp.) and Rubiaceae (13 sp.). Shrub species richness was pronounced in Leguminosae (32 sp.), Rubiaceae (24 sp.) and Euphorbiaceae (24 sp.). Among herbs grasses (Poaceae) were most specious (77 sp.), followed by sedges (Cyperaceae) with 67 sp. Orchids (Orchidaceae) were in good number [8. 10.20,21-24, 28, 30,33].

Tropical forests are major reservoirs of carbon in the terrestrial areas of the planet which is confronted with the prospects of imminent climatic change. World over all countries need to be alert to this major catastrophe. Apart from regulating pollution levels from various sources carbon sequestration in biomass has to be increased considerably. Our estimates on carbon sequestration based on tree biomass estimates from 116 forest samples show that the average carbon sequestration per hectare of forest (barren areas, scrub and grasslands excluded from sampling) was 154.251 ha. It is a significant find that the sacred *kan* forests of pre-colonial era, despite their merger with state reserved forests, and subjection of most to timber extraction pressures in the post-independence era, continue to lead the chart of sites having some of the highest carbon sequestration per unit area. **Thus the *kan* forest adjoining the Karikanamman temple in Honavar taluk had the highest carbon sequestration at 363.07 t/ha in the tree biomass alone. This is followed by Tarkunde-Birgadde in Yellapur (357.67 t/ha), and some of the swamp-stream forest samples in Kathalekan (299.66 t/ha, 275.18 t/ha, 259.21 t/ha etc.). Likewise Kanmaski-Vanalli in Sirsi had 242.43 t/ha of carbon [10.18].**

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The lowest carbon sequestered was found to be in the savannized forests, for obvious reasons of low to very low number of trees in them. These savannas whether they be in high evergreen forest belt (in Siddapur or Joida for instance) or be in drier zone of Haliyal or Mundgod have carbon storage of <50 t/ha in the tree biomass. Savannization was a necessity in the past for agricultural occupation of humans in the Western Ghats, for cattle grazing and slash and burn cultivation. Today the process is repeating to some extent still as forest encroachments have happened rampantly in all taluks increasing the porosity of otherwise in tact forests. Most bettalands allotted to arecanut orchard owners for exercising the privilege of leaf manure collection are in poor state of biomass and carbon sequestration (Eg. 14.19 t/ha in Gondsur-Sampekattu betta in Sirsi, Talekere betta in Siddapur 41.47 t/ha).

The importance of conservation of riparian forests occurring along streams and swamps is evident, not only from high species endemism but also for higher carbon sequestration. A very detailed study in Kathalekan involving nine samples of such forests versus nine samples away from such water courses reveal that the average carbon sequestration in the former was 225.506 t/ha against 165.541 t/ha in the latter. This is despite the fact both types occur within what is traditionally designated as a *kan* forest. We therefore recommend that forests adjoining or covering streams, swamps and riverbanks of the Western Ghats be considered sacrosanct and as critical areas for hydrology not only of the coast but of the entire Indian peninsula.

5.0 VALUATION OF GOODS AND SERVICES FROM FOREST ECOSYSTEM:

Forest ecosystems are critical habitats for diverse biological diversity and perform array of ecological services that provide food, water, shelter, aesthetic beauty, etc. Forests provide various services classified as supporting services, provisioning services, regulating services and cultural services Most of these services are underestimated or not estimated and are thus undervalued in policy decisions. The current work focusses on the quantification of various provisioning services from forests such as timber, fuel wood, fodder, green leaf manure, medicinal plants and NTFP. The area under different types of forest is derived from remote sensing data. Quantification of forest goods has been done based on the data compiled from the division offices of the Forest Department and micro level studies (productivity, etc.). Market prices were used for valuing the goods. The valuation of forest goods and services at micro level is expected to explore the possibilities for more effective micro level planning. This helps in integrating the environmental services with the economic goals of the region while ensuring the sustenance of natural resources and maintaining intergeneration equity [15, 17, 8, 3,4, 22, 27, 34, 35].

Valuation of the services and goods provided by the forest ecosystem would aid in the micro level policy design for the conservation and sustainable management of ecosystems. Main objective of the study is to value the forest ecosystems in Uttara Kannada forest. The flow of goods or services which occur naturally by ecological interactions between biotic and abiotic components in an ecosystem is often referred as ecosystem goods and services. These goods and services not only provide tangible and intangible benefits to human community, but also are critical to the functioning of ecosystem. Valuation of ecosystem goods and services is essential to frame, prioritise and justify sustainable development policies oriented towards the protection or restoration of ecosystem. The ecosystem goods and services with the ecological perspective of valuation have been done considering provisioning services – it includes products i.e., food (including roots, seeds, nuts, fruits, spices, fodder), fibre (including wood, textiles) and medicinal and cosmetic products.

Forests are multifunctional ecosystems that provide both ecological and economic security with provision of goods and services. The functioning and sustainability of global ecosystem depends much on the status of forest ecosystem. Forests are the basis of livelihoods for people who depend on forest goods and services. The degradation of forest is a critical problem, as it negatively affects the livelihood of the forest dwelling communities. However, the value of forest has often been overlooked in the process of decision making. In this context, valuation is necessary for effective conservation and management of forest resources. The present study estimates the value of forest ecosystem of Uttara Kannada district. The total economic value of forest ecosystem is comprised of value of provisioning, regulating, cultural and supporting services. The value of provisioning goods and services are computed by market price method. Surrogate prices are used for those provisioning goods and services which do not pass through market transaction. The value of regulating, cultural and supporting services is based on the values derived from literature. The total value of provisioning goods and services from the forests of Uttara Kannada district was estimated at Rs. 15,171 crores per year, which amounts to about Rs. 2 lakh per hectare per year. The study clearly shows the undervaluation of forest goods and services that

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is evident when the estimated total economic value of forest and the value of forest resources calculated in national income accounting framework are compared. The quantification of all benefits associated with the forest ecosystem goods and services would help in arriving at an appropriate policy and managerial decisions. In absence of the ecosystem valuation, policy decisions are lopsided in favor of environmentally degrading practices by neglecting the diffuse social interests that benefit from the use and non-use characteristics of ecosystems [15, 17].

The forest products included in the national income account framework includes: (a) Industrial wood (timber, match and pulpwood) and fuelwood and (b) minor forest products. It includes only the recorded values by forest department and thus all other benefits from forests are unaccounted in the national income. This necessitates relook at the current approach of computations of Gross domestic district product (GDDP), State Domestic Product (SDP) and Gross Domestic Product (GDP). **Gross underestimation and non-accounting of natural resources and forest resources in particular is responsible for unsustainable utilization of natural resources. Under valuation of ecosystem goods and services is evident from GDDP of Rs. 5,978 crores in 2009-10 (at current prices), which accounts as the sectoral share of forests of Rs. 180 crores contrary to the estimated valuation of provisioning services (ranges from 9707 to 15171 crores per year). This highlights the undervaluation of forest resources in the regional accounting system [15].**

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6.0 ECOLOGICALLY SENSITIVE REGIONS IN UTTARA KANNADA

Ecologically Sensitive Regions (ESRs') are the 'ecological units' that may be easily affected or harmed. It is a bio-climatic unit (as demarcated by entire landscapes) wherein human impacts have locally caused irreversible changes in the structure of biological communities (as evident in number/ composition of species and their relative abundances) and their natural habitats' (Section 3 of the Environment (Protection) Act 1986 (EPA)). This approach of conservation or ecological planning considers spatially both ecological and social dimensions of environmental variables. Ecological sensitive regions with exceptional biotic and abiotic elements are being degraded or lost as a result of unplanned developmental activities. Landscapes sustainability as a basic goal for development requires comprehensive picture of the biophysical and socio-cultural information of a region and this approach provides an opportunities and constraints for decision-making and sustainable management of natural resources. Conservation by prioritisation of sensitive regions has been widely used to improve ecosystem by conservations practices. This study prioritises the regions at Panchayat levels in Uttara Kannada district, Central Western Ghats, considering attributes (biological, Geo climatic, Social, etc.) as ESR1(Regions of highest sensitivity or Ecologically Sensitive Region 1), ESR2 (Regions of higher sensitivity), ESR3 (Regions of high sensitivity) and ESR4 (Regions of moderate sensitivity). The current research envisions the beginning of an on-going process to integrate ecological and environmental considerations into administration in the biodiversity rich district of Karnataka –Uttara Kannada district. This is a major step towards an ecological audit that eventually should result in the conservation and sustainable use of biodiversity. Ecological sensitivity concerns ecosystems and their ability to cope with various kinds of environmental disturbances that have the potential of adversely changing the structure of the natural landscapes. Ecologically sensitive regions in the district are prioritized considering biological (terrestrial and aquatic flora and fauna, estuarine biodiversity), ecological (diversity, endemism, conservation reserve), geo-climatic (altitude, slope, rainfall), renewable energy prospects (bio, solar, wind), social (population, forest dwelling communities) as outlined in Figure 8. Weights were assigned for each metric of various themes considering minimal impact on landscape and also to prioritise conservation regions for future planning. Assigning weightages based on the relative significance of themes for prioritizing eco-sensitive regions provides a transparent mechanism for combining multiple data sets together to infer the significance. The weightage is given by Equation 1 [5, 8,9].

$$Weighatge = \sum_{i=1}^{n} W_i V_i \qquad \ldots 1$$

Where n is the number of data sets (variables), V_i is the value associated with criterion i, and W_i is the weight associated to that criterion. Table 2 provides the theme wise decision variable considered with their level of significance, ranked between 1 and 10. Value 10 corresponds to highest priority for conservation whereas 7, 5 and 3 corresponds to high, moderate and low levels of prioritisation. Assigning weightages based on individual proxy based extensively on GIS techniques, has proved to be the most effective for prioritizing ESR. Visualisation of levels of ESR help the decision makers in opting eco-friendly development measures. The study area is divided in to 5'x5' equal area grids (168) covering approximately 9x9 km^2 for prioritizing ESR. A detailed database has been created for various themes covering all aspects from land to estuarine ecosystem. The theme wise description is given below highlights the consideration of variables for study and their significance in conservation priority.

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Table 2: the various themes considered and their weightages

S.NO.	Themes	Weightages / ranking				
		1	3	5	7	10
1.	**LAND**					
	Land use	FC<20%	20<FC<40%	40<FC<60%	60<FC <80%	FC > 80%
	Interior forest	IF<20%	20<IF<40%	40<IF<60%	60<IF<80%	IF> 80%
2.	**ECOLOGY**					
	Flora	NEND	END<30%	30<END<50%	50<END<70%	END>70%
	Tree diversity	SHD<2	2<SHD<2.5	2.5 <SHD<2.7	2.7<SHD<3	SHD>3
	Fauna	-	NEND	-	-	END
	Conservation reserves (CR)	-	-	-	-	National parks, Wild life reserves, Myristica swamps, Sanctuaries
	Biomass (Gg)	BM<250	250<BM<500	500<BM<750	750<BM<1000	BM>1000
3	**GEO-CLIMATIC**					
	Altitude					
	Slope	-	-	-	Slope > 20%	Slope > 30%
	Precipitation	-	1000>RF> 2000 mm	2000>RF> 3000 mm	3000>RF> 2000 mm	RF> 4000 mm

4.	**HYDROLOGY**					
	Stream flow	WA<4	4<WA<6	6<WA<9	9<WA<12	WA=12
5.	**ENERGY**					
	Solar	-	-	<5 KWh/m²/day	5-6 KWh/m²/day	6-6.5 KWh/m²/day
	Wind	-	-	2.4 to 2.55 m/s	2.5 to 2.6 m/s	2.6 to 2.7 m/s
	Bio	SD<1	SD>1	1>SD<2	2<SD<3	SD>3
6.	**SOCIAL**					
	Population density (PD)	PD>200	100<PD<200	100<PD<150	50<PD<100	PD<50
	Forest dwelling communities (Tribes)	-			Tribes are present then assigned 10; if no tribal population exists, then assigned as 0	
7.	**ESTUARINE DIVERSITY**					
	Estuarine regions	-	low	moderate	high	very high

FC-forest cover; IF-interior forest cover; END-endemic; NEND-non-endemic; BM-biomass; SD-supply to demand ratio; WA-Water availability

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Figure 9 illustrates the distribution of grids among ESR 1 to ESR 4. 88 grids represent high ecological sensitiveness with ESR 1 status This is followed by ESR 2 with 24 grids, ESR 3 with 22 grids and the ESR 4 with 34 grids. Spatially 52.38% of the district represents ESR 1, 14.29% of area respresnts ESR 2, 13.1 % of area represents ESR 3 and about 20.23 % of the district is in ESR 4. Figure 9.1 depicts ESR with taluk boundaries. It shows Supa, Yellapura, Ankola, Sirsi, Siddapura, Honnavar, Kumta taluks in ESR 1. Figure 9.2 depicts gram panchayat (gram sabhas) wise ecologically sensitive regions (ESR). Uttara Kannada district has 209 panchayats and among these, 102 panchayats are in ESR 1, 37 panchayats in ESR 2, 33 panchayats in ESR 3 and 37 panchayats in ESR 4. ESR wise villages is depicted in figure 9.3. Sahyadri and eastern part of coastal regions represents highest ecological sensitivitive-ness [5, 8, 9].

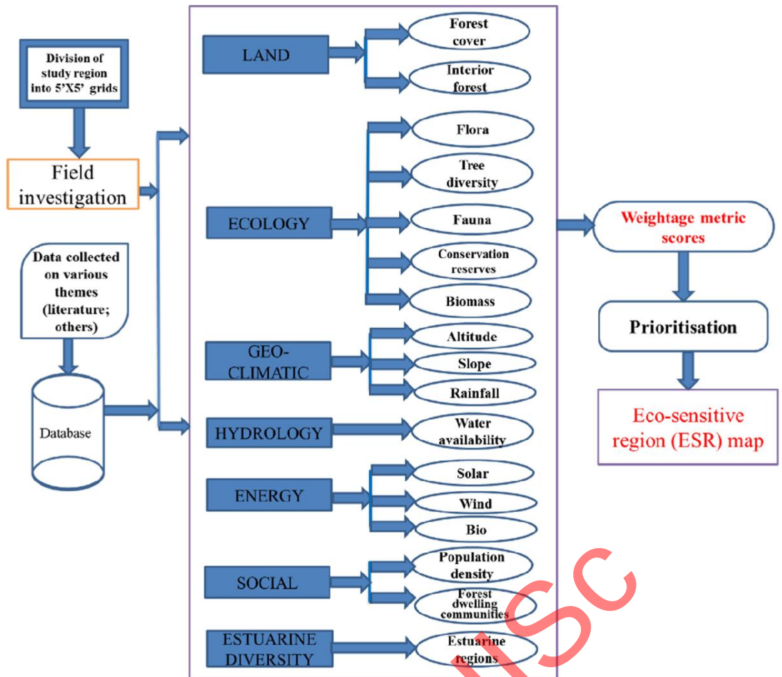

Figure 8: Criteria for prioritizing ESR

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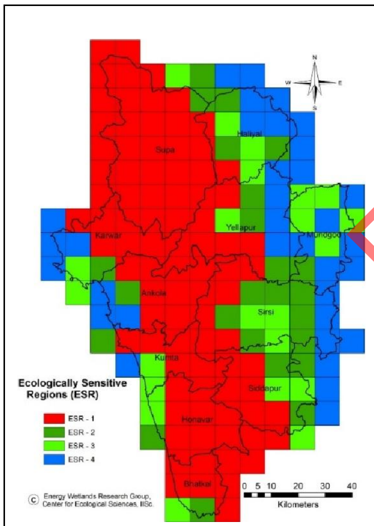

Figure 9.1: Ecosensitive zones in Uttara Kannada district

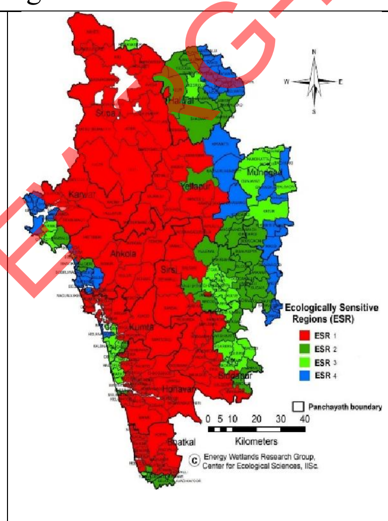

Figure 9.2: ESZ at Panchayat level

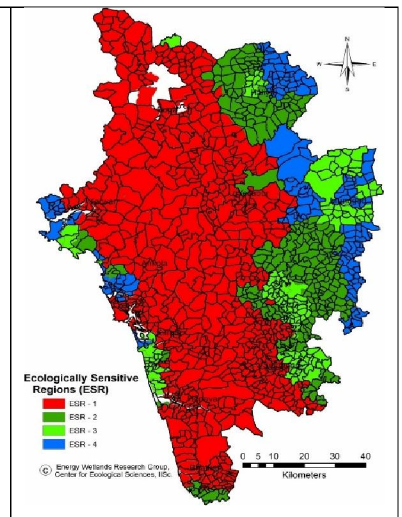

Figure 9.3: ESZ at Village level

Ecological sensitive regions (ESR) at panchayat level / disaggregated level suitable for local level planning (implementation of Biodiversity act, 2002) were delineated by overlaying spatial layer of panachayath. Uttara Kannada has 209 panchayats with the enactment of the 73rd Constitutional Amendment Act to strengthen the grassroots democratic processes. Among these, 102 panchayats are in ESR 1, while ESR 2 has 37 panchayat, ESR 3 has 33 and ESR 4 has 37 panchayats (Figure 9.2). ESR 1 and ESR 2 are most ecologically sensitive regions of the district. The degradation of these areas will have irreversible impact on the ecology, biodiversity and sustence of natural resources. Regions under ESR 1 and 2 are "***no go area***" for any developmental activities involving large scale land cover changes. ESR 2 have ecosensitiveness similar to ESR 1, and has scope to attain the status of ESR 1 with eco-restoration measures (as some pockets are degraded).

ESR 4 are regions of moderate sensitivity, wherein sectors such as agro processing, information technology (IT), and such environment friendly sectors be permitted 5, 8, 9].

7.0 INFLUENCE OF LANDSCAPE DYNAMICS IN A RIVER BASIN ON HYDROLOGICAL REGIME

Carrying capacity of a river basin refers to the maximum amount of water available naturally as stream flow, soil moisture etc., to meet ecological and social (domestic, irrigation and livestock) demands in a river basin. Monthly monitoring of hydrological parameters reveal that stream in the catchments with good forest (evergreen to semi-evergreen and moist deciduous forests) cover have reduced runoff as compared to catchments with poor forest covers. Runoff and thus erosion from plantation forests was higher from that of natural forests. Forested catchment have higher rates of infiltration as soil are more permeable due to enhanced microbial activities with higher amounts of organic matter in the forest floor. Streams with good native forest cover in the catchment showed good amount of dry season flow for all 12 months. While strems in the catchment dominated by agricultural and monoculture plantations (of Eucalyptus sp. and *Acacia auriculiformis*) are sesonal with water availability ranging between 4-6 months. This highlights the impacts of land use changes in tropical forests on dry season flows as the infiltration properties of the forest are critical on the available water partitioned between runoff and recharge (leading to increased dry season flows). This emphises the need for integrated watershed conservation approaches to ensure the sustained water yield in the streams. Assessment show that most Gram panchayats of Karwar and Bhatkal taluks, the Ghats of Supa, Ankola, Kumta, Honnawara, Siddapura, Sirsi and Yellapura have water for all 12 months (perennial). Gram panchayath in the coasts of Honnavara, Kumta and Ankola along with the Ghats of Siddapura, Sirsi, Yellapura and Supa towards the plains have water for 10 – 11 months, the plain regions of Haliyal and Mundgod taluks with part of Yellapura and Sirsi taluks show water availability for less than 9 months (intermittent and seasonal). Quantification of silt yield highlights the linkage of silt yield with the land use in the respective sub-basin. Lower silt yield in sub-basins with good vegetation cover of thick forests, forest plantations, etc. The plains due to the higher lands under irrigation and are open lands, the silt yield is comparatively higher than that of other topographic regions [6, 19, 31]. Strategies to regulate sand extraction are

- **Creation of No Development Zones (NDZ)**: Industries needs to be classified based on their type, and polices shall be amended upon which between 500 m to 10 km either sides of the river and CRZ 1 (Coastal Regulation Zone 1).
- **Fixing of time for silt removal**: Removal of sand be permitted between 7 AM and 4 PM
- **Fixing of sand removal location and quantity**: Based on category of river, sand removal shall be allowed only from the river bed, and no sand

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removal operation be allowed within 10 m of the river bank. No sand removal is allowed within 500 m from any bridge, irrigation project, pumping stations, retaining wall structures, religious places, etc. Quantity of sand extracted at particular location shall not exceed the quantity of silt yield per annum. Weighing bridges are to be fixed at identified locations to regulate the quantity of sand extracted during a year.

- **Fixing vehicle loading points**: Vehicles shall be parked at least 25 to 50 m away from the river banks, no vehicles shall be brought near the river bank. Erecting of pillars to demarcate vehicle restriction regions, beyond which vehicle should not be allowed
- **Restriction on mechanized removal**: No pole scooping or any method shall be carried out in sand removal operation
- **Restriction or ban on sand removal**: Sand shall not be removed from likely places where saline waters mixes with fresh water. Sand removal quantity per year based on scientific assessment and approval of on expert committee of district. Sustainable harvesting of sand considering the yield at point of extraction. Regions such as breeding habitat of fishes and other aquatic organisms, endemic species of riparian vegetation, and basins where ground water extraction is prevalent, are to be identified in the river basins for restricting sand mining. District collector may ban sand removal in any river or river stream during monsoons, based on the Expert Committee. Based on the acts, rules and orders made by the GOI/ state the expert committee shall prepare river development plans for protection of river to keep up the biophysical environment along the river banks
- **Liability of District Collector**: Fifty percent of the amount collected by the local authorities shall be contributed as river management fund and shall be maintained by the district collector.
- **No construction between 500 m to 1 km from flood plain**: To protect life and property damages in cases of flash floods. **Different stretch of rivers different regulations:** Rivers are dynamic, they come across different geomorphic, climatic, sociopolitical settings. Due to this different stretches of rivers faces different issues. Rivers where rivers originate, they are at the highest purity level which needs to be maintained as it is the source contributor for the downstream.
- **Flood Plain protection**: To protect against the damage that affects the floral and faunal diversity, intern maintaining the aesthetical and economic value of the river basins. No chemical based agriculture or fertilizers shall be used in the agricultural fields that affect the river channel polluting and affecting the ecosystem

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8.0 ECOLOGY INTEGRATED CLUSTERING FOR DEVELOPMENT OF LOCAL BODIES:

The geographical clustering approach for integrated, ecologically sound development seems to the only solution for sustainability in rural India, a country which is still a fair mix of advanced state of biotechnology, IT industry and global leaders in textile production, iron steel and transportation co-existing with slash and burn cultivation in the North-East, handmade clothes, village blacksmiths, bullock carts and stone age canoes. The integrated eco-cluster approach, recommended here for Uttara Kannada district, is meant to protect ecology, biodiversity, water resources, culture and traditions while paving way for locality-specific economic development, primarily aimed at elevating levels of livelihood security. Such development is meant to counter the adverse impacts of globalization on environment and human life in this fragile, humid tropical zone rich in biodiversity, both cultivated and wild, and to arrest the recent trends in mass migration of youth, deserting their villages, seeking better livelihoods in big cities. The clustering of gram panchayats, including small towns, for carrying out a proposed set of economic activities per cluster, envisaged here, is the best alternative to mega-projects and macro-economic development for a fragile tropical zone, a part of the Western Ghats, one of the Global Biodiversity Hotspots of the world. As the cities like Bangalore are becoming unliveable due to burgeoning population and chaotic development with water and power crisis looming large, rising pollution and scanty living spaces, the strains are felt in the Western Ghats for siphoning of water, producing hydro-power and even thermal and nuclear power, and extracting diverse kinds of natural raw materials, endangering ecology and impoverishing rural life, making the youth migrate in large numbers deserting their rural homes and leaving behind their traditional livelihoods [12].

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8.1 Cluster Development Approach for Uttara Kannada:

Sector-wise cluster development approach is already inherent and is gaining increasing importance in Karnataka. For, instance in the field of crop production Bangalore urban and Rural, Kolar and Tumkur constitute a mango cluster targeting production of export quality mangoes. Dakshina Kannada, Udupi, Uttara Kannada and Kolar make a cashew cluster. Most of the malnadu districts of the State belong to a cocoa cluster and so on. All sector integrated, ecology based cluster approach is lacking so far [12].

The coastal gram panchyats are grouped into coastal clusters in view of their proximity to sea, marine fishing as a form major livelihood, their threats from sea level rise and sea erosion in future, nearness or inclusion of estuaries and creeks, which themselves are highly productive ecosystems, low, hilly lateritic terrain, the possible compacted deposits of ancient Gondawanaland erosion, with specialized ecosystems and so on. The inner coastal panchayats bordering on Western Ghats are grouped into separate clusters. If major west flowing rivers intervene in the landscape the gram panchayats on either sides are grouped into separate clusters. In the Malnadu taluks the eastern relatively drier gram panchayats and western ones along the crest of the Western Ghats, clad in mainly evergreen forests, make separate clusters. The Anshi-Dandeli Tiger Reserve, inclusive of Anshi National Park and Dandeli Wildlife Sanctuary along with associated villages constitute one cluster. In this cluster developmental activities are primarily related to eco-tourism and associated ones, considering the sensitivity of the conservation area. In Mundgod and Haliyal, the taluks merging with the Deccan zone, the GPs of relatively flatter eastern portions having numerous ponds and lakes are brought in clusters separate from those bordering Malnadu forests. Development activities are proposed considering the terrain, landscape elements, ecology, farming systems, associated human life etc. The resulting clusters form self- reinforcing networks of local industries, research institutions, universities, financial bodies and public sector organisations characterised by high level of competition and collaboration.

8.2 Cluster facilitators and need for institutional structure for implementation:

Village panchayats form ideal units for implementation of cluster approach for integrated eco-friendly development. The success of cluster based development programmes will depend on the active participation of facilitators. The various Government departments, financial institutions and NGOs will have active roles to play for the success of the integrated cluster-base approach. In addition there is also need for district and taluk level facilitator committees for scrutinsation of developmental plans and review of progress achieved. The role of some facilitators, for instance, are indicated below

- As forests constitute a major asset of the district the Forest Department need to be strengthened with more manpower.
- Development of nurseries involving local people. People be encouraged and guided to make nurseries of forest trees and medicinal plants (*Coscinium fenestratum, Nothapodytes nimmoniana, Asparagus racemosus, Emblica officinalis, Saraca indica, Terminalia bellirica, Adhatoda vasica, Rauwolfia serpentina, Tinospora cordifolia* etc)
- It is suggested to look into the feasibility of purchase of medicinal plants or their products by the Forest Department itself, or by the local VFCs from the producers at fair prices, and the sale/supply of these goods to pharmaceuticals to be undertaken by the Forest Department itself. This recommendation is being made so as to stop rampant illegal collection and trade of medicinal plants from the wild.
- The local ayurvedic pharmaceuticals (within the district), and local people to be engaged in cultivation and value addition to medicinal plants be supplied with medicinal plants/products on priority basis to enrich the local economy and employment potential
- NTFP collection and value addition,
- Developing bee-keeping involving forests and mangroves. As bee-keeping is recommended as an important activity for almost all clusters, roadsides, common lands, under-stocked or degraded forest patches around villages be planted with appropriate nectar plant species.
- Contract system for collection of NTFP from forests found to be highly detrimental to forests and biodiversity and economic well being of local people be stopped forthwith and co-management system involving local people be adopted.
- Production of bamboo based products by local craftsman and effective utilization of bamboo for local development is important
- Use of alternative energy sources replacing firewood
- Development of bettas for tree farming, medicinal plants and fodder,
- Promoting backwater, mangrove, and beach tourism, development of rural tourism and home stays in the vicinity of forests and wildlife areas
- Regular conduct of training in bird-watching, wildlife studies, trekking trails, hygiene and solid waste management involving VFCs, local youth in forest and wildlife related tourism areas be arranged with view of generating eco-friendly employment potential.
- Utilization of weeds and harvestable trees/tree parts, bamboos, canes etc. from plantations or other designated areas for vegetable dyes, medicines, weaving, furniture, handmade paper, sports goods production.
- Awareness creation and conservation of sacred groves, sacred kans, which are biodiversity and hydrology significant areas

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and still playing unique cultural roles in rural society.

- All hydrologically significant forest patches, as indicated, for instance, by high Western Ghats endemism among trees, be preserved both for the sake of perenniality of water courses and for the biodiversity content.
- The Department to consider pooling back good part of income from VFC managed areas into sustainable income generating activities in the cluster level.

9.0 BIODIVERSITY DOCUMENTATION THROUGH STUDENTS

Following the Biodiversity Act, 2002 of India, many State Biodiversity Boards were constituted which in turn are involved in formation of Biodiversity Management Committees (BMC) for "promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity." The **BMCs should prepare People's Biodiversity Register (PBR) containing local knowledge on biological resources and their usages. Nationwide preparation of PBRs,** is expected to be a mammoth exercise for India, a megadiversity country [28, 30, 33, 1].

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A decade is past since the Biodiversity Act, but only tardy progress made in relation to PBRs. Major hurdles hampering the process appeared to be concepts and formats unfriendly for grassroots level people, paucity of taxonomic expertise, low funding and lack of motivation and guidance. Model PBRs prepared were at enormous expenditure, and through the deployment of experts and not easily replicable. Looking for alternatives to current model of PBR preparation, we attempted under the aegis of the Integrated Ecological Carrying Capacity Project for Uttara Kannada the deployment of student community from high schools and colleges to document biodiversity under the banner **'My Village Biodiversity'**. Simplified formats, as understood easily by high school students and village communities, were used for data collection, carried out during 2010-11 and 2011-12. The teachers were given orientation programmes about biodiversity, Biodiversity Act, and on formats to be used. Competitions were conducted for students and nominal rewards announced for the best reports and good presentations. No financing of the educational institutions was done to carry out this model of work. The objectives included:

a. ***Sensitisation of students:*** The very use of data formats were also aimed at sensitizing students to biodiversity related issues. Notable among data to be gathered included forest types, landscape and waterscape elements, plant and animal diversity as the village community understand, crop diversity, preparations and uses of bio-pesticides, organic farming, traditional storage methods, NTFP, management of village environment, community health, wildlife, human-wildlife conflicts, domestic animal diversity, production of honey and apiculture, energy sources, skilled and knowledgeable people in the villages, sacred groves etc.
b. ***Recording observations:*** The students were advised to read and understand data formats under the guidance of teachers
c. ***Vital information on crop diversity:*** Stress laid on documentation of local varieties of crops.
d. ***Low cost methods to assist PBR preparation:*** No money was paid to partner

institutions and students except for meeting the travel expenses for attending workshops.

e. ***Creating ambassadors of goodwill:*** Students, with their unbiased minds were expected to merit greater acceptability in the households, as the villagers otherwise tend to be more reserved with outside agencies like NGOs engaged in such work.

f. ***Expertise in communication:*** Students were expected to gain good communication skills.

About 580 students from 116 high schools and 6 colleges representing the 11 taluks of Uttara Kannada took part in the two year exercise, in the course of the Carrying Capacity project work. Biodiversity documentation covered about 190 villages of the total of about 1200 villages in the district. Considering the sluggish scenario of PBR progress, with only 212 panchayats of Karnataka covered by 2008, comments on their merits pending, the cost was high for the Biodiversity Board in its infancy to bear, but at the same time funding considered small by the agencies catalyzing the PBRs at panchayat levels.

Some schools fared poorly in their outputs on village biodiversity recordings, mainly on account of guiding teachers missing the orientation programmes. If the education departments, make suitable changes in the syllabi to incorporate biodiversity documentation, with due credits to the performers, the outcome would be more fascinating. The students in general found greater acceptability in the villages, got first hand learning opportunities and often turned out to be communicators of good order. To highlight some results, notably, of 190 villages where rice cultivation was reviewed, 181 varieties were recorded; out of them 101 were native varieties. Sample survey with regression analysis gives expectation of finding around 492 native varieties in the district. Countrywide adoption of the method will benefit rapid documentation of traditional varieties, feared to have dwindled from around one lakh down to 8-10 thousand, mainly due to unregulated introduction of new varieties. Documentation also covered local varieties of banana, pepper, mango, jack, sugarcane, arecanut, coconut etc. The villages have rich wealth of traditional knowledge holders like herbal healers specialized in treating ailments like rheumatism, paralysis, migraine, kidney stones, bone fractures, eye and skin problems, jaundice, herpes, paralysis, infertility, epilepsy etc. and cattle diseases. Medicinal plants were exhibited during workshops and their uses documented. Information on persons with knowhow on biopesticides, earthworm manure, water divining, organic farming etc. also is available. Villagers gave good account of local wildlife, on occasional visiting animals like tiger, leopard, bear etc. Local names of fishes available in the fresh water bodies were recorded. The students provided indications on the presence of hundreds of sacred groves in the villages. They would be interesting places from biodiversity and cultural angles. On the whole pastoralism is on the decline due to fodder scarcity, and cattle manure, inevitable for high rainfall agricultural soils, is getting scarce. This can undermine the very farming system of the district. Our experiment shows the huge potential for harnessing the student power for documentation of the immense biodiversity of the country. Biodiversity awareness creation among the younger generation is a paramount necessity for the successful documentation. **The education system has to be restructured to institutionalize biodiversity documentation, especially using student power from high school and undergraduate levels with due academic credits given to the participants.**

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