Neo Geographia

An International Journal of Geography, GIS & Remote Sensing
(ISSN-2319-5118)

Volume II Issue I
January 2013

Neo Geographia is a refereed journal.
Published by: Barloni Books, for Interactions Forum, Pune.
Printed By: Barloni Books, MIT Road, Pune-411038

Official Address:
Anand Hanumant Londhe,
Interactions Forum, I/C of
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CONTENTS

Spatial and Temporal Variability of Mean Annual Ground Surface Temperatures (MAGST) in the Gukur Catchment, Central Tian Shan

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Abstract

Permafrost temperatures in mid-latitudinal mountain ranges are predominantly warm and therefore susceptible to climate change. But only little information exists concerning the distribution and thermal state of the permafrost in Chinese part of the Central Tian Shan. In this study a dense network of 69 temperature logger was installed in the 130 km² Gukur catchment to monitor Ground Surface Temperatures (GST) over two consecutive years and assess the thermal state of the permafrost underneath. Results therefore improve the scientific knowledge on spatial and temporal variation of Mean Annual Ground Surface Temperatures (MAGST) as an indicator for permafrost. Besides topographic parameters like altitude ($r= -0.68$, $p < 0.001$ first year; $r= -0.76$, $p < 0.001$ second year), snow cover emerged as the dominant factor for spatial variability of MAGST. Thus variations of more than 4°C are common within short distances (< 350 m) and on same altitudinal levels. The insulating effect of snow shields the ground from cold air temperatures during winter. Furthermore, inter annual variations of MAGST correlate significantly ($r= 0.72$, $p < 0.001$) with variations in duration of the insulating snow cover. Thus, snow distribution could be identified as the main factor for inter annual variations of MAGST

Introduction

Detailed investigations on permafrost distribution and permafrost temperatures under climate change conditions are one of the key research topics in densely populated mountainous areas like the European Alps for natural hazard assessment and challenges in engineering (e.g. Haeberli 2013, Harris et al. 2001). Despite the low population density in the alpine areas of the Chinese Tian Shan, information on permafrost gets increasingly important for the region, as the main interest is not infrastructures or rockfalls, but water discharge in this arid continental climate (Bolch & Marchenko 2006). Climate change actually leads to an accelerated ablation and retreat of high mountain glaciers in most parts of the world, and to a runoff increase of the related rivers in the short to middle term. Whereas this is a well-known fact, the additional runoff supplied by slowly melting ground-ice and perennial snow fields is almost unknown. However, this periglacial contribution is significant. Marchenko et al. (2005) estimate the total volume of ice in permafrost to be similar to the volume of glaciers in the region. In extremely arid mountainous areas like the Central Tian Shan, the water of rivers form the vital source for the economic development of the Taklamakan basin, rich in natural resources and strongly suffering from water shortage. With a contribution of more than 70 % to the total runoff of the Tarim River, the Aksu has by far the largest impact on the water resources and the future development of this region under climate change conditions. Ground thermal regime and frozen ground are the result of energy and moisture exchange between atmosphere and the ground surface. The key variable resulting from these exchange processes is the ground surface

temperature (GST), which is transmitted into subsurface temperatures through topography, surface characteristics and ground thermal properties. The presence of frozen ground, both seasonally and perennially, in turn influences the ecological site conditions depending on its local characteristics.

The variation of frozen soil depth is closely related to varying air temperature and solar radiation. At present, these relationships are quite well understood in polar lowlands (e.g. Washburn 1979, Williams & Smith 1989, French 1996), while still little is known about the function of correspondent processes under the more pronounced topography and characteristic forms of high mountain environments (King 1984, 2000, Tenthorey 1992, Keller 1994, Hoelzle et al. 1999, Hoelzle et al. 2001, Mittaz 2002). This especially concerns the depth change of permafrost, where temperature change is decelerated for very long periods (Chen 1997).

While a wide range of low resolution maps on permafrost exist for most parts of the region, detailed investigations on small scale distribution of permafrost in the Central Tian Shan is absent (e.g. Ran et al. 2012). The availability of even basic data (e.g. mean air temperature, snow thickness etc.) is very scarce. But small scale influences cannot be neglected, as considerable changes of MAGST and permafrost temperatures are common in high mountains, even in close proximity (Gubler at al. 2011). Hence, the main scientific tasks of this study include an improvement of knowledge on the variability of ground surface temperatures and permafrost distribution as well as deriving the factors having the largest effect on these parameters. These results are also fundamental to better understand the contribution of permafrost and snow to the water discharge in the Aksu catchment and the Central Tian Shan.

Study area

The Tian Shan, situated in Central Asia, extends some 2,500 km from east to west. It is one of the highest mountain ranges in the world and can be divided into a Western, Inner, Northern, Central and Eastern Tian Shan. Maximum altitudes range from more than 7,000 m a.s.l. in the Central Tian Shan to about 6,000 m a.s.l. in the Inner and 5,000 m a.s.l. in the other parts of the Tian Shan, respectively. Apart from the southwest, where it is bordering the Pamir Mountains, the Tian Shan is surrounded by (semi-) arid lowlands. The climate can be described as highly continental, with decreasing precipitation from northwest to southeast. Therefore the average annual precipitation in the Central Tian Shan is very low, even in high altitudes. The altitudinal lower limits of continuous permafrost in the region have been identified at 3,500 m a.s.l. for the Northern and Eastern, 3,600 m a.s.l. for the Inner and 3,800 m a.s.l. for the Western Tian Shan (Gorbunov et al. 1996). Furthermore geothermal observations show an increase in temperature between 0.3 °C and 0.6 °C for the last 30 years (Marchenko et al. 2007). As permafrost warms up and the active layer is thickening – by about 23 % since the early 1970s (Marchenko et al. 2007) - seasonally frozen ground has decreased by 7% in the northern hemisphere since 1900 and the annual average of snow cover in the period of 1988- 2004 shows a reduction by 5% compared with the period of 1967-1987 (Lemke et al. 2007).

Stretching across the China-Kyrgyzstan border, the Aksu catchment is located in the highest parts of the Central Tian Shan between 41°10'N-42°50'N and 78°30'E-80°30'E. The largest glaciers are mainly originating from the vicinity of Tomur Peak, with 7,435 m a.s.l. the highest mountain of the Tian Shan. The presence of large amounts of debris on top and surrounding these glaciers are typical for the region (Wang et al. 2011). This leads to a close interaction of the glacial and permafrost environment. Debris covered glaciers, ice cored moraines and rock glaciers are very common in the Aksu catchment. Detailed field investigations are carried out in the 130 km² Gukur catchment (Figure. 1) and started in August 2010. The catchment, sited in the vicinity of Tomur Peak, is a direct tributary to the Aksu river. Altitudes range from about 2,000 m a.s.l. up to 5,986 m a.s.l.. The three main glaciers are known as No. 72, No. 74 and No. 76 according to the Glacier Inventory of China and are surrounded by an extensive periglacial area.

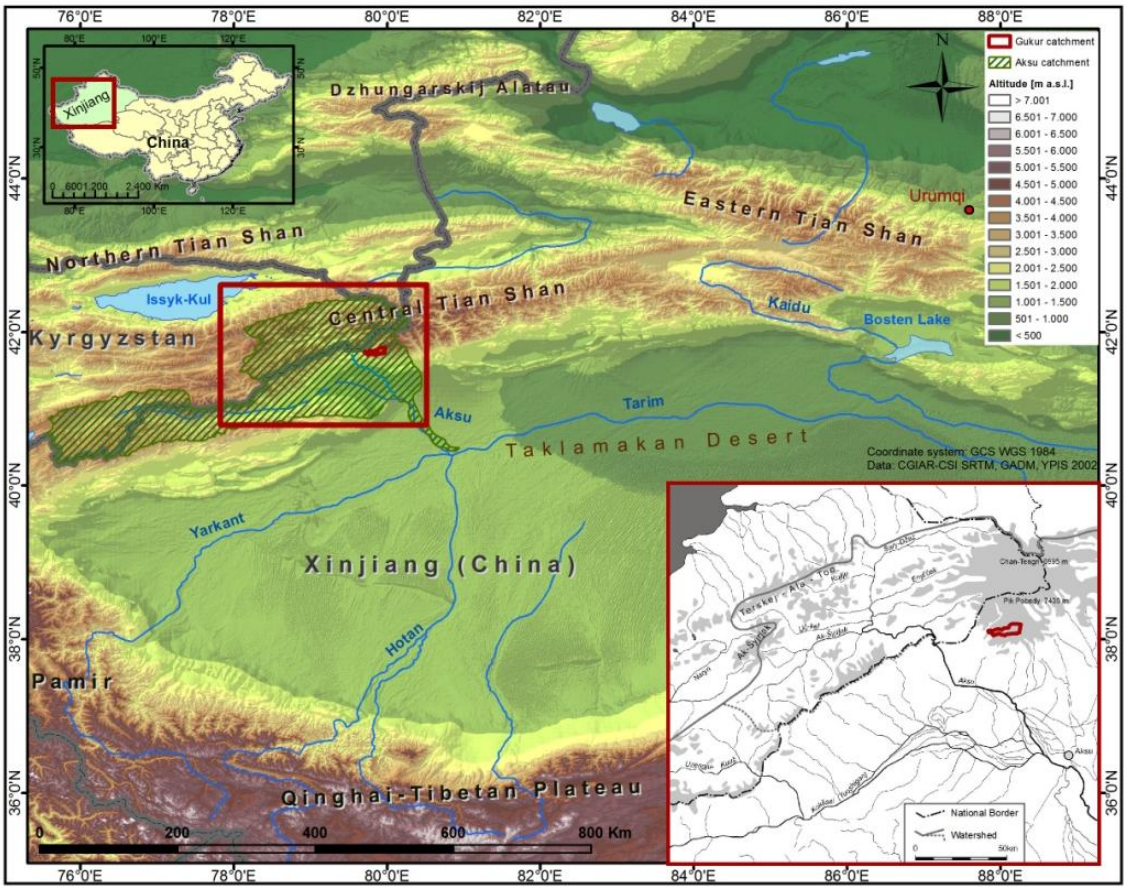

Fig. 1: Regional overview and location of the research area (Gukur catchment) within the Aksu catchment, Central Tian Shan.

Data and Methodology

Instruments

A dense network of 46 high resolution thermistor strings and 23 mini temperature data loggers were installed at a total of 69 locations in the Gukur catchment.

The commercial M-Log5W (GeoPrecision, www.geoprecision.com) wireless mini data loggers with inbuilt PT1000 sensors are used to measure the ground surface temperature (GST). They have a high memory capacity (2048 kB), low energy consumption and come in a small, but waterproof housing. The inbuilt PT1000 temperature sensor has a high resolution of 0.01 °C and an overall accuracy of ± 0.1 °C. These features minimize the maintenance to a minimum (battery change every 5 to 10 years, depending on temperature conditions) and are thus ideal for continuous temperature monitoring in remote areas. Furthermore, the wireless interface with an operating range of up to 100 m (433 MHz) allows reading-out data remotely by laptop and a USB-dongle.

For the temperature measurements at multiple depths in the active layer, the same M-Log5W wireless mini data loggers are used. But, instead of an inbuilt temperature sensor, they can be attached to thermistor strings (Figure 1). For maximum cost benefits, the thermistor strings were designed and manufactured at the Institute for Physics at the University of Giessen with the help of GeoPrecision. The chosen DALLAS DS1820 temperature sensor has a lower resolution (0.065 °C) and accuracy (± 0.25 °C) in the expected temperature range, but is cheap and easy to handle. The unique 64-Bit serial code allows multiple DS1820 sensors to function on the same 1-Wire bus and can therefore be controlled with an M-Log5W. For each string, five DS1820 sensors were used with intervals of 20 cm, 20 cm, 30 cm and 50 cm, adding up to a total length of 120 cm. Some extra cable ensures that the attached M-Log5W can be buried safely and hidden from any human or animal disturbances. The temperature strings are waterproof and resistant to tensile stress.

Experiment design

For best representation of GST, the upper most sensor of the thermistor string as well as the M-Log5W with inbuilt sensor are buried at a depth of about 2-3 cm below the surface to prevent the sensor from direct surface exposure. Temperatures are recorded at an hourly interval at all locations. In order to identify the factors having the largest influence on GST and active layer depth, the 69 locations were carefully chosen to represent the local conditions in terms of altitude, topography, substrate and vegetation cover as well as probable thickness of snow pack and duration of snow over (Figure 2). Depending on local conditions, the depths of the deepest sensor of the thermistor strings range from 52 cm to 125 cm below surface.

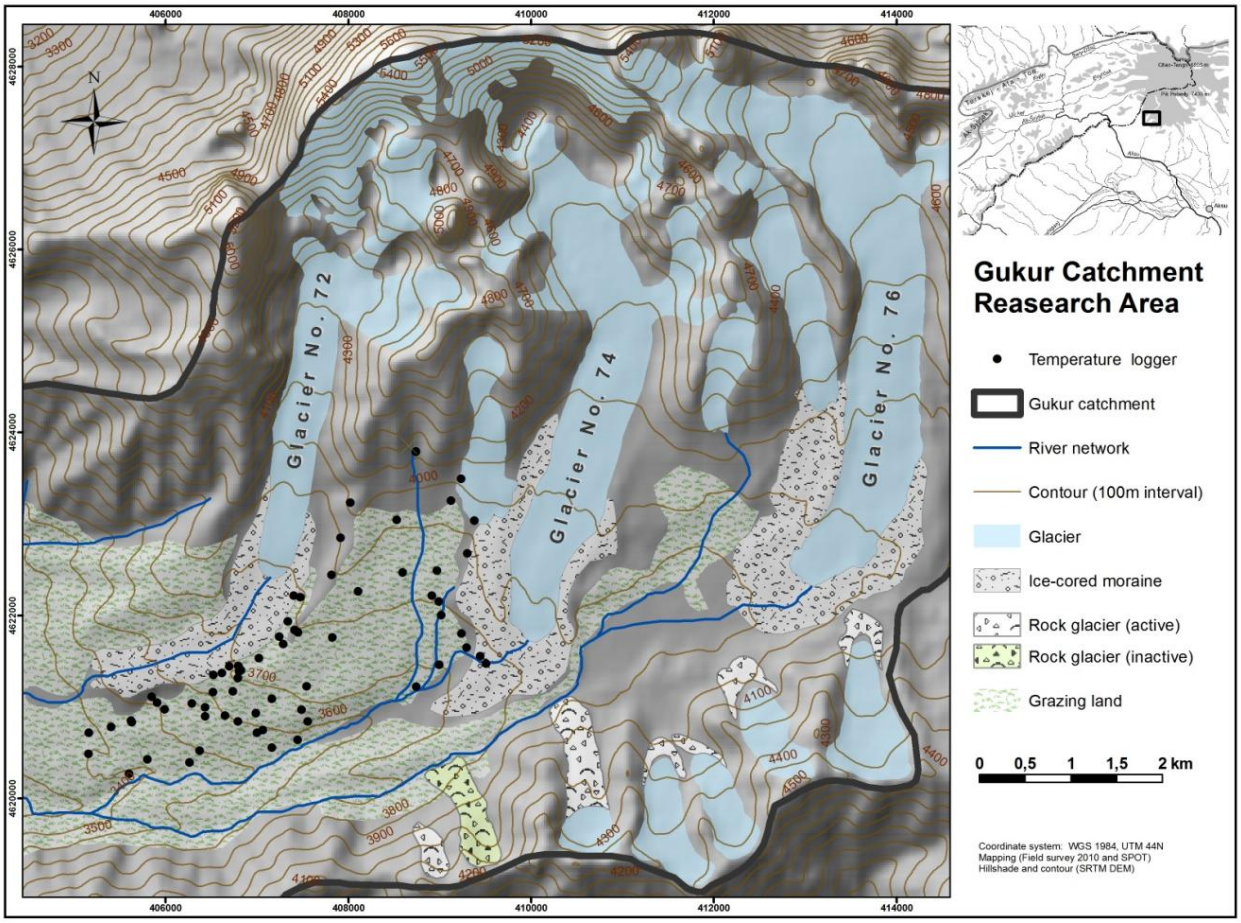

Fig. 2: Position of all 69 temperature loggers in the Gukur catchment research area.

Topographic factors

To obtain a reliable temperature gradient, altitudes of logger positions range from 2,476 m to 4,129 m a.s.l.. The majority of loggers are placed between 3,400 m and 4,000 m a.s.l. as this is considered the altitudinal band, where the lower limit of continuous permafrost is expected (Gorbunov et al. 1996). For further analysis slope is categorized in "flat" (≤ 8°), "medium" (8° - 16°) and "steep" (<16°), aspect in the four major geographic directions north, east, south and west.

Substrate and vegetation cover

In the given altitudinal range, vegetation cover is limited to graze land and depends strongly on the substrate. Thus, vegetation cover (VC) is grouped into the three classes: (VC1) dense grass cover, (VC2) sparse grass cover and (VC3) total absence of grass cover. Similarly the substrate can be divided according to ISO 14688-1 into (S1) fine grained, mostly silty material, d < 2 mm; (S2) a matrix (silt) supported gravel, d < 63 mm and (S3) larger

open work debris (mostly cobbles) at talus slopes and young moraine deposits $d > 63$ mm. Singular cobbles and larger boulders are randomly enclosed in all categories.

Snow cover and wind exposure

Due to the remoteness and inaccessibility of the study area, there is no direct information on snow thickness and snow distribution. Snow has a significant insulating effect on the ground below, due to its low thermal conductivity (e.g. Smith, 1975; Goodrich, 1982; Zhang et al., 1996; Ishikawa, 2003; Zhang, 2005). Therefore, daily GST variation can be used to identify the onset and duration of a substantial snow cover. Daily temperature amplitudes (Rödder and Kneisel, 2012) or thresholds for daily standard deviation are proposed in various studies ranging from 0.09 °C for hourly temperature intervals (Schmidt et al., 2009) to 1 °C for sampling intervals of 4 hours and a snow thickness of at least 2.5 cm (Danby and Hik, 2007). Schmid et al. (2012) propose a more complex approach using different thresholds for positive (0.1 °C) and negative (0.3 °C) temperatures.

Obviously, the duration of snow cover is slightly underestimated with this method. A snow cover is only identified if snow depth is sufficient to alter the daily temperature amplitude. But this is by no means a drawback, but rather intended in this study, as only a snow depth that considerably insulates the ground from air temperatures is relevant for further investigation in this study. After analysis and interpretation of the dataset and taking into account the accuracy and resolution of the temperature loggers, a threshold of $\sigma \leq 0.2$ °C was chosen for the daily standard deviation of GST in this study.

Additionally the position was described in situ as being "exposed" to or "sheltered" from wind. This factor describes the immediate local condition like ridges or small depressions and does not correspond to general wind directions.

Zero curtain

Zero curtain periods are calculated using a threshold for temperature deviation from 0 °C. Following the approach by Gubler at al. (2011) the final threshold was chosen by testing a very small threshold and stepwise increasing it until homogeneous results were produced. The resulting threshold of ≤ 0.12 °C and ≥ -0.12 °C thus is also an indication for data accuracy of the instruments in the given temperature range.

Due to the release of latent heat in the freezing process of water, the duration of zero curtain periods in different depth of the active layer can further be used to identify locations with higher water content in the catchment.

Results

Data quality

The instruments proved to be highly reliable and easy to handle. Time consuming recovery of data loggers is not applicable due to the wireless data interface. Operation range of the wireless data transmission is in general less than 10 m due to the burial of the loggers below the ground. Although being less than the 100 m stated above, it is more than sufficient for this application. If necessary, larger operating ranges can be achieved using a directional antenna. Still, eight loggers showed clear indications of animal disturbance. This resulted in corrupt measurements as sensors were dug out and exposed to the surface or complete failure in two

locations, where thermistor strings were bitten through. Furthermore, six loggers could not be approached in 2012 due to harsh weather conditions during field work. This leaves a total of 61 loggers for the time frame of August 16th 2010 to August 15th 2011 and 55 for August 16th 2011 to August 15th 2012.

Analysis of zero curtain periods (see above) furthermore indicates, that accuracy of the DALLAS DS1820 temperature sensors are probably around 0.12 °C in the relevant temperature spectrum and therefore much higher than the 0.25 °C stated above.

Site specific parameters

The main site specific parameters, which are not altered considerably within the time period of a year, are shown in Figure 3. Slopes vary between less than 3° and up to 25° while aspect shows a slight tendency of over presenting south and west exposed locations, giving credit to the main orientation of the Gukur catchment (see Figure 2). Same is applicable for vegetation cover which represents the extensive grazing areas between glacier No. 72 and glacier No. 74 with its fine grained silty substratum.

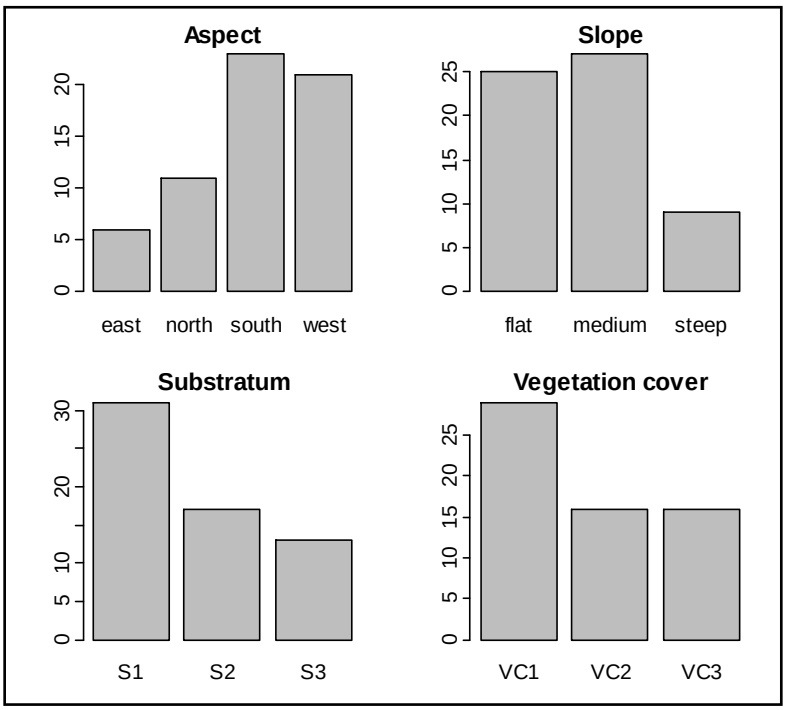

Fig. 3: Number of temperature loggers representing site specific parameters (substratum: S1 = fine (d < 2 mm), S2 = medium (d between 2 mm and 63 mm), S3 = coarse (d > 63 mm); vegetation cover: VC1 = dense grass cover, VC2 = sparse grass cover, VC3 = total absence of grass cover)

Ground surface temperatures

Table 1 lists all temperature loggers and thermistor strings that were installed in the catchment together with MAGST and calculated snow covered days for the two years monitored (if available) and all metadata recorded in the field. The measured temperatures (MAGST) range between 4.86 °C and -3.28 °C for the first and 4.82 °C and -4.74 °C for the second year. Extensive variations in MAAT can be expected at the different locations due to the altitudinal differences of more than 1,600 m (between 2,476 m and 4,129 m a.s.l.). As a result, altitude is the factor having the highest correlation with MAGST ($r = -0.68$, $p < 0.001$ for first year, $n = 61$; $r = -0.76$, $p < 0.001$ for second year, $n = 55$). Looking for other factors effecting MAGST this correlation and the difference in altitude of the locations needs to be incorporated.

Figure 4 gives an overview of relevant parameters in relation to MAGST and altitude for the first year of monitoring. It clearly indicates that MAGST is most significantly influenced by the factors aspect and snow cover. While slope, substrate and grass cover show clear tendencies, the effect is overlain by the aforementioned more dominant factors.

Logger ID	Altitude [m a.s.l.]	Slope [°]	Aspect	Substrate	Vegetation cover	MAGST [°C]			Snow cover [days]	
						(1)	(2)	$\bar{x}$	(1)	(2)
A50222	2476	7	north	S1	VC1	4.86	4.82	4.84	3	5
A5021D	2826	5	west	S1	VC1	3.98	3.68	3.83	21	13
A50208	3213	11	west	S2	VC2	2.15	1.62	1.89	27	26
A10212	3406	9	north	S2	VC2	-1.75	-1.76	-1.75	28	25
A10229	3416	5	east	S1	VC1	2.20	1.77	1.99	31	48
A1022A	3439	7	south	S3	VC3	2.62	2.07	2.34	198	139
A1022B	3442	10	north	S1	VC1	-1.34	-1.62	-1.48	112	110
A5021F	3477	8	north	S2	VC1	-0.32	-1.36	-0.84	244	248
A10234	3482	15	south	S1	VC2	1.64	1.53	1.58	31	19
A10200	3483	9	south	S2	VC2	2.72	2.24	2.48	36	16
A10204	3520	13	south	S1	VC1	2.05	1.64	1.84	34	21
A5021C	3523	8	west	S1	VC1	0.80	0.42	0.61	49	32
A10226	3533	9	north	S1	VC1	-0.39	-0.98	-0.69	163	128
A50226	3542	22	south	S1	VC1	3.03	2.18	2.60	7	10
A1022E	3558	9	west	S1	VC1	0.59			207	
A10223	3571	6	west	S1	VC1	-1.68	-1.43	-1.56	60	39
A50214	3577	11	west	S1	VC1	-0.90	-1.63	-1.27	84	29
A1021E	3587	14	south	S1	VC1	0.27			41	
A1023D	3594	9	south	S1	VC1	0.62	-0.77	-0.08	23	12
A50224	3607	19	south	S2	VC2	-0.77	-1.33	-1.05	7	8
A5020C	3633	8	south	S1	VC1	1.30	-0.33	0.48	205	79
A1021D	3637	18	south	S3	VC3	0.68	0.19	0.44	66	34
A50223	3650	25	south	S1	VC1	0.77	-0.11	0.33	13	13
A10214	3680	10	south	S2	VC2	-0.80	-1.14	-0.97	31	18
A1020C	3681	7	north	S1	VC2	-1.11	-2.32	-1.71	218	209
A1024C	3681	17	south	S1	VC1	0.87	0.15	0.51	49	33
A1023B	3683	12	south	S2	VC3	0.43	0.25	0.34	49	29
A1021C	3690	8	west	S1	VC2	-1.51	-1.54	-1.53	78	52
A5020D	3696	12	north	S1	VC1	-0.83	-2.55	-1.69	225	190
A10241	3698	4	west	S1	VC1	-1.38	-2.66	-2.02	192	123

A5021B	3702	5	south	S2	VC2	0.14	-0.11	0.02	37	19
A1021A	3703	12	south	S2	VC3	0.26	-1.54	-0.64	236	78
A10236	3703	9	north	S2	VC2	1.06	-0.17	0.45	234	239
A10243	3710	7	south	S2	VC2	0.76	-0.38	0.19	219	100
A1023E	3720	8	north	S1	VC1	-0.16	-3.15	-1.65	229	60
A10240	3733	4	west	S2	VC2	-2.14	-4.74	-3.44	58	25
A50215	3755	7	west	S3	VC3	0.83	0.42	0.63	13	14
A10216	3758	9	west	S3	VC3	1.05	-1.75	-0.35	235	212
A1024A	3781	11	south	S3	VC3	-0.86	-1.15	-1.01	93	34
A50203	3782	3	west	S3	VC3	-2.48	-3.88	-3.18	130	34
A10215	3784	7	south	S1	VC1	-0.42	-1.91	-1.17	150	38
A5020E	3784	8	west	S3	VC3	-0.39	-0.32	-0.36	12	3
A1020A	3785	9	west	S3	VC3	0.26	-2.49	-1.12	235	62
A10244	3793	11	north	S3	VC3	-1.33			167	
A10235	3796	8	north	S1	VC1	-0.77	-3.09	-1.93	218	68
A5020F	3797	8	west	S1	VC1	-1.85	-3.12	-2.49	150	150
A50204	3805	14	west	S2	VC2	-0.82	-4.20	-2.51	213	13
A50206	3807	17	east	S3	VC3	0.34	-2.59	-1.13	213	0
A1020D	3818	13	east	S3	VC3	0.80	-0.40	0.20	144	28
A10239	3825	8	west	S3	VC3	-3.28	-3.31	-3.30	30	14
A10237	3849	9	east	S3	VC3	0.74	-1.89	-0.58	232	84
A1023A	3850	6	east	S1	VC1	-1.88	-3.85	-2.87	203	96
A1021B	3859	7	east	S2	VC2	-0.20	-1.22	-0.71	243	243
A50213	3887	24	west	S1	VC2	-2.02	-2.86	-2.44	167	20
A1023F	3920	10	west	S1	VC2	-3.13	-3.28	-3.20	66	45
A10245	3929	25	west	S1	VC1	-1.31	-2.96	-2.14	158	20
A1024B	3936	13	south	S2	VC1	-0.62	-2.64	-1.63	225	51
A10211	3971	11	south	S2	VC1	-0.11	-3.08	-1.59	247	153
A10248	4049	14	south	S1	VC1	-1.03			248	
A10232	4060	7	west	S2	VC3	-2.56			109	
A50212	4129	21	south	S1	VC1	-1.44			238	

Table 1: Metadata of all installed temperature loggers in the Gukur catchment (MAGST and snow cover for the two years of measurement, (1) = 16/08/2010 – 15/08/2011, (2) = 16/08/2011 – 15/08/2012; substratum: S1 = fine (d < 2 mm), S2 = medium (d between 2 mm and 63 mm), S3 = coarse (d > 63 mm); vegetation cover: VC1 = dense grass cover, VC2 = sparse grass cover, VC3 = total absence of grass cover).

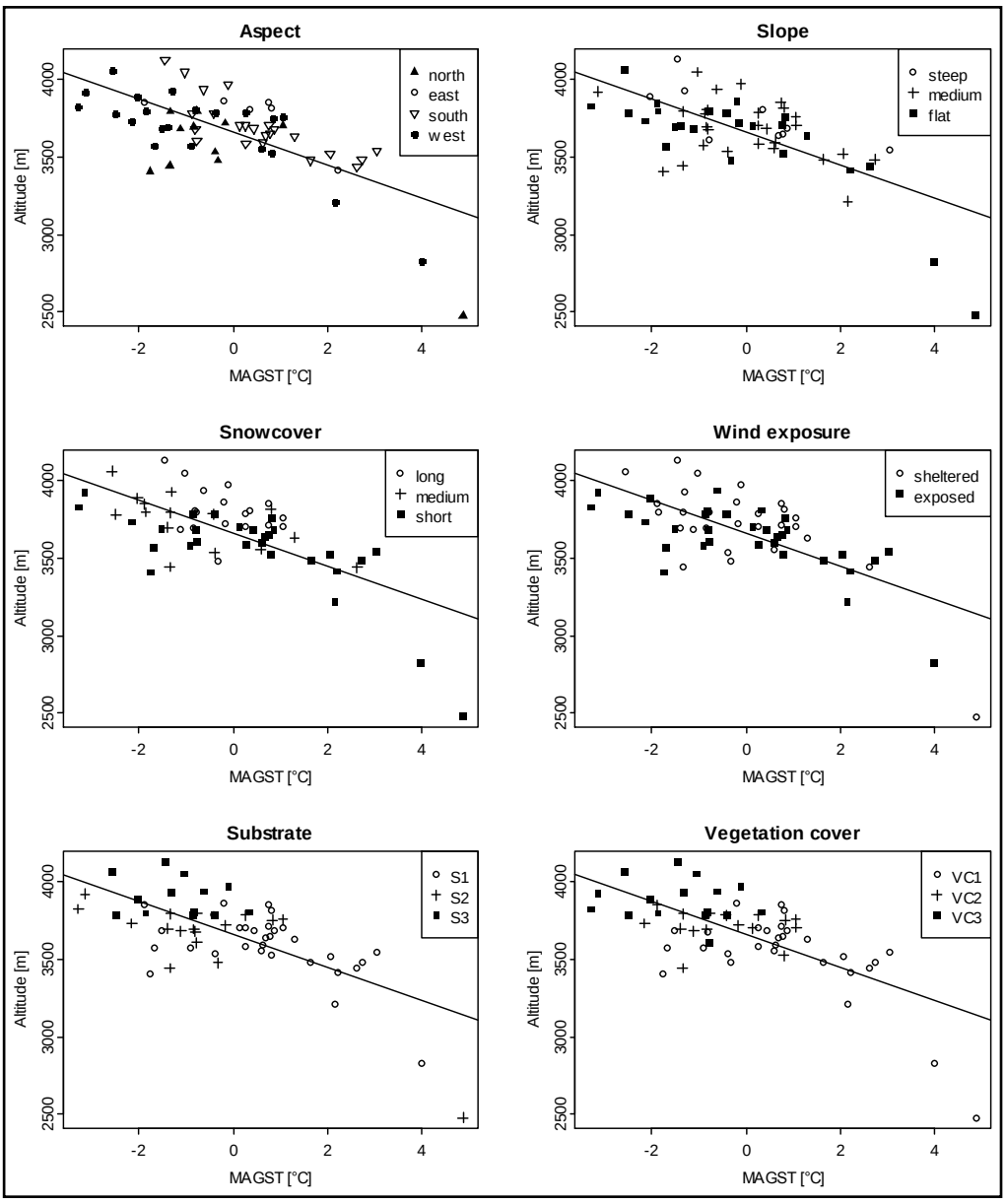

Figure 4: Selected parameters in relation to MAGST and altitude for the period 16/08/2010 – 15/08/2011 (linear regression of MAGST and altitude: y = -106.56x + 3661.9; r= -0.68, p < 0.001).

Discussion

Following, the influence on spatial and inter annual variation of MAGST is discussed for applicable parameters.

Spatial variation of MAGST

Snow distribution

Besides thickness of snow pack, the onset and duration of a considerable snow cover is of great

importance for the MAGST (e.g. Bartlett et al., 2004). Due to the close proximity, the onset of snow is at the same date at all given locations. The difference in duration of snow cover can be explained due to melting and more importantly the redistribution of snow by wind. Drift snow is an important and common factor in cold and arid environments and results in a thicker snow cover at foot slopes, small depressions and lee positions and considerably affects the thermal state of the permafrost in the region.

Coldest MAGST were measured at wind exposed positions (e.g. ridges) which remain snow free for most of the winter (< 30 days snow covered). Wind sheltered locations on the other hand show a much longer duration of snow cover on same altitudes and close proximity. Figure 5 gives the daily variation of GST for two exemplary locations less than 350 m apart. The thick and long duration of snow cover at location A10237 shields the ground from the cold air temperatures during winter while location A1023F is exposed throughout the winter. This insulating effect is the main factor for the significant difference in MAGST of 4.02 °C at these exemplary two locations.

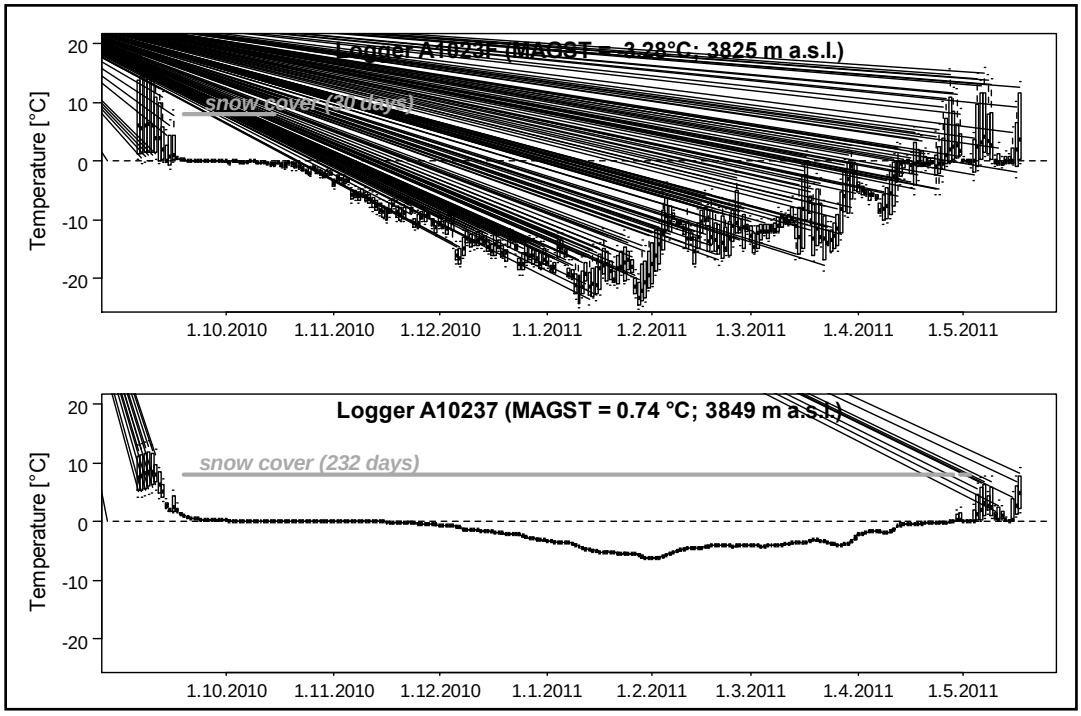

Figure 5: Daily variation of GST for two exemplary sites in close proximity (< 350 m) and same altitudinal levels (< 24 m apart) for the winter period (5.9.2010 – 15.5.2011); duration of snow cover is indicated in grey.

On the other hand, snow cover will have a cooling effect on the subsurface especially in spring time. Snow has a high albedo and shields the underlying ground from direct solar radiation. Furthermore, a longer duration of snow cover results in a more profound zero curtain period in spring due to percolation of meltwater through the snow pack and the release of latent heat during refreezing at or near the ground surface. Although this effect is visible in Figure 5, it is more profound in lower altitudes, where ground temperatures recorded at snow patches have considerable cooler spring temperatures than surrounding snow free areas.

However, the results in this study clearly point out that the insulating effect in winter time is more dominant than the cooling effect in spring, especially at higher altitudes. This relationship of MAGST and duration of snow cover is highly significant. Therefore a longer duration of snow cover results on average in warmer MAGST on same altitudinal levels. These findings furthermore underline the significance of snow distribution and drift snow for permafrost distribution in the Central Tian Shan.

Topographic parameters

As mentioned above, significant variations in MAAT can be expected at individual locations due to the difference in altitudes. This is clearly reflected in the measured MAGST. Besides altitude, slope and aspect are identified as important factors in many studies on permafrost distribution (e.g. Riseborough et al. 2008, Gruber & Hoelzle 2001) as they are key factors for the amount of incoming solar radiation. Results in this study stress the significance of aspect, as north exposed locations show considerably cooler MAGST as compared to south exposed locations (Figure 4).

Besides the direct influence resulting from different exposure to solar radiation, slope and aspect are important factors for depth and duration of a substantial snow cover. Due to higher incoming solar radiation, south exposed slopes show in general a shorter duration of substantial snow cover than north exposed slopes. However, findings in this study suggest that the redistribution of snow by wind considerably alters the general north-south assumption. Snowdrift in this cold and dry environment therefore is of great importance for the snow distribution in the study area. Local wind conditions and small scale topography (e.g. depressions) can result in a thick snow cover even on south exposed slopes in the catchment till late spring while north exposed slopes and ridges can stay snow free even during winter time. Visual interpretations of satellite imagery (LANDSAT, SPOT) of exemplary parts of the whole Aksu catchment as well as interviews of the local population confirm these findings.

Substratum and vegetation cover

Influence of substratum and vegetation cover on MAGST in this study is to a large extend overlain by the more dominant topographic factors and snow cover. On the other hand its contribution should not be underestimated. A cover of large blocky debris material favors the occurrence of permafrost, as cold air can circulate freely between the large blocks. Due to the surface roughness it is less likely for a consistent and insulating snow cover to form. Therefore, temperatures in coarse debris with air filled voids are typically 2.5 - 4 °C colder than the surrounding mean annual air temperature

(MAAT) (Gorbunov et al., 2004). This is of great importance for the study of rock glaciers and ice cored moraines in the region, as permafrost can occur in coarse blocky material even at lower altitudes, where the MAAT exceeds 0 °C.

Inter annual variation of MAGST

The dataset shows significant differences in MAGST from the first to the second year. Taking all 55 loggers with continuous measurements from August 2010 to August 2012 into account, the MAGST decreased 1.1 °C on average between the two years. Therefore, MAGST are significantly cooler in the second year of measurement as compared to the first. With topographic and other site specific factors (e.g. substratum, vegetation cover) being constant, the difference thus results from changes in air temperatures or snow.

To eliminate the temperature factor, a reference logger (Altitude: 1,538 m a.s.l; latitude: 41.57370044°; longitude: 79.701906°) is installed in close proximity to the Gukur catchment. At an altitude of 1,538 m a.s.l. influence of snow on MAGST is negligible as in both years, as a considerable snow cover is limited to two or three days per year. With a MAGST of 13.68 °C in the first and 14.11 °C in the second year, it clearly indicates, that general cooler temperatures in the second year are not the explanation for the significantly colder MAGST measured in the Gukur catchment. This is also confirmed by loggers, where a short duration of snow cover has been calculated for both years. Here, only minor changes in MAGST from first to second year occurred. Furthermore general cooler temperatures would have a more evenly distributed cooling effect at all locations. But while the temperatures decreased on average by -1.1 °C from first to second year, the variation is striking. With a standard deviation of 0.95 °C, changes in MAGST range from fairly detectable up to 3.39 °C at individual locations. Onset of snowfall can also be neglected, as no significant difference in air temperature before snowfall or starting date can be detected (with 16.08.2010 and 16.08.2011 being incidentally the same day of the year).

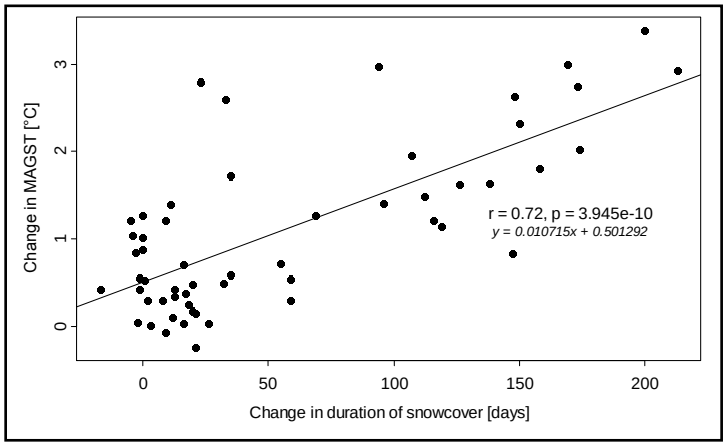

Fig. 6: Linear relationship between change in MAGST [°C] and change in duration of snow cover [days] from second year (16/08/2011 – 15/08/2012) to first year (16/08/2010 – 15/08/2011) of measurements.

On the other hand, the change in duration of snow cover correlates significantly (r= 0.72, p < 0.001) with the change in MAGST (Figure 6) between the two years and can therefore be considered the single most important factor for inter annual variations of MAGST in the research area for the two monitored years. Another implication stressing the importance of the duration of a snow cover is the overall decline of variation of MAGST at same altitudinal levels from the first to the second year (compare Figure 4 and Figure 7). This is further indorsed by a higher correlation coefficient in the second year as compared to the first year of temperature recording (r= --0.66, p < 0.001 for first year, n= 55; r = -0.76, p < 0.001 for second year, n = 55). With less snow fall and an on average shorter duration of a considerable snow cover in the second year, spatial variations in MAGST are less profound and more directly correlated to the change in MAAT and therefore altitude.

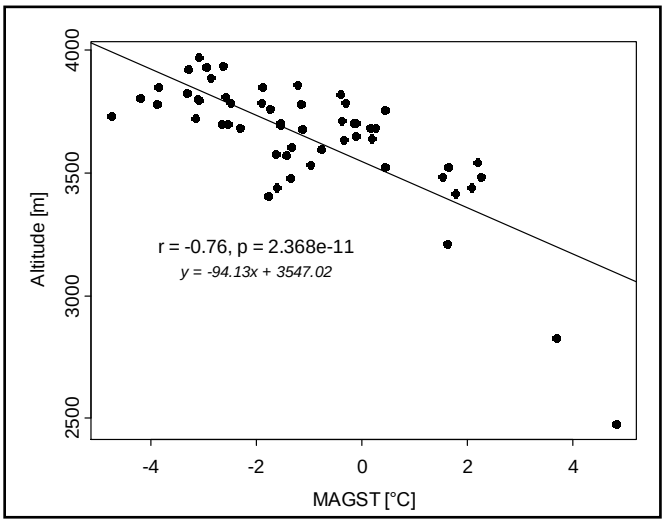

Figure 7: Linear relation between altitude [m a.s.l.] and MAGST [°C] for the time period 16/08/2011 – 15/08/2012

Conclusion and outlook

The main findings of this study include:

- Altitude is identified as the most dominant factor for MAGST in the study area (r= -0.68, p < 0.001 first year; r= -0.76, p < 0.001 second year)
- MAGST can vary considerably (> 4 °C) even in close proximity and on same altitudinal levels.
- Distribution of snow has the most significant influence on the thermal state of underlying frozen soils on same altitudinal levels
- Extensive spatial variations in thickness and duration of snow cover occur in the study area due to redistribution by wind common in cold and arid regions

- Variation in MAGST between the two monitored years is > 1.1°C on average and up to 3.39 °C at individual locations
- Inter annual variations in MAGST for the two years can be largely explained by the difference in snowfall and hence, the duration of a considerable snow cover at given locations
- While the probability of permafrost occurrence is highest at altitudes of 3,700 m a.s.l. and above, permafrost presence can be expected in favored positions at altitudes as low as 3,400 m a.s.l. (MAGST = -1.75 °C)

Results presented here will be used to establish a statistical-empirical model for permafrost distribution in the Chinese part of the Central Tian Shan. Besides the factors analyzed in this paper, DEM and satellite derived parameters will be incorporated to extrapolate the results over a larger area.

While this study gives great insight into the state of the ground thermal regime, a longer time series would help to better understand the influence of climate change on this regime as well as the state and distribution of permafrost. The durability, accuracy and easiness to handle, make the instruments used in this study ideal for the necessary monitoring of ground temperatures over long periods of time.

Acknowledgments

The authors would like to thank Prof. Li Zhongqing (Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Lanzhou, China) and his team of researchers for their support in organizing and conducting the fieldwork. Special thanks go to Prof. Gao Qiangzhao for his constant support and advice. Furthermore, we thank the Deutsche Forschungsgemeinschaft (DFG) for funding the Aksu-Tarim-Cryo project (KI261/22-1), which is an integral part of the Aksu-Tarim research bundle.

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Analysis of Drainage Morphometry and Watershed Prioritization in Rogni Watershed, Sikkim (India) Through Remote Sensing and GIS Techniques

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Abstract

In this study, morphometric analysis and prioritization of the twenty two miniwatersheds of Rongni watershed of East district in Sikkim state, India is carried using Remote Sensing and Geographical Information System (GIS) techniques. The morphometric parameters considered for analysis are stream length, bifurcation ratio, drainage density, stream frequency, texture ratio, form factor, circulatory ratio, elongation ratio and compactness constant. Rongni watershed has a dendritic drainage pattern. The highest bifurcation ratio among all the miniwatersheds is 8.016 which indicate a strong structural control on the drainage. The maximum value of circularity ratio is 0.836 for the miniwatershed 3A1B3H2b. The miniwatershed 3A1B3F2a has the highest elongation ratio i.e. 0.759. The form factor values are in range of 0.392 to 0.453. The compound parameter values are calculated and prioritization rating of twenty two miniwatersheds in Rongni watershed is carried out. The miniwatershed with the lowest compound parameter value is given the highest priority. The miniwatershed 3A1B3H2a has a minimum compound parameter value of 7.375 is likely to be subjected to maximum soil erosion hence it should be provided with immediate soil conservation measures.

Introduction

Morphometric analysis of a watershed provides a quantitative description of the drainage system which is an important aspect of the characterization of watersheds[1]. Morphometric analysis is a significant tool for prioritization of micro-watersheds by studying different linear and aerial parameters of the watershed even without the availability of soil maps[2]. Pioneering work on the drainage basin morphometry has been carried out by Horton[3], Miller[4], Schumn[5], Strahler[1] and others. Many works have been reported on morphometric analysis using GIS. Tamang *et al.*[6] has used Remote Sensing and GIS techniques in morphometric analysis and prioritization of miniwatersheds in Rongni watershed, Sikkim. Thakkar and Dhiman[7] has used Remote Sensing and GIS techniques in morphometric analysis and prioritization of miniwatersheds in Mohr watershed, Gujarat. Kanth and Hassan[8] carried out morphometric analysis and prioritization of watersheds for soil and water resource management in Wular catchment. Rekha *et al.*[9] carried out morphometric analysis and micro-watershed prioritization of Peruvanthanam sub watershed, the Manimala River Basin, Kerala, South India. Nookaratnam *et al.*[10] carried out study on check dam positioning by prioritization of micro-watersheds using the sediment yield index (SYI) model morphometric analysis using Remotesensing and GIS. Javed *et al.*[11] has used Remote Sensing and GIS techniuees in prioritization of Sub-watersheds based on morphometric and land use analysis. Rudraiah *et al.*[12] carried out morphometry using Remote

Sensing and GIS techniques in the Sub-Basin of Kagna River Basin, Gulburga District, Karnataka, India. Saud[13] worked on morphometric analysis of Wadi Aurnah Drainage System, Western Arabian Peninsula.

In the present study the drainage and watershed map have been prepared for prioritization of miniwatersheds through morphometric analysis. A Remote Sensing and GIS technique has emerged as a powerful tool for morphometric analysis. During the literature survey it was found that there is no published data on the morphometry of Rongni watershed based on Remote Sensing and GIS techniques. Therefore, the present study aims at the morphometric analysis on miniwatersheds using Remote Sensing and GIS. The quantitative analysis of morphometric parameters is found to be of immense utility in watershed for soil and water conservation and natural resources management at micro level and this study would help the local people to utilize the resources for sustainable development of the area.

Study area

The Rongni Chu (river) is a tributary of Teesta river, which meets Teesta near Singtam, covers an area of 255.551 km^2 located East District as shown in Fig. 1. The study lies between 27°13'12.81"N to 27°23'49.18"N latitude and 88°29'6.496"E to 88°43'19.132"E longitude. As per National and Natural Resource Information System, Rongni watershed area code is designated as per National and Natural Resource Information.

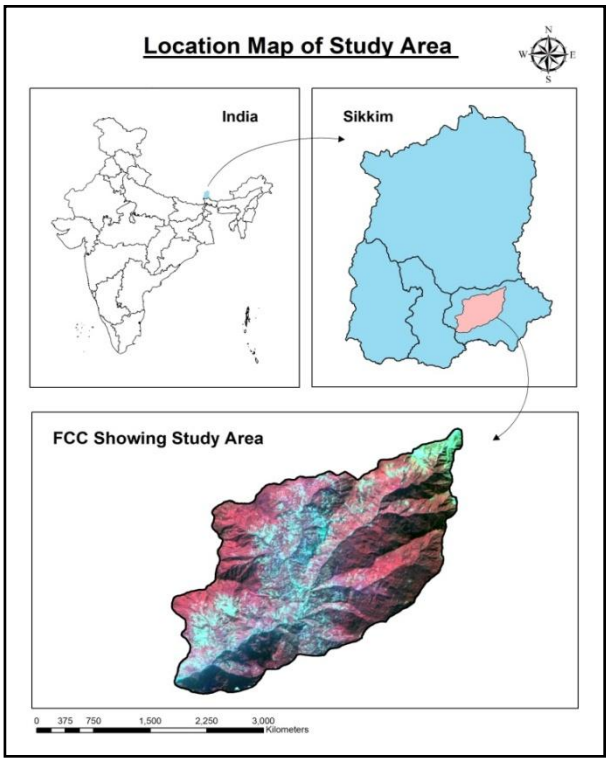

Fig 1.

Methodology

In the present study, morphometric analysis and prioritization of miniwatersheds in Rongni Watershed is based on the integrated use of Remote Sensing and GIS techniques. The study was carried out on watershed level using SOI toposheets of Sikkim (India). The study was carried out in GIS environment using ArcGis 10.0 for digitization. The various steps employed in the study are given in Fig. 2.

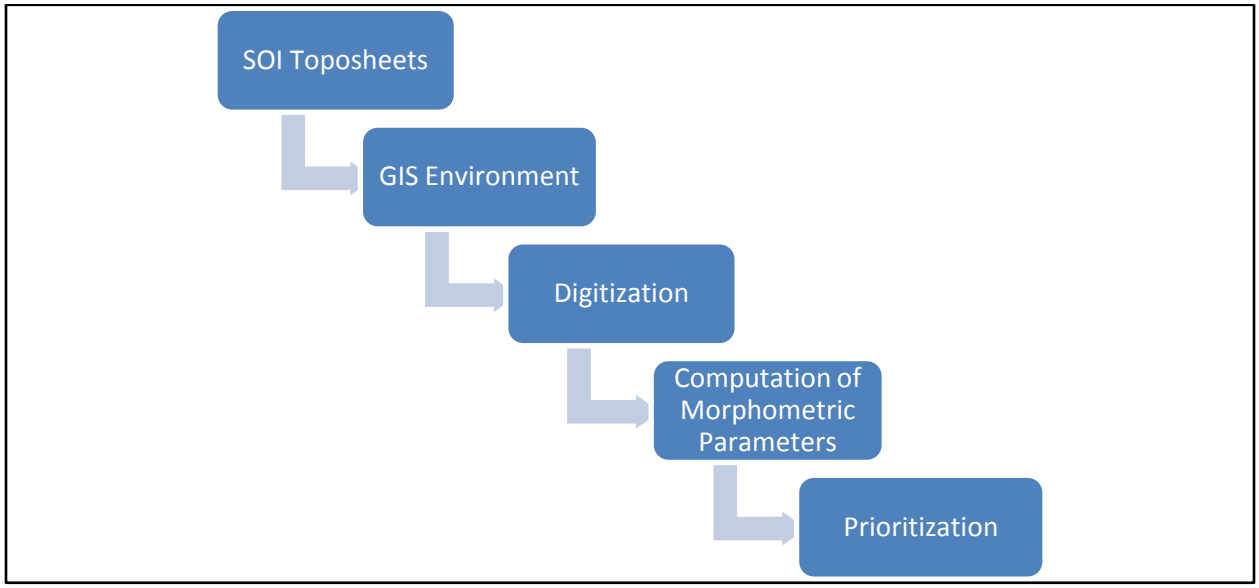

Fig. 2. Steps of methodology

The digitization of dendritic drainage pattern was carried out in GIS environment. The stream ordering was carried out using the Strahler's law. The fundamental parameters namely; stream length, area, perimeter, number of streams and basin length were derived from the drainage layer. The morphometric parameters for the watershed area were calculated based on the formula suggested by Horton[3], Strahler[1], Schumn[5], Nookaratnam *et al*.[10] and Miller[4] given in Table 1.

Table 1. Formulation for Computation of Morphometric parameters

SL. No.	Morphometric Parameters	Formula	Reference
1	Stream Order (u)	Hierarchical Rank	Strahler[1]
2	Stream Length (L_u)	Length of the stream	Horton[3]
3	Mean Stream Length (L_{sm})	$L_{sm} = \frac{L_u}{N_u}$ Where, L_{sm} = Mean Stream Length L_u = Total Stream length of Order u	Strahler[1]

		N_u = Total number of stream segments of order u	
4	Bifurcation Ratio (R_b)	$R_b = \frac{N_u}{N_{u+1}}$ Where, R_b = Bifurcation ratio N_u = Total number of stream segments of order u N_{u+1} = Number of stream of segment of next higher order	Schumn[5]
5	Mean Bifurcation Ratio (R_{bm})	R_{bm} = Average of bifurcation ration of all orders	Strahler[1]
6	Basin Length (Lb)	$Lb = 1.312 * A^{0.568}$ Where, Lb = Length of Basin (km) A = Area of Basin (km^2)	Nookaratnam *et al.*[10]
7	Drainage Density (D_d)	$D_d = \frac{L_u}{A}$ Where, D_d = Drainage density L_u = Total Stream length of all Order A = Area of the basin (km^2)	Horton[3]
8	Stream Frequency (F_s)	$F_s = \frac{N_u}{A}$ Where, F_s = Stream frequency N_u = Total number of streams of all order A = Area of the basin (km^2)	Horton[3]
9	Texture Ratio (T)	$T = \frac{N_u}{P}$ Where, T = Texture ratio Nu = Total number of streams of all order P = Perimeter (km)	Horton[3]
10	Form Factor(R_f)	$R_f = \frac{A}{Lb^2}$ Where, R_f = Form factor A = Area of the basin (km^2) Lb = Length of the basin (km)	Horton[3]
11	Circularity Ratio (R_c)	$R_c = \frac{4\pi A}{P^2}$ Where, R_c= Circulatory ratio A = Area of the basin (km^2) P = Perimeter (km)	Miller[4]
12	Elongation Ratio (R_e)	$R_e = \left(\frac{2}{Lb}\right) * (A/\pi)^{0.5}$ Where, Re = Elongation ratio Lb = Basin length (km) A = Area of the basin (km^2)	Schumn[5]
13	Compactness Constant (C_c)	$C_c = 0.2821 \left(\frac{P}{A^{0.5}}\right)$ Where, C_c = Compactness Ratio P = Perimeter of the basin (km) A = Area of the basin (km^2)	Horton[3]

The various morphometric parameters such as stream length, bifurcation ratio, drainage density, stream frequency, form factor, texture ratio, elongation ratio, circularity ratio and compactness constant were computed. The linear parameters such as drainage density, stream frequency, bifurcation ratio, texture ratio have a direct relationship with erodibility, higher the value, more is the erodibility. Hence for prioritization of miniwatersheds, the highest value was rated as rank 1, second value was rated as rank 2 and so on, and the least value was rated last in rank. Shape parameters such as elongation ratio, compactness constant, circulatory ratio and form factor have an inverse relationship with erodibility[10], lower the value, more is the erodibility. Thus the lowest value of shape parameters was rated as rank 1, next lower value was rated as rank 2 and so on and the highest value was rated last in rank. Hence, the ranking of the miniwatersheds has been determined by assigning the highest priority/rank based on highest value in case of linear parameters and lowest value in case of shape parameters.

Prioritization rating of all the twenty two miniwatersheds of Rongni watershed was carried out by calculating the compound parameter values. The miniwatershed with the lowest compound parameter value was given the highest priority. The various indicators which have been used in the prioritization of Rongni watershed are described in Table 2.

Table 2: Description of Indicators of Prioritization

Parameter	**Characteristics**
Linear	
Stream order (u)	It is a method of assigning a numeric order to links in a stream network. This order is a method for identifying and classifying types of streams based upon their no. of tributaries.
Mean Stream Length (L_{sm})	It is the characteristic property related to the drainage network and its associated surfaces. Generally higher the order, longer the length of streams is noticed is nature.
Bifurcation ratio (R_b)	It shows a small range of variation for different regions or for different environments except where the powerful geological control dominates.
Drainage density (D_d)	It shows the landscape dissection, runoff potential, infiltration capacity of the land, climatic conditions and vegetation cover of the basin. High drainage density is the resultant of weak or impermeable subsurface material, sparse vegetation and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture.
Stream frequency (F_s)	It is the total no. of stream segments of all the orders per unit area. Generally, high stream frequency is related to impermeable sub-surface material, sparse vegetation, high relief conditions and low infiltration capacity.

Texture ratio (T)	It is the total no. of stream segments of all order s per perimeter of that area.
Shape	
Form factor (R_f)	It may be defined as the ratio of the area of the basin and square of basin length. The value of the form factor would always be greater than 0.78 for a perfectly circular basin. Smaller the value of form factor, more elongated will be the basin.
Circulatory ratio (R_c)	It is the ratio of the area of the basins to the area of the circle having the same circumstance as the perimeter of the basin. It is helpful for assessment of flood hazard. Higher the R_c value, higher is the flood hazard at the peak time at the outlet point.
Elongation ratio (R_e)	It is defined as the ratio of diameter of a circle of the same area as the basin to the maximum basin length.
Compactness constant (C_c)	It is defined as the ratio between the area of the basin and the perimeter of the basin.

Results and interpretation

The drainage map of the Rongni watershed (Fig.3) is prepared using the spatial tools. Fig. 4 shows the map of miniwatersheds of Rongni watershed. The stream order analysis is carried out using the ArcGis. The highest stream order for the Rongni watershed study area is six.

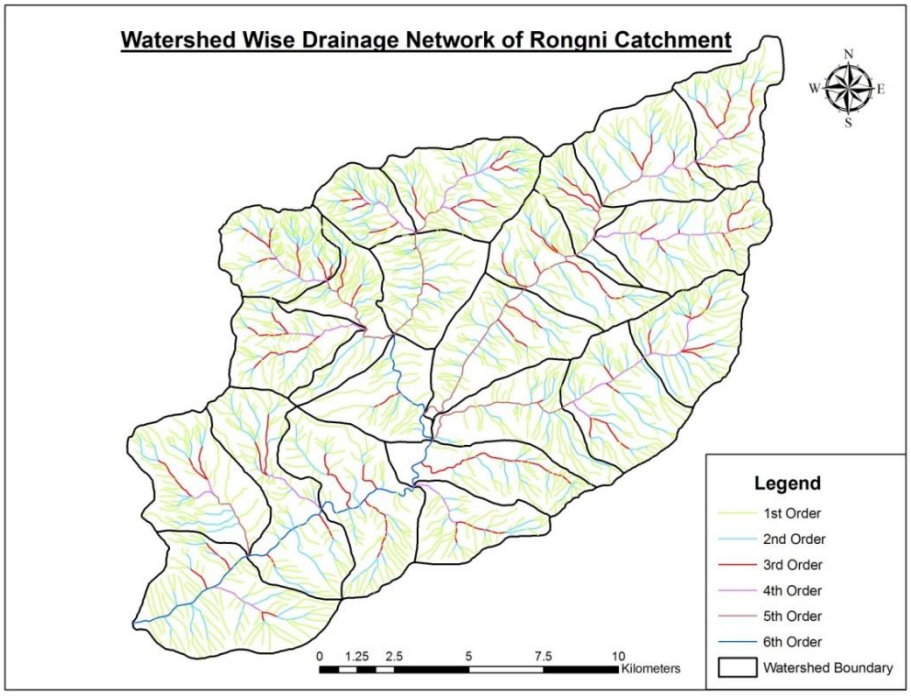

Fig. 3.

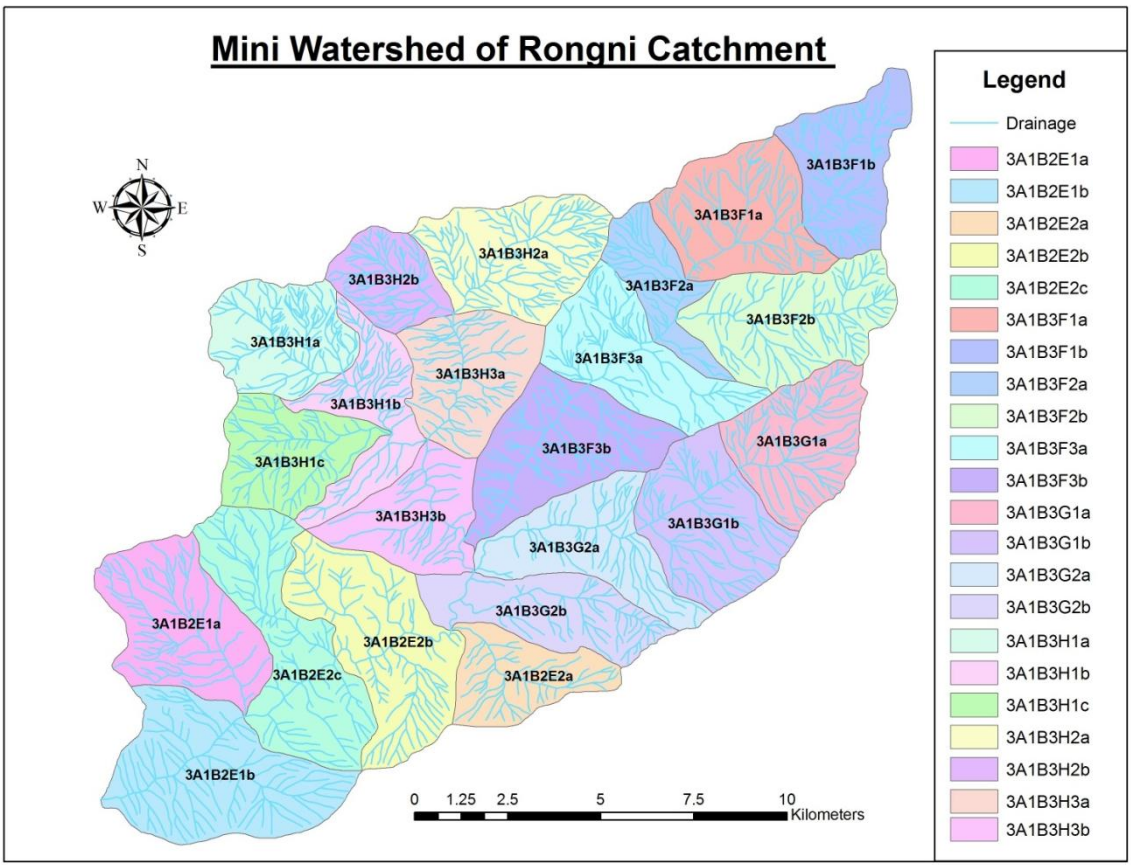

Fig. 4.

The number of streams of a given order, stream length and cumulative stream length for all the twenty two miniwatersheds of Rongni watershed are shown in Table 3.

Table 3: Stream analysis

Watershed Code		Stream Order					
		1st	2nd	3rd	4th	5th	6th
3A1B2E1a	No. of streams	54	25	12	5	10	0
	stream length (m)	33068.769	9549.502	3784.450	1259.547	2664.135	
	Cumulative Stream Length	33068.769	42618.271	46402.721	47662.268	50326.404	

	(m)						
3A1B2E1b	No. of streams	78	30	9	7	0	30
	stream length (m)	55014.579	10117.786	2877.421	1848.217		4574.899
	Cumulative Stream Length (m)	55014.579	65132.365	68009.786	69858.003		74432.902
3A1B2E2a	No. of streams	37	14	13	8	0	0
	stream length (m)	20621.857	4382.121	2343.649	2139.873		
	Cumulative Stream Length (m)	20621.857	25003.979	27347.628	29487.501		
3A1B2E2b	No. of streams	71	37	16	0	0	15
	stream length (m)	37335.037	9680.880	5673.765			4117.516
	Cumulative Stream Length (m)	37335.037	47015.917	52689.682			56807.198
3A1B2E2c	No. of streams	79	40	16	12	0	8
	stream length (m)	38944.912	97.745	4713.819	2208.734		3091.643
	Cumulative Stream Length (m)	38944.912	39042.657	43756.476	45965.210		49056.853
3A1B3F1a	No. of streams	56	29	10	11	7	0
	stream length (m)	28552.132	10353.080	2808.755	2306.107	1667.475	
	Cumulative Stream Length (m)	28552.132	38905.212	41713.967	44020.075	45687.550	
3A1B3F1b	No. of streams	58	22	22	10	0	0
	stream length (m)	26159.724	5632.537	6155.186	1690.995		
	Cumulative Stream Length (m)	26159.724	31792.261	37947.447	39638.443		
3A1B3F2a	No. of streams	33	14	8	0	12	0
	stream length (m)	20920.812	4027.421	3220.723		1980.648	
	Cumulative Stream Length (m)	20920.812	24948.233	28168.956		30149.604	
3A1B3F2b	No. of streams	79	31	21	22	0	0

	stream length (m)	41388.647	7940.481	4138.597	4733.418		
	Cumulative Stream Length (m)	41388.647	49329.128	53467.725	58201.144		
3A1B3F3a	No. of streams	63	29	20	3	11	0
	stream length (m)	30398.006	10694.234	6078.739	280.989	2263.442	
	Cumulative Stream Length (m)	30398.006	41092.240	47170.979	47451.968	49715.410	
3A1B3F3b	No. of streams	66	33	5	0	29	0
	stream length (m)	31990.591	9464.096	2813.184		5849.286	
	Cumulative Stream Length (m)	31990.591	41454.687	44267.872		50117.157	
3A1B3G1a	No. of streams	70	36	17	14	0	0
	stream length (m)	33249.426	11818.908	4074.620	2496.768		
	Cumulative Stream Length (m)	33249.426	45068.334	49142.953	51639.721		
3A1B3G1b	No. of streams	63	32	10	17	2	0
	stream length (m)	33456.064	11443.321	3482.666	3601.939	406.397	
	Cumulative Stream Length (m)	33456.064	44899.385	48382.051	51983.990	52390.387	
3A1B3G2a	No. of streams	44	22	1	0	21	0
	stream length (m)	28981.288	8594.978	184.349		5222.255	
	Cumulative Stream Length (m)	28981.288	37576.267	37760.616		42982.871	
3A1B3G2b	No. of streams	46	19	21	0	0	3
	stream length (m)	20491.582	5880.644	5626.270			2042.426
	Cumulative Stream Length (m)	20491.582	26372.227	31998.496			34040.922
3A1B3H1a	No. of streams	91	45	26	17	0	0
	stream length (m)	37852.414	9953.131	4823.080	2395.835		
	Cumulative Stream Length	37852.414	47805.545	52628.624	55024.459		

	(m)						
3A1B3H1b	No. of streams	55	24	10	0	20	0
	stream length (m)	29569.019	7019.314	2087.944		3707.889	
	Cumulative Stream Length (m)	29569.019	36588.333	38676.277		42384.166	
3A1B3H1c	No. of streams	60	26	19	12	0	0
	stream length (m)	27431.598	5358.672	4890.276	2782.744		
	Cumulative Stream Length (m)	27431.598	32790.269	37680.545	40463.289		
3A1B3H2a	No. of streams	97	48	20	16	11	0
	stream length (m)	47236.390	11166.457	6022.516	2651.770	1308.589	
	Cumulative Stream Length (m)	47236.390	58402.847	64425.363	67077.133	68385.723	
3A1B3H2b	No. of streams	57	29	13	13	0	0
	stream length (m)	24934.853	7978.010	2839.452	2249.311		
	Cumulative Stream Length (m)	24934.853	32912.863	35752.315	38001.626		
3A1B3H3a	No. of streams	61	27	2	0	33	0
	stream length (m)	33151.035	7357.773	763.366		3740.744	
	Cumulative Stream Length (m)	33151.035	40508.807	41272.173		45012.918	
3A1B3H3b	No. of streams	28	8	3	0	0	18
	stream length (m)	21570.733	2229.016	1007.214			4569.707
	Cumulative Stream Length (m)	21570.733	23799.749	24806.963			29376.670

The fundamental parameters namely area, perimeter, basin length and mean stream length for each of the watersheds are calculated and shown in Table 4. The stream morphometric parameters namely bifurcation ratio, drainage density, stream frequency, form factor, texture ratio, elongation ratio, circularity ratio and compactness constant are calculated and are shown in Table 5 and Table 6. Rongni watershed shows a dendritic drainage pattern. The highest

bifurcation ratio is 8.016 for 3A1B3G2a miniwatershed. The highest circularity ratio is 0.836 for miniwatershed 3A1B3H2b. The miniwatershed 3A1B3F2a has the highest elongation ratio (0.759) indicating possibility of less erosion. The form factor values are in range of 0.392 to 0.453. The compound parameter values of twenty two miniwatersheds of Rongni watershed are calculated and prioritization rating is shown in Table 7.

Table 4: Miniwatershed Parameters

Mini Watershed Code No	Drainage Area of Miniwatersheds(km^2)	Perimeter (km)	Length of Basin (km)	Mean Stream Length (km)
3A1B2E1a	13.980	16.299	5.869	5.033
3A1B2E1b	18.010	19.134	6.777	2.481
3A1B2E2a	7.991	13.348	4.272	3.686
3A1B2E2b	16.281	19.452	6.400	3.787
3A1B2E2c	16.092	21.898	6.357	6.132
3A1B3F1a	12.663	14.910	5.549	6.527
3A1B3F1b	10.586	14.925	5.012	3.964
3A1B3F2a	6.259	14.887	3.718	2.512
3A1B3F2b	13.998	16.158	5.874	2.646
3A1B3F3a	12.091	16.822	5.405	4.520
3A1B3F3b	13.687	17.386	5.799	1.728
3A1B3G1a	11.118	13.628	5.153	3.689
3A1B3G1b	12.998	14.559	5.631	26.195
3A1B3G2a	11.519	17.947	5.258	2.047
3A1B3G2b	10.413	16.738	4.965	11.347
3A1B3H1a	10.022	12.509	4.858	3.237
3A1B3H1b	9.055	21.812	4.586	2.119
3A1B3H1c	9.601	13.591	4.741	3.372
3A1B3H2a	13.019	14.924	5.637	6.217
3A1B3H2b	6.263	9.702	3.720	2.923
3A1B3H3a	10.651	13.197	5.029	1.364
3A1B3H3b	9.253	13.950	4.643	1.632

Table 5: Morphometric Parameters

Mini Watershed Code No.	Stream frequency	Length of Basin (km)	Circularity ratio	Form factor	Elongation ratio
3A1B2E1a	7.582	5.869	0.662	0.406	0.719
3A1B2E1b	8.551	6.777	0.618	0.392	0.706
3A1B2E2a	9.010	4.272	0.564	0.438	0.747
3A1B2E2b	8.537	6.400	0.541	0.398	0.711
3A1B2E2c	9.632	6.357	0.422	0.398	0.712
3A1B3F1a	8.923	5.549	0.716	0.411	0.724
3A1B3F1b	10.580	5.012	0.597	0.421	0.732
3A1B3F2a	10.704	3.718	0.355	0.453	0.759
3A1B3F2b	10.930	5.874	0.674	0.406	0.719
3A1B3F3a	10.421	5.405	0.537	0.414	0.726
3A1B3F3b	9.718	5.799	0.569	0.407	0.720
3A1B3G1a	12.322	5.153	0.753	0.419	0.730
3A1B3G1b	9.540	5.631	0.771	0.410	0.722
3A1B3G2a	7.640	5.258	0.450	0.417	0.728
3A1B3G2b	8.547	4.965	0.467	0.422	0.733
3A1B3H1a	17.860	4.858	0.805	0.425	0.735
3A1B3H1b	12.037	4.586	0.239	0.431	0.740
3A1B3H1c	12.186	4.741	0.653	0.427	0.737
3A1B3H2a	14.748	5.637	0.735	0.410	0.722
3A1B3H2b	17.884	3.720	0.836	0.453	0.759
3A1B3H3a	11.548	5.029	0.769	0.421	0.732
3A1B3H3b	6.160	4.643	0.598	0.429	0.739

Table 6: Values of drainage density, texture, compactness and bifurcation ratios

Mini Watershed Code No.	Drainage density	Texture Ratio	Compactness constant	Mean R_{bm}
3A1B2E1a	3.600	6.503	1.230	1.786
3A1B2E1b	4.133	8.048	1.272	1.863
3A1B2E2a	3.690	5.394	1.332	1.782
3A1B2E2b	3.489	7.146	1.360	1.766

3A1B2E2c	3.049	7.078	1.540	1.827
3A1B3F1a	3.608	7.579	1.182	1.828
3A1B3F1b	3.744	7.504	1.294	1.945
3A1B3F2a	4.817	4.500	1.679	1.591
3A1B3F2b	4.158	9.469	1.218	1.660
3A1B3F3a	4.112	7.490	1.365	2.640
3A1B3F3b	3.662	7.650	1.326	2.924
3A1B3G1a	4.645	10.053	1.153	1.759
3A1B3G1b	4.031	8.517	1.139	3.564
3A1B3G2a	3.732	4.903	1.492	8.016
3A1B3G2b	3.269	5.317	1.463	3.442
3A1B3H1a	5.490	14.309	1.115	1.761
3A1B3H1b	4.681	4.997	2.045	1.731
3A1B3H1c	4.214	8.609	1.237	1.753
3A1B3H2a	5.253	12.866	1.167	1.781
3A1B3H2b	6.068	11.544	1.094	1.732
3A1B3H3a	4.226	9.320	1.141	5.273
3A1B3H3b	3.175	4.086	1.294	2.111

Table 7: Prioritization Results of Morphometric Analysis

Mini Watershed Code	R_{bm}	D_d	F_s	T	R_f	R_c	C_c	R_e	Compound Parameter	Final Priority
3A1B2E1a	12	18	21	16	5	14	9	5	12.500	16
3A1B2E1b	9	10	17	9	1	12	11	1	8.750	2
3A1B2E2a	13	15	15	17	20	8	15	20	15.375	20
3A1B2E2b	15	19	19	14	2	7	16	2	11.750	13
3A1B2E2c	11	22	13	15	3	3	20	3	11.250	11
3A1B3F1a	10	17	16	11	9	16	7	9	11.875	14
3A1B3F1b	8	13	10	12	14	10	12	14	11.625	12
3A1B3F2a	22	4	9	21	22	2	21	22	15.375	20
3A1B3F2b	21	9	8	5	4	15	8	4	9.250	4
3A1B3F3a	6	11	11	13	10	6	17	10	10.500	9
3A1B3F3b	5	16	12	10	6	9	14	6	9.750	7
3A1B3G1a	17	6	4	4	12	18	5	12	9.750	7
3A1B3G1b	3	12	14	8	8	20	3	8	9.500	5
3A1B3G2a	1	14	20	20	11	4	19	11	12.500	16
3A1B3G2b	4	20	18	18	15	5	18	15	14.125	19
3A1B3H1a	16	2	2	1	16	21	2	16	9.500	5
3A1B3H1b	20	5	6	19	19	1	22	19	13.875	18
3A1B3H1c	18	8	5	7	17	13	10	17	11.875	14
3A1B3H2a	14	3	3	2	7	17	6	7	7.375	1
3A1B3H2b	19	1	1	3	21	22	1	21	11.125	10
3A1B3H3a	2	7	7	6	13	19	4	13	8.875	3
3A1B3H3b	7	21	22	22	18	11	13	18	16.500	22

Miniwatershed 3A1B3H2a with a compound parameter value of 7.375 receives the highest priority with the next in the priority list is miniwatershed 3A1B2E1b having the compound parameter value of 8.750. Miniwatersheds 3A1B3G1b and 3A1B3H1a has the same compound parameter i.e. 9.500. Similarly, Miniwatersheds 3A1B3F3b and 3A1B3G1a has 9.750, 3A1B3F1a and 3A1B3H1c has 11.875, 3A1B2E1a and 3A1B3G2a has 12.500, 3A1B2E2a and 3A1B3F2a has 15.375 as compound parameter. High priority indicates the greater degree of erosion in the particular miniwatershed and it becomes potential candidate for applying soil conservation measure. The final prioritized map of the study area is shown in Fig. 5. Thus the soil conservation measure can first be applied to

miniwatershed area 3A1B3H2a and then to other miniwatersheds depending upon their priority.

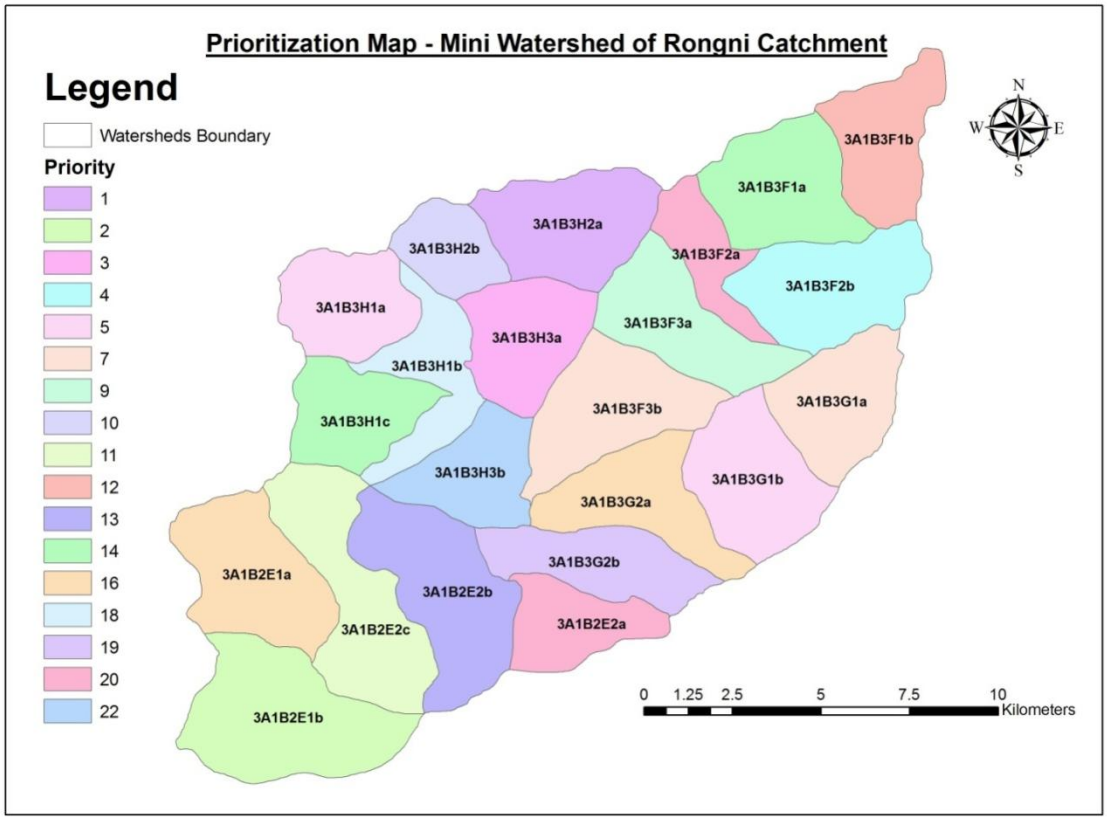

Fig 5.

Conclusions

The present study demonstrates the usefulness of Remote Sensing and GIS techniques for morphometric analysis and prioritization of the miniwatersheds of Rongni watershed of Sikkim. Further, the Remote Sensing techniques have been found to be suitable for the preparation of updated drainage map in a timely and cost-effective manner and should be preferred in soil erosion studies for deriving input data. Results of morphometric analysis show that miniwatersheds 3A1B3H2a and 3A1B2E1b are possibly having high erosion. Hence, suitable soil erosion control measures are required in these miniwatersheds to preserve the land from further erosion

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Urbanization and its Environmental Issues - Bangalore City, Karnataka, South India

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Abstract

Bangalore city (12^{o} $58^{|}$ N and 77^{o} $35^{|}$ E) situated at 949 meters above MSL is the principal administrative, industrial, commercial, educational and cultural capital of Karnataka state, in the South-Western part of India. Blessed with a strong educational and technological base and agreeable climate, Bangalore is witnessing a tremendous growth in industry, trade and commerce leading to a rapid growth of the city and large scale urbanization. The population of Bangalore city stands at 5.7 million as per 2001 census records, and continuing with this growth rate, the city's population is expected to reach around 11 and 22 million in 2021 and 2041 respectively. This unprecedented growth is due to several factors, such as good infrastructure facilities, availability of abundant technical manpower and skilled labour and sound scientific and industrial base, a salubrious climate, and in recent times due to the coming of age of Information Technology (IT) which, today is the prime driving force, fuelling the growth of Bangalore city.

Rapid growth of population, coupled with severe geographic limitations extreme congestion, urban blight, and a myriad of economic, social and environmental problems today burden the city with insurmountable obstacles. The paper focuses on the histogenesis, development and analysis of the present day access to housing, amenities and infrastructure. It also tries to highlight the effect of rapid urban growth and urbanization on land use, particularly the mushrooming of squatters and slums; and the environmental quality. An appraisal has also been made to ascertain the role of metropolitan planning in the city's development. Finally, the future possibilities have been also examined in the contest of globalization the transformation. Against the theoretical formulations, an empirical methodology has been grafted in order to focus on the magnitude of the problems; in the light of the future possibilities and sustainability of this Bangalore city.

Introduction:

With the growth of civilization and urban population, cities have been expanding alarmingly from the past century. This has resulted in widening gap between available resources and their demand in urban areas. Urbanization is considered as an indicator of development but at the same time it is creator/producer/generator of several problems viz. increasing solid waste, creation of slums, traffic congestion, and social conflicts presently E-waste and overall environmental degradation and related problems. Therefore, there is urgent need to take necessary measures to create an enabling urban structure to cope with.

Bangaluru (earlier known as Bangalore) is the capital of Karnataka and is the primate city of South India - one of the largest growing metropolitan regions of the world. With the Information Technology (IT) and Bio-Technology (BT) boom, Bangalore is one of the fastest growing cities in India and Asia. Bangalore serves as the global example of the potentials and problems facing mega-cities in

the developing nations. Rapid growth of population, coupled with extreme traffic congestion, e-waste generated by the city, urban blight, and a myriad of economic, social and environmental problems today burden the city with insurmountable obstacles. The paper focuses on the effect of rapid urban growth and urbanization on urban sprawl, land use, Existing Transport Scenario. The focal point of the study is to find out the changes in the air pollution levels, reduce the intensity of high congested traffic problems, reduce the number of road accidents often resulting in human fatalities and injuries, and how far it changes the more non-productive man hours during transit and waiting points and also some extents towards treating e-waste etc., are discussed in this qualitative paper.

Study Area:

Bangalore, a tiny village in the 12th century grew through times to become one of the fastest growing cities in Asia in the 21st century. Bangalore is a city of past, present and future. It has a rich history of 469 years. The story of transition from a tiny hamlet to the present Silicon Valley of India has a great impact towards the image of Bangalore in the global market.

The population of Bangalore city stands at 5.7 million as per 2001 census records, and continuing with this growth rate, the city's population is expected to reach around 11 and 22 million in 2021 and 2041 respectively. With the Information Technology (IT) boom, Bangalore is one of the fastest growing cities in India and Asia. With the emerging Bio-Technology (BT) boom, Bangalore's population growth may be even faster in the forth-coming decades. Bangalore is booming with other growth which is evident from its nicknames viz., "India's Silicon Valley", "Fashion Capital of India", "The Pub City of India", and so on.

Bangalore City is located in Bangalore District, which is in southeastern part of Karnataka in South India and Capital City of Karnataka. The area lies between 12^{o} $58^{|}$ to 13^{o} $0^{|}$ North Latitude and 77^{o} $37^{|}$ to 78^{o} $18^{|}$ East Longitude. Bangalore City lies at an altitude of 949 meters (3,113 feet) above mean see level and it covers an area of about 2190 Sq. Kms. It has a maximum temperature of 33^{o} C to lowest minimum of 14 ^{o} C. Climatic conditions are March to May warmest, June to September rainy and December to January cold. It has a moderate and pleasant climate. Summers are mild and winters are cool. Bangalore is accessible by air, road, and rail. (Fig.1.)

Bangalore is the principal administrative, cultural, commercial and industrial centre of the state of Karnataka. The city enjoys a pleasant and moderate climate throughout the year. Its avenues and boulevards have led to it being called the 'Garden City' of India. Bangalore city's regional language is Kannada but English, Hindi, Telugu and Tamil are widely spoken and understood.

Objectives: The paper aims to study the following:

- The history of increasing growth of population in Bangalore city.
- How the population pressure is more responsible for environmental degradation.

- The effects of rapid urban growth, urbanization on land use, particularly that of Transportation in Bangalore city.
- To study the impact of increasing vehicular population on environment.
- The study is to highlight the Environmental Health Hazards linked with Air Pollution.
- The growing problems of e-waste, and recycling of e-waste.

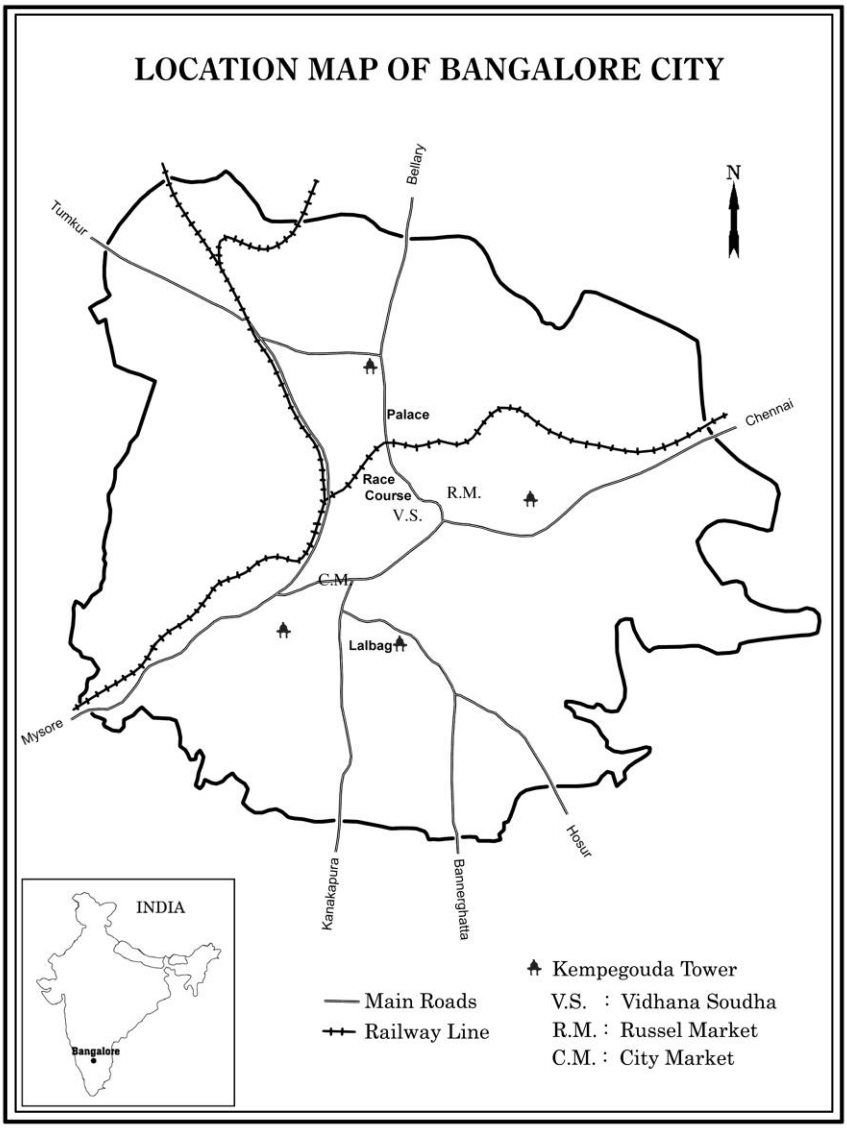


Fig.1.

Methodology:

In the present study of Urbanization and its Environmental Issues - Bangalore City, data from secondary as well as primary sources like Bangalore District Census Hand Book, data from Karnataka State Pollution Control Board (KSPCB), and data of Metro covered area has been collected and analyzed. As the study is qualitative in nature simple tables and suitable maps have been generated. Since Bangalore City is a dynamic metropolis there are a series of popular articles published in leading dailies from which information has been elicited.

Urban Growth:

The population of Bangalore city stands at 5.7 million as per 2001 census records, and continuing with this growth rate, the city's population is expected to reach around 11 and 22 million in 2021 and 2041 respectively. With the Information Technology (IT) boom, Bangalore is one of the fastest growing cities in India and Asia. With the emerging Bio-Technology (BT) boom, Bangalore's population growth may be even faster in the forth-coming decades. Bangalore is booming with other growth which is evident from its nicknames viz. "India's Silicon Valley", "Fashion Capital of India", "The Pub City of India", and so on. All these factors contribute to the growth of population of city. The table 1 below shows the growth trends. (fig2.)

Table 1: Population Growth of Bangalore City 1871-2001)

Year	Area (in km2)	Population	Sex Ratio	Density	Decadal Variation in %
1871	NA	144,479	NA	NA	--
1881	NA	155,857	1,128	NA	7.88
1891	NA	180,366	981	NA	15.73
1901	NA	163,091	962	NA	-9.58
1911	60.35	189,485	938	NA	16.18
1921	NA	240,054	893	NA	26.69
1931	NA	309,785	903	NA	29.05
1941	NA	410,967	900	NA	32.66
1951	NA	786,343	883	NA	91.34
1961	501.21	1,206,961	874	2,408	53.49
1971	177.30	1,664,208	875	9,386	37.88
1981	365.65	2,921,751	896	7,991	75.56
1991	445.91	4,130,288	902	9,263	41.36
2001	531.00	5,686,844	906	10,710	37.69

Source: Census of India, District Census Handbook -2001.

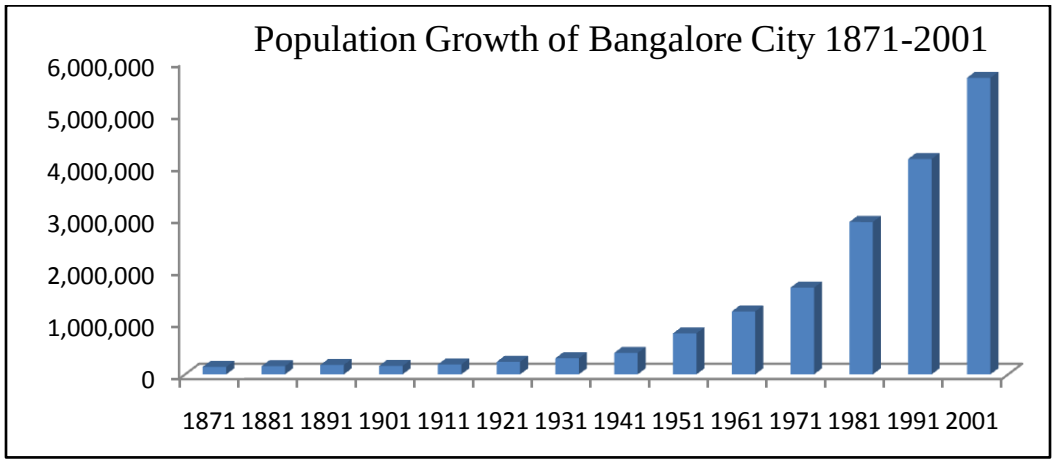


Fig.2.

Due to rapid urbanization the existing urban structure of Bangalore is seriously affected and is confronted with many problems such as urban sprawl, change in land-use pattern, traffic congestion, air pollution, e-waste and environmental degradation etc.

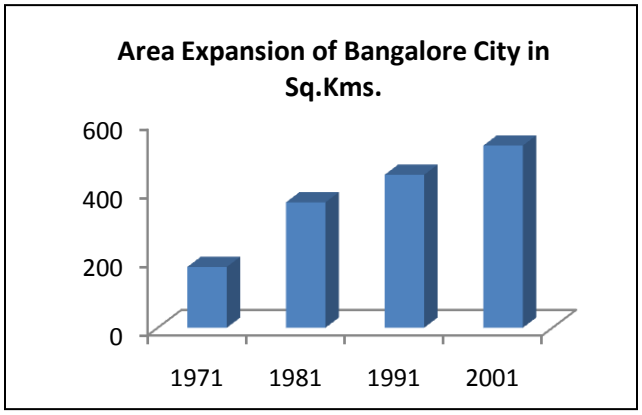
The spatial extent of Bangalore City in the year 1971 was about 177.30 sq.km. which increased to 365.65 Sq.Km. in 1981 and 445.91 Sq.Km. in 1991 to 531.00 Sq.Km. in 2001 respectively. As it is evident from the census figures (Table 1) urbanization in 1971-81due to expansion of urban area, we can see the real emergence of city outgrowths. Of course this includes factory type of urbanized areas plus the enormous outgrowth of urbanized fringe villages with new layouts with or without civic amenities. Where the latter is a kind of phenomenon that exists in these newer urbanized areas even at all India level (B.K.Ray1993). In the year 1981 the Bangalore City along with its outgrowths has a population of 2.9 million, which increased to 4.1 million to 5.6 million in 1991 and 2001 respectively. It attributes fastest growth in aerial expansion of Bangalore City.

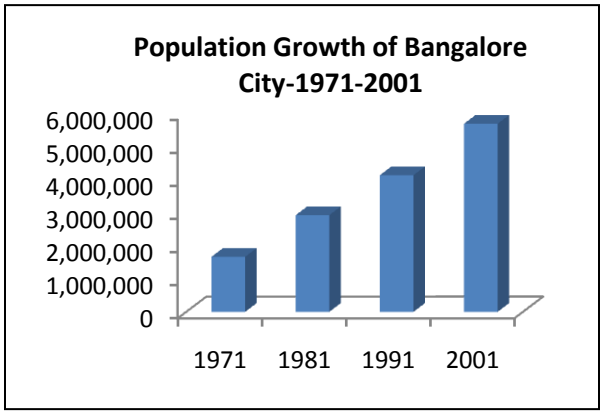
The urban aerial expansion of Bangalore city has shown remarkable growth in recent years. Table 2 shows temporal dynamics of urban sprawl of Bangalore City.

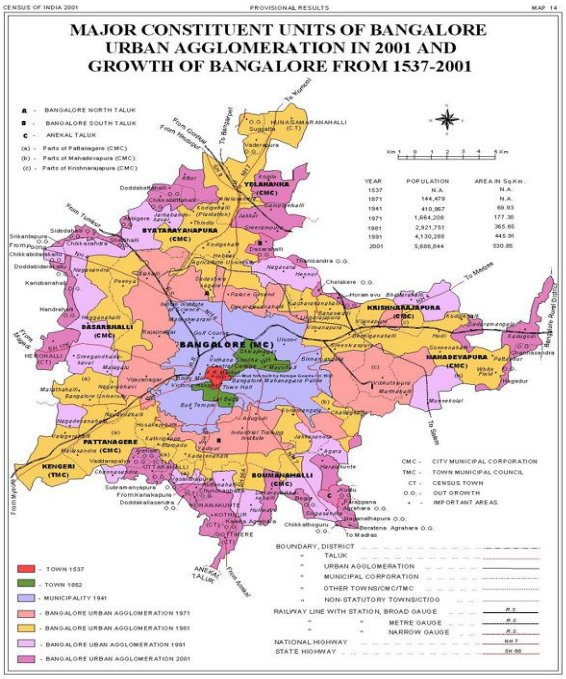
Table 2: Urban Sprawl of Bangalore City in the recent decades

Year	Area Sq.Km.	% Growth/year	Population	% Growth/year
1971	177.30	-	1,664,208	37.88
1981	365.65	27.35	2,921,751	75.56
1991	445.91	22.43	4,130,288	41.36
2001	531.00	18.83	5,686,844	37.69

Source: Compiled from population Statistics– Kendriya Sadana Koramangala, Bangalore.







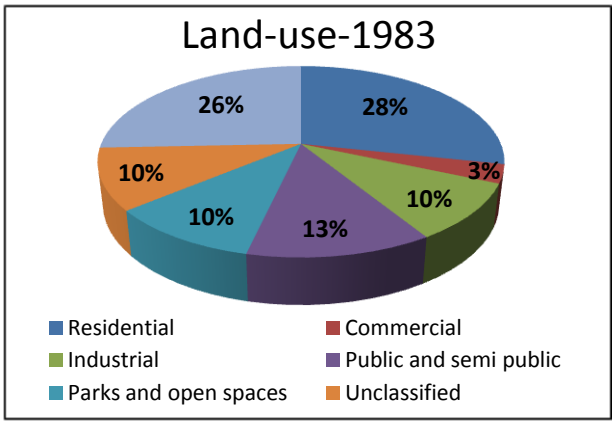
Land use pattern of Bangalore City:

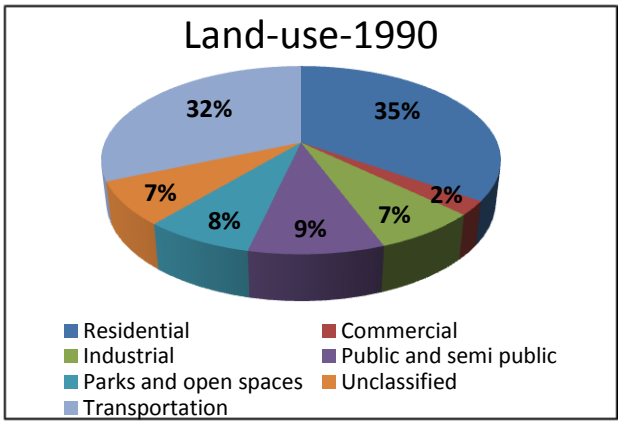
The other major effect of urban growth is the change in land use pattern of Bangalore City. In the year 1983 the total land area was 20283.18 hectares, which increased to 28400 hectares in 1990 to 42432 hectares in 2001, further it will be increased to 56462 hectares in 2011. The map below shows the growth of Bangalore from 1537 – 2001. And the table 3 below shows land-use classification of Bangalore City 1983-2011.

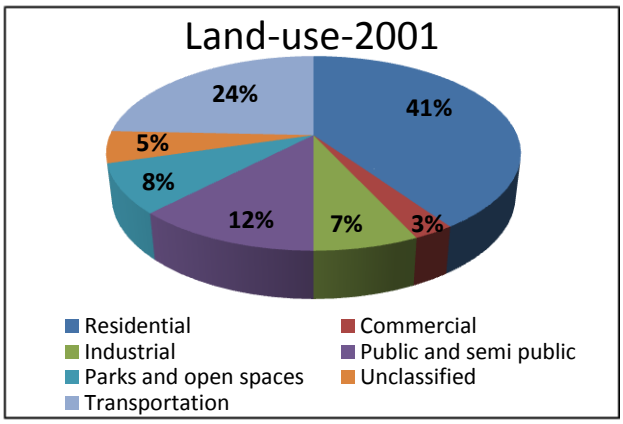
Table 3: Trends in land use in Bangalore City 1983-2001 and 2011

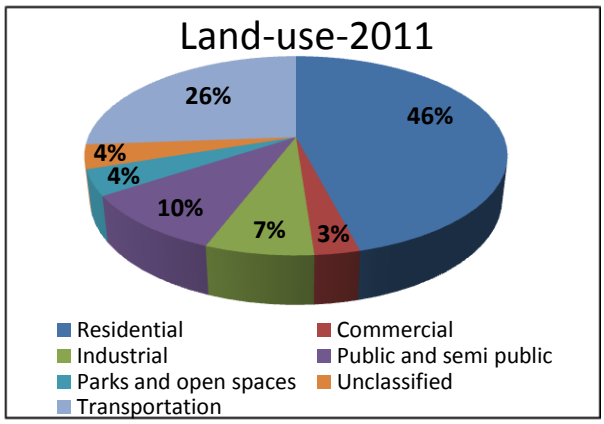
Land-use	Area (Ha) (1983)	%	Area (Ha) (1990)	%	Area (Ha) 2001	%	Area (Ha) 2011	%
Residential	5777.65	28.48	9877.65	34.88	17123	40.61	24369	45.94
Commercial	634.07	3.14	675.07	2.38	1159	2.85	1643	2.91
Industrial	1956.61	9.75	2038.61	7.18	2941	6.95	3844	6.98
Public and semi public	2533.64	12.60	2615.64	9.21	5201	12.25	4908	9.89
Parks and open spaces	2050.16	10.41	2132.16	7.67	3520	8.25	7788	4.17
Unclassified	2114.24	10.42	2114.24	7.45	2164	5.32	2213	3.92
Transportation	**5216.81**	**25.82**	**8946.63**	**31.60**	**10321**	**24.3**	**11697**	**26.19**
Total	**20283.18**	**100**	**28400**	**100**	**42432**	**100**	**56462**	**100**

Source: Data Collected and Compiled from BMP Master Plan.









The land-use for residential purpose was 28.48% 1983 which increased to 34.88% in 1990, to 40.61% in 2001 and it is likely to increase around 45.94% in 2011. This increase will be due to formation of new residential layout in outgrowth of Bangalore. Similarly land-use for commercial purpose was 2.38% in 1990, increased to 2.85% in 2001, and more or less it is going to be around 3% only. Land-use for industrial purpose will also remain around 7%. Whereas the land-use for Public and Semi Public was 12.60% in 1983, reduced to 9.21% in 1990 and it increased to 12.25% in 2001. But it is going reduce to further by 9.89% in 2011. This will be attributed to Public and Semi Public (soft ware sector) already established in the last decade. The land-use for parks and open space was around 10.41% in1983, reduced to 7.67% in 1990 and 8.25% in 2001. It is going to be around only 4.17% in 2011- all due to the upcoming Bangalore Metro and widening of roads in around Bangalore City. Whereas the land-use for unclassified sector was 10.42% in 1983, reduced to 7.45% in 1990 and further declined to 5.32% in 2001, and it is further going to reduce to 3.92% in2011, due to urban developmental activities of the city. The land-use for transportation was 25.82% in 1983, 31.60% in 1990. It reduced to 24.3% in 2001 and it is further going to increase by around 26.19% in 2011. This will due to the upcoming Bangalore Metro.

Existing Transport Scenario:

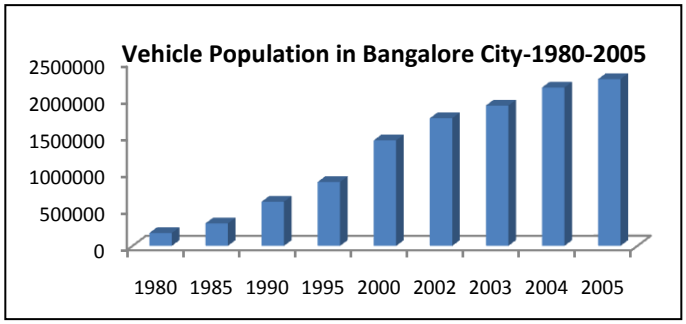
Bangalore city has a population of 5.7 million according to the census statistics for the year 2001, as against the city's earlier population of 2.92 and 4.13 millions in 1981 and1991 respectively. This shows that the population is growing at a rapid pace and has nearly doubled in the last twenty years, and presently the annual growth rate is around 3.8% annually. The geographical boundaries of the city are also expanding fast, as evident from the census data, which showed the city areas as 386, 446 and 531 sq. km. during the years 1981, 1991 and 2001 respectively. With increasing population and reduced available land area the city's population density stood at 7983, 9260 and 10,710 persons/km2 for the above corresponding period. It is further projected that the population size of Bangalore Urban Agglomeration (BUA) will be around 7.8 million in 2011 and 11.0 million in 2021. A large city of this size and a rapidly rising population of the above magnitude, demands a whole range of civic services, including the vital transportation sector.

Presently Bangalore City has the population of 6.52 millions, with the vehicle population of around 1.6 millions of two wheelers, 3 lakh Cars and 4000 Buses. The table 4 below shows Vehicle Population in Bangalore City-1980-2005.

Table 4: Vehicle Population in Bangalore City-1980-2005

Year	1980	1985	1990	1995	2000	2002	2003	2004	2005(30.5.05)
Total Vehicles	175325	306589	601059	870659	1438057	1738929	1912341	2157480	2272239

Source: Data Collected and Compiled from Vehicle population Statistics.



The present public transport infrastructure of Bangalore city is largely dependent upon the BMTC operated bus network facility, which is the mainstay for a population size of nearly six million. As the services offered by BMTC falls severely short of the public expectations and satisfaction, it has given rise to a situation in Bangalore where there is a preponderance of private transportation – mainly consisting of two wheelers and three wheelers, besides a good number of four wheelers and light vehicle population. Given this scenario, Bangalore city is also being promoted as a high profile investment destination by Government, Private industries and Multi-Nationals and the good response thus received, has resulted in a chaotic situation as far as Urban Transport Sector is concerned. The present vehicular fleet on Bangalore roads is around 1.8 million vehicles traversing in the city area, in which 50 to 60% is accounted by two wheelers and the rest shared by three wheelers, cars and HMV's including buses. However the BMTC share of vehicle population on the city's roads is less than 2%, with which it practically carries most of the intra-city transport burden. Due to resource and management constraints, BMTC operations cannot match the raising demands of the city population, as evident from overcrowded buses, ever increasing average trip length with corresponding increase in average journey transit time exceeding even 60 minutes and more and long waits at bus stops. As a sequel to this and to meet the genuine needs of a rapid, efficient and convenient mode of city transport, there is a growing trend to use personalized vehicles in Bangalore with attendant problems of high road congestions, large fuel consumption, heavy air pollution levels, besides growing number of accidents on

the road as mentioned earlier. To address these problems singularly and in order to bring in considerable relief to the travelling public, the Government of Karnataka has decided to introduce Metro rail system for the benefit of the city's commuting population on the lines of the Metro rail at Delhi.

Current Scenario:

Rapid growth in economy demands infrastructure that keeps pace with it. However, Bangalore, a 'pensioner's paradise' as it was once known has swiftly changed into a bustling cosmopolitan city, thereby widening this gap. With the increase in 'floating population', the burden of urban banes like poor infrastructure, traffic congestion and inadequate public transport have started taking a toll on the city.

The table 5 & 6 below shows Category Wise Vehicles in Bangalore City (up to 30.06.2007), and the Road Accident Scenario of Bangalore City (up to 31.12.2007).

Table 5: Category Wise Vehicles in Bangalore City (up to 30.06.2007)

Two Wheelers	L.M.V	A/R	H.T.V.	H.G.V.	Others	Total
2101174	434428	91899	77842	94921	82300	2880426

Table 6: Road Accident Scenario of Bangalore City (up to 31.12.2007)

Years	2001	2002	2003	2004	2005	2006	2007
Fatal	668	783	843	875	796	880	957
Killed	703	820	883	903	836	915	981
Non-Fatal	8358	9073	9662	8226	6782	6681	7469
Injured	6929	7577	7980	6921	5899	6048	6591
Total	9026	9856	10505	9101	7578	7561	8426

Source: Data Collected and Compiled from News papers.

Today Bangalore, with around 29 lakh vehicles on the roads, has an accident rate of 130 for a one lakh population, compared with 56 in Chennai, 175 in

Mumbai and 65 in Delhi. Of course, the city also has the highest vehicle density of 37,571 per one lakh population. A study of road accidents compiled by the city police reveals that cars, taxis and SUV's account for the largest number of vehicles involved in road accidents, closely followed by two-wheelers. Vans, tempos and maxi cabs. Followed by buses and trucks. Auto rickshaws come next on the accident list. The city accounts for an average of 10,000 accidents a year (according to figures compiled since 2000) and close to 900 deaths. The accident rate has gone up in proportion to the increased number of vehicles, the police admit. Mass rapid transit systems such as the metro rail may not become the only public transport option, but can considerably reduce congestion on the roads, traffic planners point out. With the State Government firmly committed to implementing the metro rail project, one positive fallout the city police look forward to is decrease in the

number of vehicles and consequently less number of accidents on roads. Latest statistics of current transport related scenario of Bangalore City are shown in the table 7.

Table 7: Shows the Transport related Scenario of Bangalore City (29.12.2009)

Fine Amount	Major Violations	Non-fatal Accidents		Accident Victims	Traffic Signals
2007-19 cr	38,000 Drunken Drive	2007	7,469	Pedestrians 60%	2008 – 163 2009 – 330
2008-28 cr	60,000 Over Speeding	2008	6,908	Motorists 32%	40,000 junctions
2009-35 cr	5,00,000 Jumping Signal	2009	5,623	Others – 08%	4000 / 700 Major/Manned

Source: Data Collected and Compiled from News papers.

Air Pollution Surveys:

The urban air pollution is contributed generally by a variety of sources such as industrial, commercial and transportation sectors. However, at Bangalore air pollution problems which are quite severe are mainly compounded by the transportation sector while the other sources such as industrial etc. are contributing less. As the core transportation sector presently consists mainly of petrol and diesel driven vehicles operating throughout the city, the major air pollutant components are contributed by the automobile exhaust emissions, which consist of; Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Oxides of Nitrogen and Sulphur, Carbon Monoxide etc. Presently many of these air pollutant concentrations are being monitored by the Karnataka State Pollution Control Board (KSPCB) at some locations and by the Central Pollution Control Board (CPCB) at some selected important intersections of the city. However, as these data were being collected with quite different objectives, actual primary site specific data for the proposed metro were generated by organizing air pollution monitoring surveys by field teams by employing standard methods of sampling and analysis. Baseline air pollution

concentration for above parameters was mapped at about 20 sampling stations covering both the proposed alignment tracks. Secondary data values collected from PCB sources for selected locations were also mapped to enable comparison of the both the data. Supplementary data relating to the vehicle demography- i.e. statistics of vehicle population over the years to the present day, vehicle category data, annual fuel consumption for the city vehicle population, pollution emission factors for various types of automobile fuel uses were collected to evaluate precisely the air pollution status at the proposed Metro corridors. The details of baseline (2003) AQI values and quality criteria at Metro corridors are given in Table 8. The accepted criteria for Air Quality Index are given in Table 9.

Table 8: Details of AQI values and Criteria at Metro Corridors

Name of Stations	*AQI Values	Air Quality Criteria
Yeshwanthpur	256	Severe Air Pollution
Navarang Junction (Rajajinagar)	148	Severe Air Pollution
Seshadripuram / Swastik Cirlce	140	Severe Air Pollution
Anand Rao Circle	189	Severe Air Pollution
National College / Vanivilas Circle	238	Severe Air Pollution
South End Cirlce	173	Severe Air Pollution
KIMS Circle	146	Severe Air Pollution
Sri Aurobindo Circle (Jayanagar 5th block)	178	Severe Air Pollution
KIMCO Junction Vijay Bus Depot Mysore Road	256	Severe Air Pollution
Vijayanagar Tollgate (Magadi Junction)	140	Severe Air Pollution
Okalipuram	310	Severe Air Pollution
Anil Kumble Circle	76	Heavy Air Pollution
Shanthala Silks (Majestic)	314	Severe Air Pollution
Trinity Circle	232	Severe Air Pollution
Cauvery Bhavan (Mysore Bank Circle)	241	Severe Air Pollution
Old Madras Road	194	Severe Air Pollution

*AQI - Air Quality Index

Table 9: Generally accepted criteria for AQI

Range	Criteria
0 to 25	Clean Air
26 to 50	Light Air Pollution
51 to 75	Moderate Air Pollution
AQI > 75	Heavy pollution
AQI > 100	Severe Air Pollution

Environmental Health Hazards linked with Air Pollution:

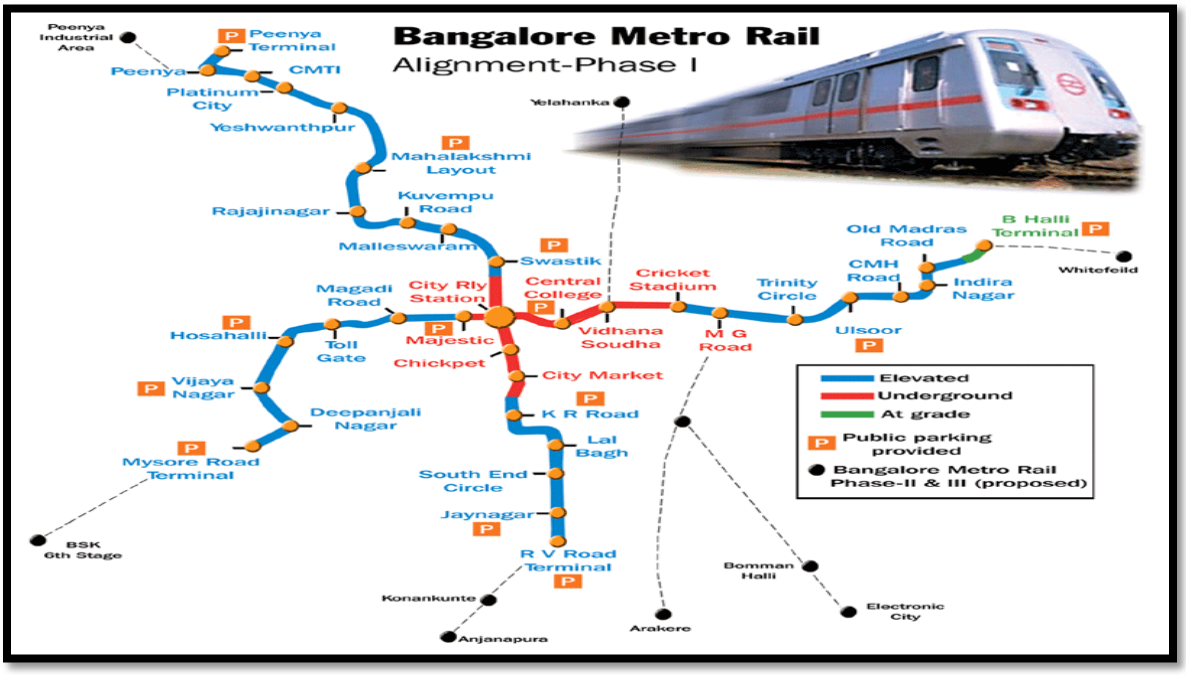
Increasing air pollution levels, shrinking greenery and shrinking of lung spaces over the past few years has made Bangalore City the Asthma capital of India. Due to rapid urbanization and pollution has led to increase incidence of Asthma - children are most vulnerable to asthma. According to Pediatric Pulmonologist – "Though asthma can be hereditary, the Environment plays a key role in causing the disease". Changing lifestyle, eating habits and rise in traffic congestion are some of the reason leading to asthma among the urban population. Based on the study conducted over the past 30 years children suffering from asthma increased from 9% in 1979 to 25.6% in 2009. Though there is no cure for asthma, timely intervention, regular medication and appropriate

changes in the environment can help contain the disease.

Environmental Impacts due to Forth Coming Bangalore Metro:

The proposed metro rail project for Bangalore city – which is passing through a phenomenal growth rate and rapid urbanization – while providing a strong infrastructure and serve as a vastly efficient transportation system for the city, will also have implications on certain environmental fronts. While the accrued benefits to the urban community in terms of an alternative and superior mode of transportation would be sustainable and far reaching, the very size and nature of the metro could have a significant bearing due to the numerous positive and negative environmental and socioeconomic impacts on the environment and the community.

Map shows Bangalore Metro and its corridors



Negative Impacts due to Bangalore Metro:

The Bangalore Metro Rail should have been introduced at least 20 years ago. Unfortunately the project has taken off only in recent years. Due to Bangalore Metro work, the deadly mix of increasing vehicular traffic, diversions of traffic and indisciplined, chaotic deriving has resulted in a perpetual traffic deadlock.

Trees which get affected due to Bangalore Metro:

Bangalore city, with its rich flora and abundant green cover and being the home of Lalbagh and Cubbon park, which are renowned botanical gardens, is rightly called the Garden City of India. Bangalore City bagged the central government sponsored 'Indira Priyadarshini Vruksha Mitra' award in the late 1980s in recognition of its extensive green cover. But today, lung space is shrinking in the city and core areas have lost green cover with increase in concrete structures. A detailed tree census was carried out along the proposed alignment as part of environmental baseline studies for EIA purposes. A summary of the data of the affected trees is given in Table 10 below.

Table 10: Type of tree population within 0-5m affected due to Bangalore Metro

Type of Tree	East-West metro corridor	North-South metro corrido	Total
1. Big canopy trees with girth >70cm at GBH	144	90	234
2. Medium canopy trees girth 40 to 70 cm at GBH	95	23	118
3. Coconut	32	5	37
4. Small canopy trees and shrubs with girth <40 cm	12	11	23
Total trees to be cut	283	129	412
Bio mass (in tonnes)	310.6	235	545.6

Among the 412 trees to be cut due to the Bangalore Metro out of which only 274 are healthy and the rest are either aged, stunted or mutilated (Table 9), which may need replacement in the near future. Also the total biomass loss is of the order of 545 .60 tonnes for a total of 412 trees which comes to 1.32 tonnes per tree which shows that the trees are, on an average, medium size and not large ones. Considering the benefits of the project, and the compensatory afforestation plan envisaged, it has been observed with management plans consisting of planting of trees in the ratio of 1:10, proactive afforestation for green cover and development of green ribbon along the elevated stretch, it will abundantly compensate the green cover.

Positive Impacts due to Metro:

A major positive contribution is reduction of consumption of fossil fuel. To estimate the possible saving of fossil fuels, it is opined from the public that, about 50% of the two wheelers and three wheeler commuters expressed their willingness to shift to Metro. So, even a conservative realistic figure would be 30% of two wheelers and 20% of three wheeler commuters would shift to Metro. Based on this, the estimated reduction of fuel consumption and Air pollutant emission is furnished in the Table 11 and 12 below.

Table 11: Expected reduction of fuel consumption in 2011

Category of Vehicles	Number of Of Vehicles Without Metro	Number of Vehicles with Metro	Fuel consumption with out Metro (litres)	Fuel consumption with Metro (litres)	Fuel saved (litres)
Two Wheelers	2394075	1676137	1795556	1257102	538454
Three Wheelers	157224	125829	786120	629145	156975
Total Saving in Fuel, litres per day					695429

Table 12: Estimated reduction of Air Pollutant Emission

Pollutant	Exhaust Factor* petrol in kg/litres	Total decrease in air pollutant release (in MT)
Carbon Monoxide	391.0	271
Hydrocarbons	34.0	23
Oxides of Nitrogen	19.2	13
Oxides of Sulphur	1.5	1
Particulate Matter	1.9	1
Total		309

*Exhaust emission factor as per H.B. Mathur, 1984

Reducing emission by introducing 4-stroke LPG Auto Rickshaws:

To reduce the emission, the Government of Karnataka has flagged off the 4-stroke green Auto Rickshaws, which will gradually replace ageing 2-stroke auto rickshaws in the city. They will run on environmental-friendly auto LPG, cutting down drastically on the vehicle emission, including toxic gases and particulate matter. Furthermore, it will be profitable to run these autos as their operation cost will come down by 50 percent.

Environmental Impacts due to e-waste generated & recyclers for treating e-waste:

Bangalore has changed from the 'Pensioner's Paradise' to 'IT capital of India' and also nicknamed "India's Silicon Valley". Today, the city is the nerve-center for many Indian as well as Multinational Companies in Biotechnology, Information Technology, Fashion, Machine tools and even in Research and Development Companies. Bangalore is home for Indian corporate giants in IT like Infosys, Wipro, Satyam, Aditi and even for major MNC's like H.P., Compaq etc. This has led to variety of attractions for nearly every taste, from sprawling IT Parks, residential apartments, to glamorous clubs. The current lifestyle of Bangalore is the best indicator of the social impact of globalization, corporate culture, consumerism and other social and economic shifts which have taken place in recent years. With the development in IT field, it produces enormous amount of e-waste, which is a great threat to the environment. The country produces about 1.5 lakh metric tonnes of e-waste and the Bangalore City alone contributes about 8,000 tonnes annually. However, e-parisara says that the city figure is only from the IT industries and

the domestic e-waste like television; fridge, AC and others are not included. For the treating of e-waste in the city, Karnataka State Pollution Control Board (KSPCB) has launched a project 'Crystal' to bring waste treating companies together and help them in treatment of waste using state-of-art facilities. The project taken up by KSPCB through Hazardous Waste and Water Management (HAWA) will ensure scientific extraction of precious metals like gold, silver and platinum. According to Environmental Advisor, HAWA – the printer circuit board connector and other computer have a fraction of precious metal. That portion will be extracted and sent to Belgium for recovery.

Conclusion:

The Bangalore City with rapid urbanization and its environmental issues focused problems could be to some extent reduced by creating and concentrating on developing suburbs; reducing the emission by introducing 4-stroke LPG auto rickshaws; to introduce treating e-waste by Precious Metal Refinery and e-waste agency (EWA). And reduce the traffic congestion and air pollution through Metro project being an infrastructure project for Bangalore city designed to promote an efficient and commuter friendly transport sector for the benefit of the urban community is also expected to bring in a number of positive impacts on the environment and the general public. Depending upon their significance and magnitude, some of them could be considered as tangible while others could be viewed as intangible benefits. The positive impacts of metro would be steadily realized during sustained running operations of the metro system.

The Bangalore Metro comes with a package deal. Comfortable, quick, safer and economical, its energy requirement per passenger km. is only one-fifth of that of road based systems. Commuters and children can breathe easy; there will be no air pollution as the system runs on electric power. The economic rate of return is 22.3 percent.

Suggestions:

1. With traffic decongestion being the key, the primary aim of the Bangalore Metro should be to encourage commuters to leave their vehicles in their garages and use public transport. Positioned as a complementary, rather than competitive mode of transport, the Bangalore Metro should work in tandem with other transport system like buses and mono rails.
2. The city bus corridors will not run parallel to Bangalore Metro corridors; instead buses will act as feeders. The mono rail network planned for the city will not overlap with that of the metro, but will connect at major junctions as feeders.
3. On certain high density corridors, three wheelers will be regulated. Feeder bus services will be provided to all the metro stations. Bus bays and parking facilities for private vehicles will be available at all major stations. State-of-the-art satellite bus-cum-metro terminals are being planned in the city outskirts, to control the entry of inter-city buses.

Environmental Impact Criteria on significant beneficial impacts of ***Natural***

resources, Environmental Quality and Global Sustainability by Bangalore Metro are:

- Air Quality of the urban "pollution dome" due to fuel driven vehicles as expected to be diffused to a large extent by improving the air quality (CO2, SO2, NOX, Pb reduction).
- Noise levels - The noise along corridors will be reduced as on-road vehicular population density goes down and the noise in other areas can be marginal due to overall reduction of density.
- Fossil fuel conservation - Huge reduction due to reduction of fueled vehicles and opting for electrical traction.
- Livability - Quality of life improved by reduced vehicles on road, lesser pollution, lesser road accidents, quicker and comfortable mode of transport.
- Cultural heritage - Cultural heritage by Urbanity enhanced, internal and external image of city enhanced.
- Transport energy efficiency (modes) - The well planned corridors provide encouragement to modal shift from private owned vehicles to Metro rail which operates on electrical traction.
- Renewable energy potential - Corridors provide conservation of fossil fuel which is fast depleting.
- CO2 fixing - Increased potential for growing trees both along corridors and other selected areas of forestation.
- Transport energy efficiency (Trips) - The trips on metro rail will lower the traffic density on roads.

Some of other positive benefits of Bangalore Metro are:

- Quick service and safety.
- Reduced traffic density on roads.
- Reduced fuel consumption by automobile sector & accompanying import Savings.
- Reduction in road accidents.
- Reduction in air pollution and noise levels.
- Improvement in road conditions and extended life of roads.
- Benefits of transfer of technology.
- Employment opportunities.
- Enhanced rural economy.
- Saving in productive man-hours due to rapid mode of transport.
- Reduction in green house gases emission.
- Reduced need for expansion of roads, laying new roads, flyovers etc.
- Better environmental landscape, aesthetics.
- Boost to industry, trade, commerce, communication and culture.

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A GIS-based Multi-Criteria Land Suitability Evaluation for Agricultural Crops in Mahaoya DSD, Ampara District, Sri Lanka.

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Abstract

The present study has been carried out to evaluate the suitability of the land for agricultural crop production by using GIS applications. Evaluation of land in terms of suitability classes is based on the method described in FAO guideline for land evaluation. The factors that are considered for evaluation of the land suitability for agricultural crop production are the slope, soil drainage, soil texture, soil depth, soil type and current land uses of the study area. Multi-criteria decision evaluation method has been used to evaluate the physical land characteristics for crop production. Analytical Hierarchical Process (AHP) incorporates expert knowledge and judgment by decision-makers at various levels. The techniques, which have been used to weigh and standardize the factors, are the pair-wise comparison and weighted linear combination. After evaluating the physical land suitability for agricultural crops, a land suitability map has been developed. This map has been classified into five suitability classes based on the FAO guidelines. The evaluation of physical land qualities indicates that the study area has potentials for agricultural crops in the Mahaoya Divisional Secretariat Division (DSD) in Ampara District, Sri Lanka.

Introduction

Agriculture is one of the world's most important activities supporting human life. From the beginning of civilization, humans have used land resources to satisfy their basic and other needs. Land resources regeneration is very slow while population growth is very fast, leading to an imbalance. On a global scale, agriculture has proven potential to increase food supplies even faster than the growth of the population (Davidson, 1992). Lack of wise and suitable agricultural practices results in the degradation of natural habitats, ecosystems and agricultural lands round the globe. Therefore, the concept of land suitability evaluation has been evolved.

Land suitability evaluation is a process of determining the fitness of a given tract of land for a defined use (Marsh and MacAulay, 2002). Land systems analysis, through improved methodology of land suitability evaluation, is the main aim of present research undertaken in Mahaoya Divisional Secretariat Division of Ampara District in Sri Lanka.

The concept of sustainable agriculture involves producing quality crops in an environmentally friendly, socially acceptable and economically feasible way (Addeo *et al*., 2001). This implies an optimum utilization of available natural resources for efficient agricultural production. An efficient agricultural

production system requires proper planning and timely management of available agricultural areas under an appropriate land allocating scheme. Obviously, such a scheme includes an evaluation of land capability and determination of suitability of each of these areas for different agricultural crops.

Agricultural crop production is determined by land characteristics, namely, elevation, slope, aspect, soil (depth, drainage and texture), land cover and climate. All these factors collectively determine the suitability of a given area for a particular type of crop cultivation. Thus, in order to build an efficient crop production system, evaluation of land suitability from time to time is essential.

The process of land suitability classification is the evaluation and grouping of specific areas of land in terms of their suitability for a defined use. This suitability is a function of crop requirements and soil/land characteristics. Matching the land characteristics with the crop requirements gives the suitability. Hence, suitability is a measure of how well the qualities of a land unit match the requirements of a particular form of land use (FAO,1976).

Problem of Study

The terrain of the Mahaoya Divisional Secretariat Division (DSD) is undulating to rolling land uses and land management practices, reinforced by the population growth, which has in the study area led to suffer from severe land degradation and consequent decline in crop and livestock production and productivity. As a consequence of the decline in agricultural productivity, the factors contributing to decline in agricultural productivity are numerous, which are acting together to further tighten the *strings* of deprivation of the farm households in the study area. The cropping land parcels are small and fragmented. Scarcity of cultivable land has enforced them to cultivate on cleared forest lands. This has led to soil erosion, flooding and natural resources degradation. Besides that, the agricultural lands are depleted of nutrients, due to improper land use and land management practices. The terrain of the Mahaoya DSD is mountainous, rugged and undulating, coupled within appropriate land uses and land management practices, reinforced by population growth, which has led the Mahaoya to suffer from severe land degradation and consequent decline in crop and livestock production and productivity. As a result of the decline in agricultural productivity, the Mahaoya has been depending on food aid for more than 30 years.

Research Objectives

General Objective: The general objective of the study is to evaluate the land physical characteristics and its quality for land suitability of main agricultural crops in Mahaoya DSD. The aim of this research is to explore and examine the use of Analytical Hierarchical Process (AHP) in a multi-criteria evaluation of land suitability for agricultural crops and compare the results with those of the existing standard methodologies.

Specific Objectives: The specific objectives of the study are embedded in the development of a multi-criteria decision making technique using the APH land suitability analysis for agricultural crops. The primary objective of the study is to examine the physical properties of the soils, that is, the soil texture,

soil drainage, soil depth and soil types of the study area. The other objectives are:

- To develop a land suitability classification for the study area;
- To develop a land suitability map for the study area; and
- To develop agricultural crops suitability maps for different land utilization types of the study area

Limitations of the Study

Due primarily to shortage of data on the chemical properties of the soils of the study area, the chemical properties have not been evaluated for land suitability and crop suitability analysis. Only the physical characteristics of the lands of the study area have been evaluated.

As there has been a lack of time and budget in the collection and analysis of the soils, their physical as well as chemical characteristics, the soil map obtained from the Ministry of Land and Land Development has been used in the study.

A Brief profile of the Mahaoya DSD

The Mahaoya DSD is in the eastern parts of Sri Lanka. It consists of agricultural lands, reserves of forests and national parks and residential pockets away from major land uses. The Mahaoya DSD (Figure 1) is divided into seventeen (17) administrative, Grama Niladhari Divisions (GNDs).

The study area is bounded by Batticaloa and Polonnaruwa Districts on the north, Monaragala District on the south, Padiyatalawa DSD on the west and Batticaloa District on the east. The study area has limited variations in geomorphological units. It has an extent of680.83 km^2.

Materials and Methods

Materials used in the present study include:

1. 1: 50,000 topographic maps used to generate DEM layer;

2. Global Positioning System (GPS) for collection of ground control points;

3. The soil map of the study area, obtained from the Ministry of Land and Land Development;

4. 10 years' monthly maximum and minimum temperatures, 10 years' average monthly rainfall data, collected from the Meteorological Department, Irrigation Department and Agriculture Department of the Eastern Province.

Different application software systems have also been used in the study and they are: ArcGIS 9.3;ERDAS 9.1;3DEM; and Global Mapper 11.

The objective of the multi-criteria suitability analysis is to determine the suitability of the land based on multiple criteria or factors that regulate or determine the suitability of land for specific uses. In conventional GIS analysis also, the multi-criteria techniques can be performed; however they do not provide any mechanism to incorporate the decision maker's judgment and priorities in the evaluation process. The approach followed in this research has integrated the GIS-based spatial analysis techniques and MCDM techniques (Figure 2).

Map of Study Area

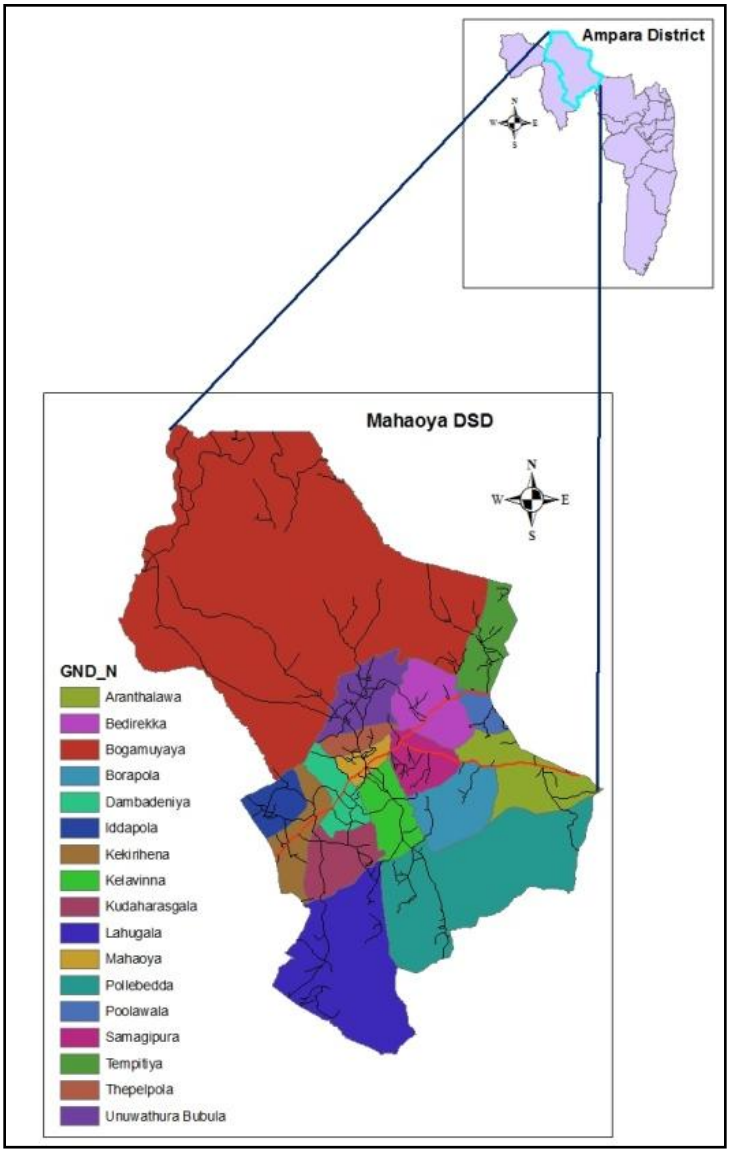

Fig. 1.

Methodology

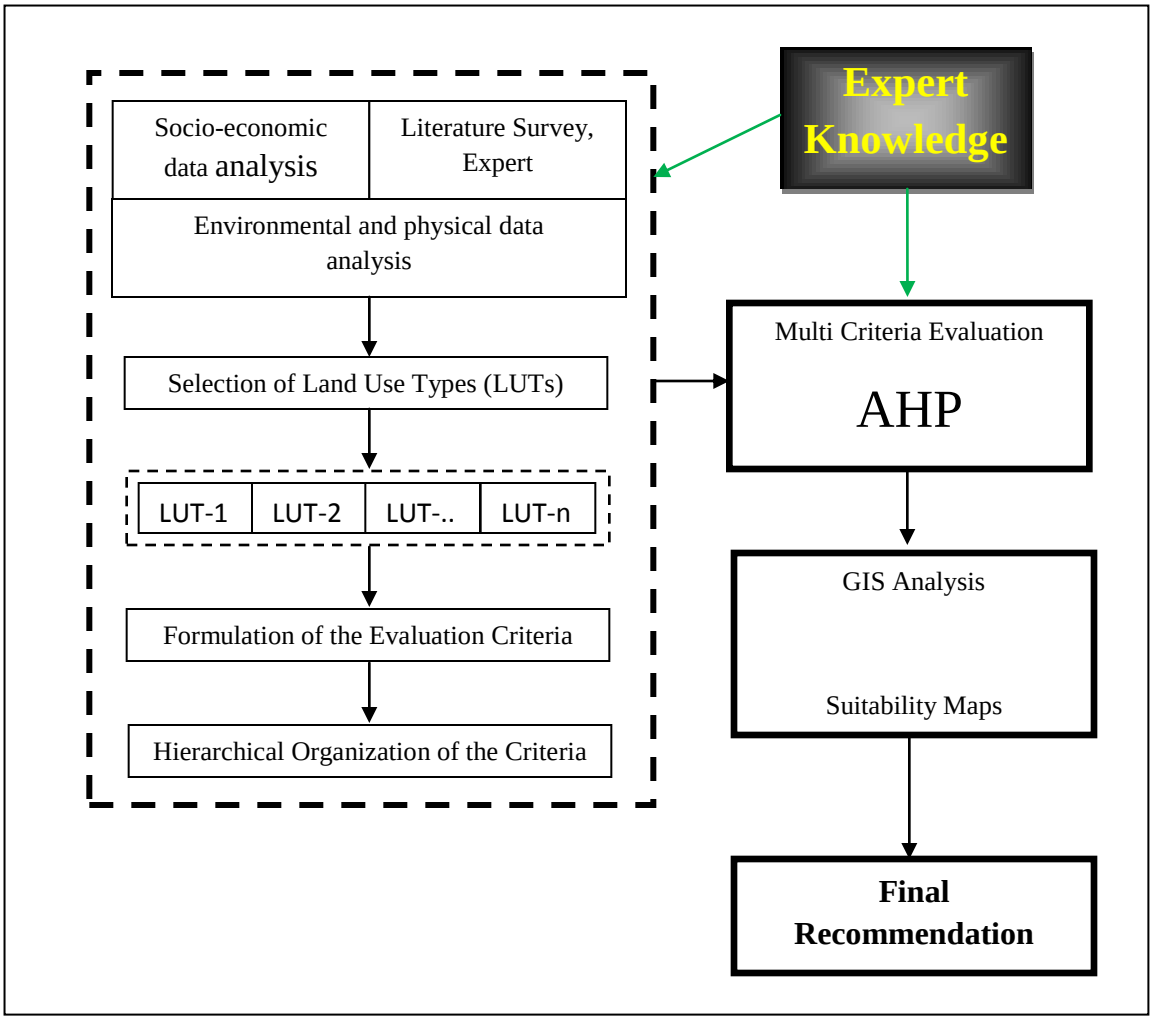

Figure 1.2

The MCDM incorporates the differential importance of the different decision criteria and attributes associated with them, in the evaluation process. This also provides for a mechanism to use expert knowledge and decision maker's judgments in the GIS based suitability analysis. The decision making problems of the land suitability analysis for agricultural crops has been analyzed using the Simons model with required modifications.Figure2 shows the conceptual structure of the research approach used in the study.

Physical land suitability evaluation is based on the biophysical conditions of the study area. The process of selecting the main criteria and sub-criteria is iterative in nature. Analytical study and the local opinions have been the basic tools for the selection of evaluation criteria. Based on the FAO framework for Land Evaluation, mapping units have been determined and their physical land suitability assessed on the basis of soil parameters that follow:

- Soil unit type (according to FAO soil classification system);
- Soil texture;
- Soil effective depth;
- Soil drainage; and
- Soil slope degree.

Results and Discussion

The physical and chemical characteristics of the land as well as climate are the major factors that determine crop suitability of a given land (FAO, 1986). However, in this paper only the physical properties of lands have been evaluated to analyze the land suitability for agricultural crop production. The physical land properties of the study are include the drainage, slope gradient, soil texture, soil depth, soil type, and land use. Climate (temperature and rainfall) of the study area has also been used for crop suitability analysis.

Slope Gradient

Slope is important for soil formation and management because of its influence on the runoff, soil drainage, erosion, use of machinery, and choice of crops. Slope is the incline or gradient of a surface and is commonly expressed in percent. The slope of study area has been represented in percentage terms. The result obtained after the evaluation has been that 81.50 per cent of the study area is below 2 per cent of slope, 5.47 per cent of the area is between 2 per cent to 15 per cent of slope, 5.85per cent of the geographical area of the study area is between 15 per cent and 30 per cent of the slope, 7.18 per cent of the area is between 30 per cent and 60 per cent of the slope and 1.15 per cent of the study area is in slopes greater than 60 per cent. This has indicated that 81.5 per cent of the study area is found to be highly suitable for agricultural crops (as shown in Figures 3 and 4).

Slope Suitability Classes

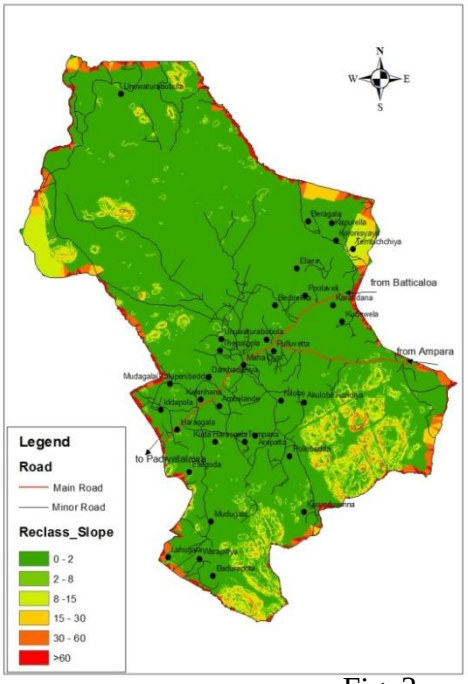

Fig. 3.

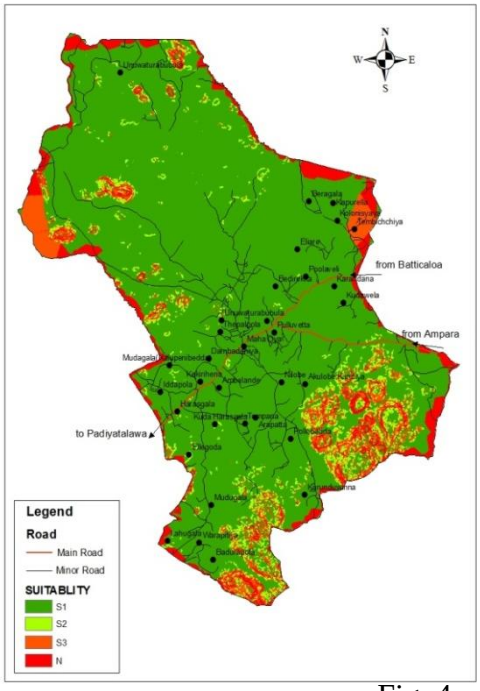

Fig. 4

Soil Depth

A soil depth variation from place to place determines the growth of plants and also affects the growing of plant roots. The thickness of the soil materials, which give structural support, nutrients and water for crops, is referred as soil depth. The soil depth of the study area has been classified into three classes of depth as well as suitability classes of land for cropping, as shown in Figures 5 and 6, below. Soil series which are bedrocks between 10 and 50 centimeters from the surface are described as shallow. Bedrock between 50 and 100 centimeters are described as moderately deep and 100 - 150 centimetres are deep and those greater than 150 cm are very deep.

Depth of Soil

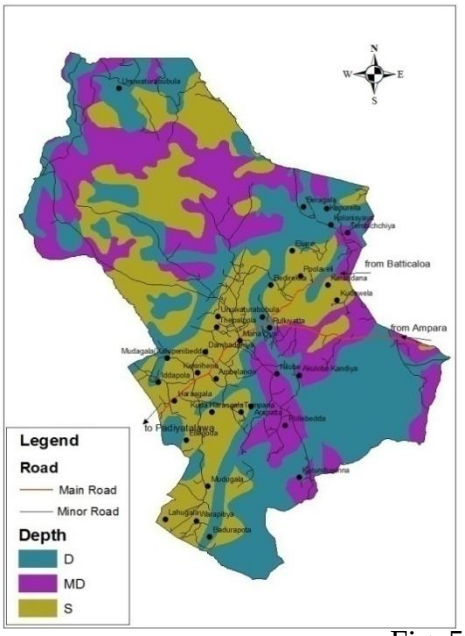

Fig. 5.

Depth Suitability Classes

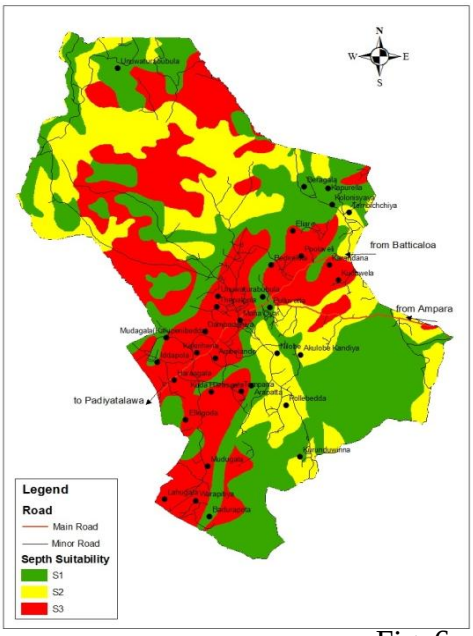

Fig. 6.

Soil Texture

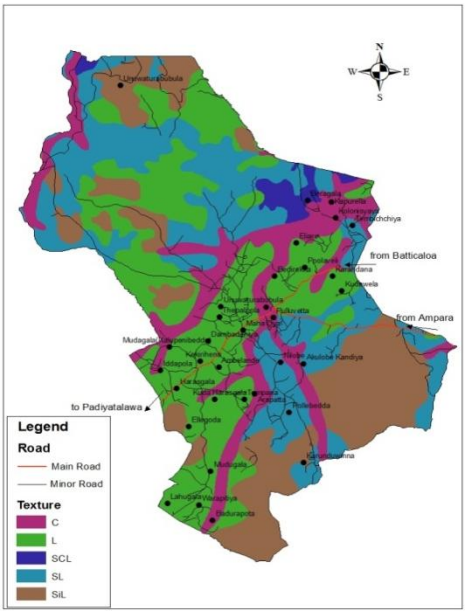

Fig. 7.

Texture Suitability Classes

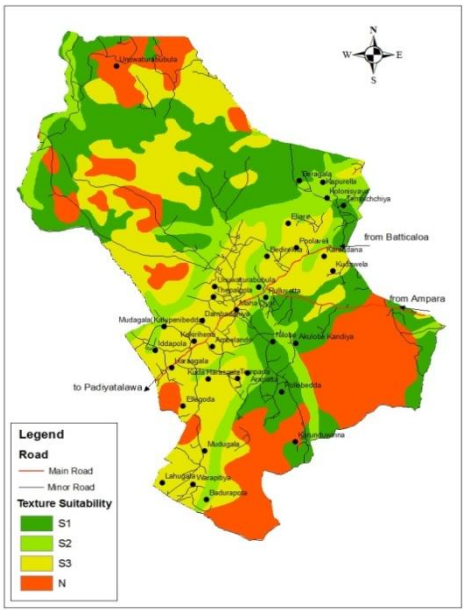

Fig. 8.

Soil Texture

The soil texture of the study area has been evaluated and classified into clay, sandy clay loam and sandy loam. The dominant soil texture types of the study area are sandy loam, loam followed by sandy clay loam(Figures7 and 8).

Soil Drainage

Evaluation of the soil drainage requirement is a critical element in selecting land for crop production, because it permits normal plant growth. Adequate soil drainage is essential to ensure sustained productivity and to allow efficiency in farming operations. Soil permeability properties of the study area are classified as well-drained, moderately well-drained, poorly drained, very poorly drained and imperfectly drained (Figures 9 and 10). Four suitability classes of land have been recognized as well, as shown in Figure 10.

Present Land Use/Land Cover

The type of land use/land cover in the study area includes cultivated and agricultural/unused lands, forests, scrub lands, water bodies, homesteads /gardens and rocks (Figures 11 and 12).

There are five land suitability classes based on the land uses, namely, highly suitable, moderately suitable, marginally suitable, not suitable and permanently not suitable, as shown in Figure 12.

Climate

Crops need specific requirements of temperature and rainfall for growth. The climate of the study area is characterized by Dry Zone Low Country and Intermediate Low Country. The mean annual temperature ranges between 25^0 Cand27^0C (Figure 13).The other major element of climate, which is the major requirement for crops production, is the rainfall. From Inverse Distance Weighted (IDW) interpolation technique, the rainfall distribution map of the study area has been developed. The result is shown in Figure 14.

Multi-Criteria Decision-Making

The Multi-Criteria Decision Making is a set of procedures designed to facilitate decision-making. The basic purpose is to investigate a number of choice possibilities in the light of multiple criteria and objectives. Weighting method has been used to develop a set of relative weights for a group of factors in the multi-criteria environment. The weights are developed by providing a series of pair-wise comparisons of the relative importance of the factors to the suitability of pixels for the activity (agricultural cropping) being evaluated. The pair-wise comparisons are then analyzed to produce a set of weights that sum to 1. The factors and their resulting weights can be used as input for the multi-criteria environment module for weighted land cover (WLC). Table 1 below shows the standardized results and weights of all six parameters of the physical land suitability. The coefficients used in the classification of land suitability for agricultural crops are shown below the table. Consistency is acceptable.

Drainage Map

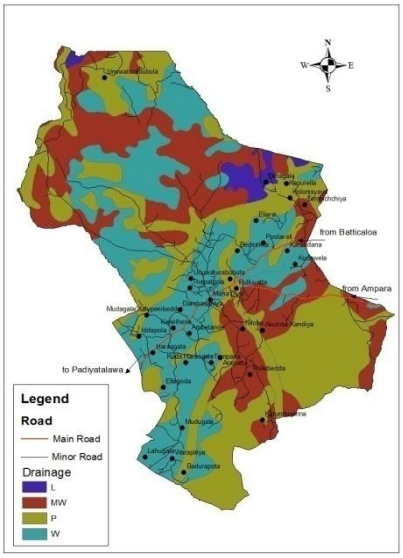

Fig. 9.

Drainage Suitability Class

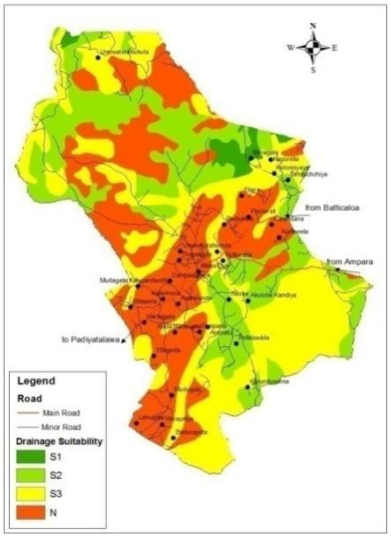

Fig. 10.

Land use map

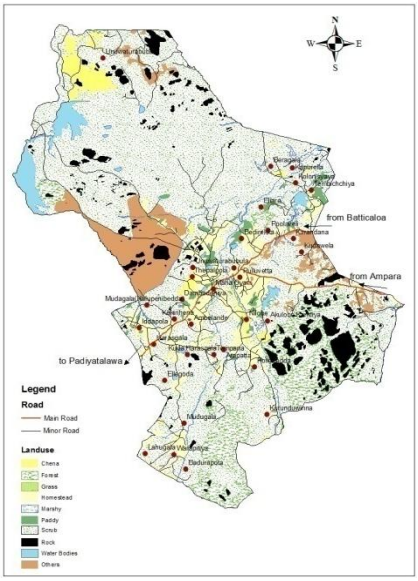

Fig. 11.

Land Use Suitability Classes

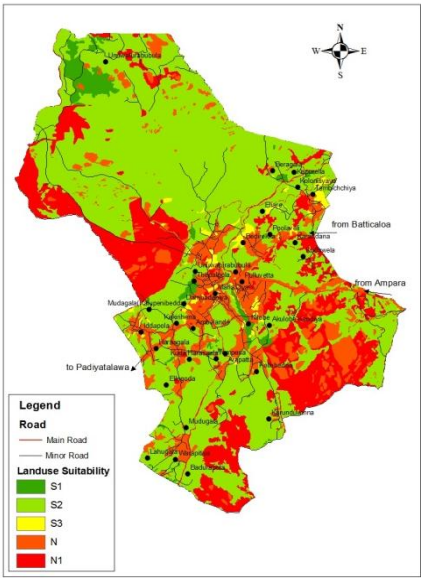

Fig.12.

Map of Temperature

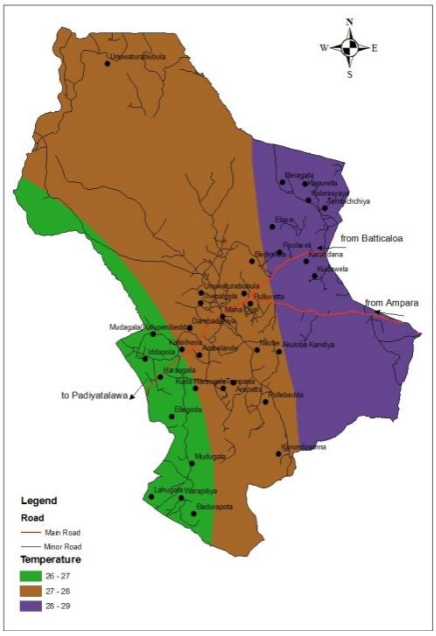

Fig. 13.

Map of Rainfall

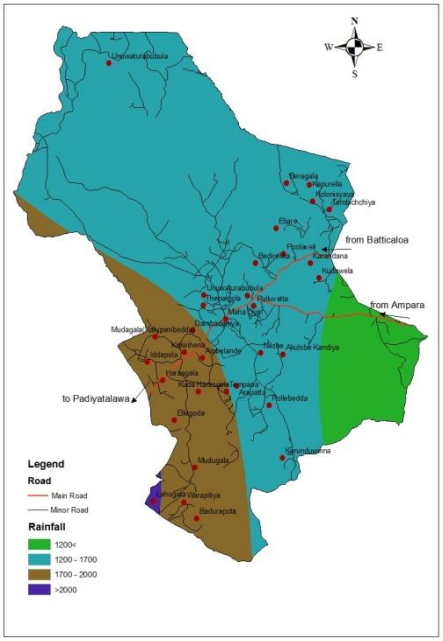

Fig. 14.

Table 1: Standardized results and weights of all six parameters of the physical land suitability

Factors	Soil Depth	Soil Drainage	Slope	Soil Texture	Soil Type	Present Land use
Soil Depth	1	3	3	5	5	7
Soil Drainage	1/3	1	3	5	5	7
Slope	1/3	1/3	1	3	3	5
Soil Texture	1/5	1/5	1/3	1	3	3
Soil Type	1/5	1/5	1/3	1/3	1	3
Present Land use	1/7	1/7	1/5	1/3	1/3	1

Source: Authors' computations of weighting 2012.

Coefficients of weighting used in land classification

Consistency ratio = 0.07; Slope factor: 0.1584; Soil texture factor: 0.1004 and the eigenvectors of weights are: Soil type factor: 0.0582; Soil depth factor: 0.3863; Soil drainage factor: 0.2638; and Land use factor: 0.0328.

Land Suitability Classification

From a total geographical area of land of the study area,118.77 km^2(17.45 per cent) is highly suitable, 178.03 km^2(26.16 per cent) is moderately suitable, 206.53km^2(30.34 per cent) is marginally suitable, 36.7 km^2 (5.39 per cent)

is not suitable and 140.63 km^2(20.66 per cent) is permanently unsuitable for agricultural crop production (Figure 15 and Table 2)

Table 2: Land Suitability of the Area for Agricultural Crops

Suitability	Area km^2	Per cent
Highly Suitable	118.77	17.45
Moderately Suitable	178.03	26.16
Marginally Suitable	206.53	30.34
Not Suitable	36.7	5.39
Permanently Not Suitable	140.63	20.66

Source: Authors' computation 2012.

Map of Suitability Classes for Agricultural Crop

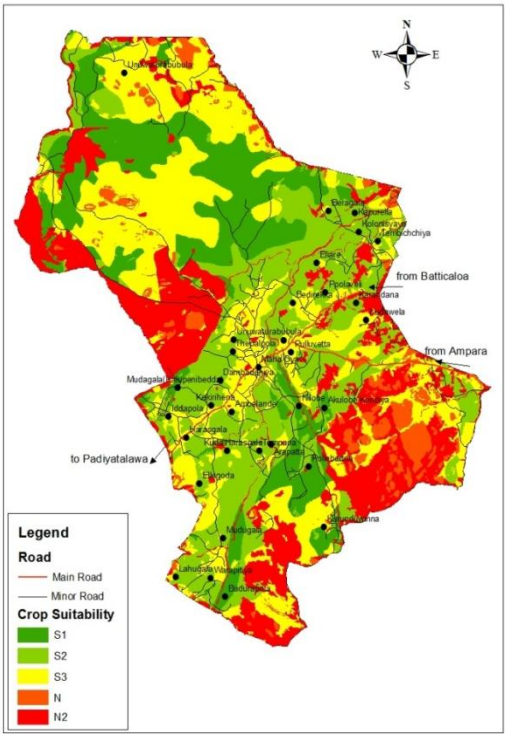

Fig. 15.

Recommendations

The physical land suitability has great potential for agricultural crop production. But land suitability has been carried out based on the physical land qualities of the study area. Chemical properties of soils are also very necessary for land suitability classification in a specific area of agriculture. Therefore, a study may be conducted on the evaluation of chemical properties of the soils such as pH, soil fertility in the study area. The effects of each of the alternative uses or classes should be appraised in environmental, economic and social terms, to be of any use in agricultural land use planning.

It is recommended that appropriate physical and chemical soil and water conservation structures are erected in moderately suitable areas for maximizing crop production and to sustain soil productive capacity of the study area. Areas which are not suitable for agricultural crops may be used for forest production and area closure may be attempted to rehabilitate the degraded areas. Google earth images and remotely sensed data may be used to obtain the relevant information for the types of vegetation, hydrology and land use patterns in the study area in future studies planned.

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Description of A Longitudinal Profile; A Case Study Of River Mula in Basaltic Upland Maharashtra

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Abstract

An ideal longitudinal profile is usually smooth and concave to the sky. However, in reality they are associated with the breaks in the profile. These breaks are due to the knick points at the stretches of rapids, hard rocks, waterfalls, gorges, lakes etc. These knick points are the places where the hydraulic geometry of the river changes drastically. The present study attempts to study the longitudinal profile of River Mula in Semi-arid upland Maharashtra following the Hacks (1973) method. The study revealed that 144 km of river length from its source up to Mula dam is in the above grade condition. SL Index values suggest knick points on the river at the distance of 6 km, 54 km, 92 km, and 120 km from the source. The deep and narrow gorge sections at this kick points, paired terraces at either side of the channel, upraised fluvial cut arches and platforms suggest local post-volcanic upliftment and erosion by multi-scale discharges due to episodic rainfall at these sites

Introduction

Longitudinal profile of a river is a graph of distance on 'x' axis against elevation in 'y' axis. It extends from source to the mouth of a river. It reflects spatially-distributed form-process feedbacks between all aspects of channel morphology operating at a range of poorly defined time- and space-scales, and in the presence of natural controls (Harmer & Clifford 2007). It can be used to identify the river morphological response to climate, lithology, structure and tectonics (Rhea 1993; Brookfield 1998; Zaprowski et al. 2005). Kale and Shejwalkar (2007) studied the longitudinal profile of seven major Konkani rivers and concludes uniform head cutting and growth of drainage into the Ghat front, crucial role of tributaries in overall recession of the Ghat and high concavity of the rivers by severely deepening their upper medial portions suggesting dominance of fluvial process rather than hill slope process. Besides, long profile of the river has also been used extensively to evaluate active tectonism in two active orogens, the Southern Alps of New Zealand and the Central Range of Taiwan (Knuepfer P.K.L 2004).Widdowson and Cox (1996) supports the local post-volcanic uplift of the Deccan traps which have no effect on the regional drainage patterns. The present study discusses the analysis of the longitudinal profile of 144 km long semiarid west to east flowing River Mula and identify the knick points with field observation along with their characteristics. Further, the frequency of knick points along a single stretch rejuvenates the river several times, thereby, drastically changing its behavior

Study Area

Location and Physiography

The study area extends from source of River Mula up to Mula Dam extending between

74° 28' 11"E to 73° 41' 07" E longitudes and 19° 02' 14" N to 19° 27' 06" N latitudes (Fig 1). Mula rises on the eastern slopes of Sahyadris between Ratangad and Harischandragad on south western taluka of Ahmednagar district in Maharashtra, India. Its headwater stream originates on the hills surrounding Kumshet, a small village on western Akole taluka. The main headwater stream originates in Ajuba Dongar (1375 m ASL). Muda Dongar (1522 m ASL) on the northeastern part of Kumshet village is the highest point of Mula origin.

Physiographically basin forms the part of Deccan plateau. All the left bank tributaries of River Mula form the watershed on the south facing slopes of Baleswar range and the right bank tributaries occupies the north facing slope of Harischandragad range. Therefore, the river forms the Gorge between these two wests to east running parallel ranges. Mula valley on its upper course is described as the 'Dangs' or the hill country. The entire landscape here is characterized by conical peaks, summits, Mesas or structural terraces at high levels, boulder-strewn slopes and regions of excellent onion weathering and fragmental amygdule and columnar basalts. The river flows past wild Dang essentially of ridge and vale topography on Akole and some parts of Sangamner in west to east trend. The major part of the basin is underlain by basaltic lava flows, which were formed by the intermitted fissure type eruption during upper cretaceous to lower Eocene age. The Deccan trap has succession of 19 major flows in the elevation range of 420 m to 730 m above mean sea level. Prominent units of vesicular and massive basalts characterize these flows. The soils found on the catchment can be classified into three groups; Black or *Kali;* Red or *Tambat*; Laterite and Grey soils or *Barad or Pandhari (Ref. from Gazetteer of India, 1976, Ahmednagar district).*

Climate

The climate of the region is characterized by hot summers and general dryness throughout the year except during the southwest monsoon season, June to September. The mean maximum temperature is 39.1^{o}C and the mean minimum temperature is 12.3^{o}C. The normal rainfall over the region varies from 470 mm to 680 mm. Rainfall is highest on the source region of River Mula and decreases towards the rain-shadow area on the east. Average annual rainfall on Akole taluka (Mula source region) from 1995 to 2004 is 572 mm. The same on the Mula-Pravara confluence is 476 mm. Natural vegetation represents the "Southern Tropical Dry Deciduous type" with commercially important species like Teak, Neem, Babul, Sisoo, Sandalwood, etc. The growth of forest is shunted and poor, occasionally dominated by vast stretches grasslands.

Drainage morphometry

The study catchment covers the area of 2346 km^2. River Mula is a seventh order stream with the length of 163.69 km from the source (Ajuba Dongar) up to Mula dam. Maximum basin length of the catchment is 105 km as against maximum basin width of 46.22 km. Total number of stream from first to seventh order is 9767 with the total length of 6741 km. It has the drainage density of 2.87 km/km^2 and the stream frequency 4.16 streams / km^2 (Fig 2). Absolute relief of the catchment is 1522 m ASL and relative relief 1012 m ASL. Horton's form factor (R_f) is 0.20, which suggest, it is a elongated basin (Table - 1)

Table 1 Morphometric characteristics

1	Catchment Area	2346 km ^{2}
2	Stream Order	7th
3	Total stream Length	163.69 km
4	Maximum Basin length	105 km
5	Maximum Basin width	46.22 km
6	Total no. of Streams (SOI: 1: 50, 000)	9767
7	Mean Bifurcation ratio	3.85
8	Drainage Density	2.87 km/km^2
9	Stream Frequency	4.16 streams / km^2
10	Absolute Relief	1522 m ASL (Muda Dongar)
11	Relative Relief	1012 m ASL
12	Horton's Form Factor	0.2
13	Total Right bank tributaries	231
14	Total left bank tributaries	220

Location Map of the Study Area

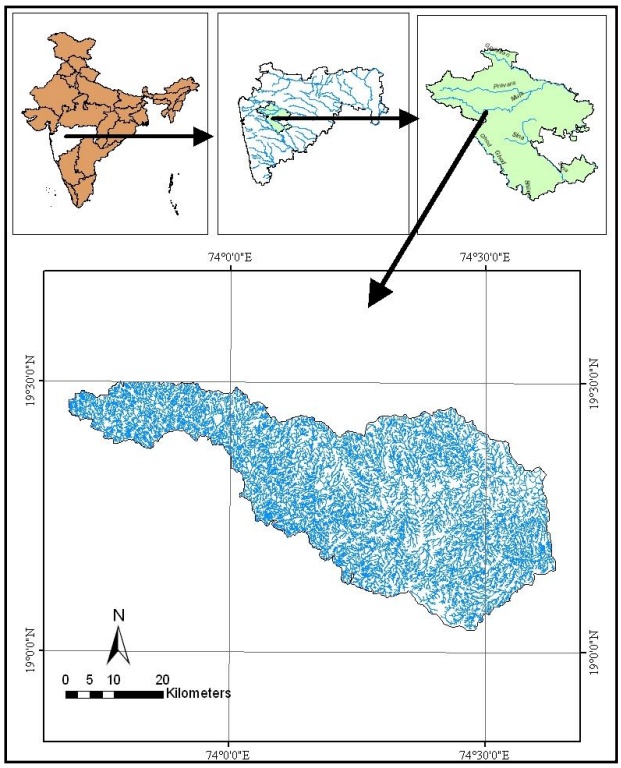


Fig. 1.

Drainage map of the study area

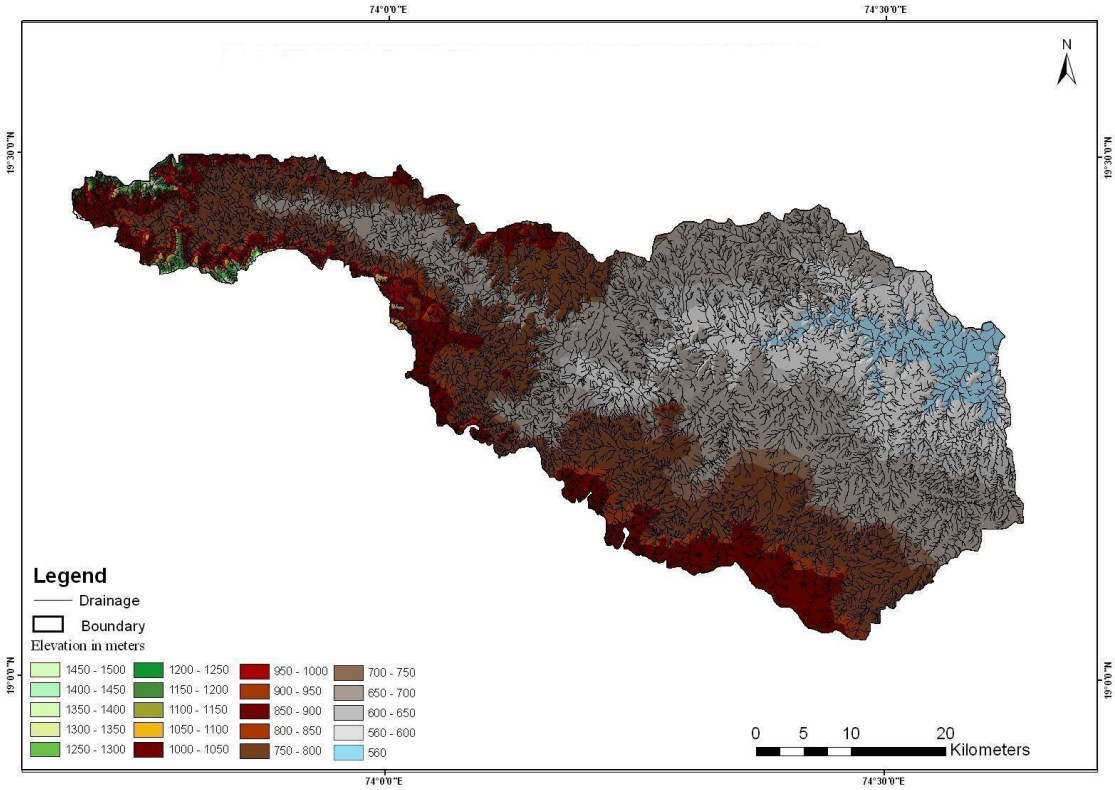


Fig – 2

Methodology

For derivation of long profile, the distance is plotted against elevation on the arithmetic graph paper (Fig 4). Hack (1973), suggested plotting height and distance in semi-logarithmic graph paper and calculation of stream gradient index.

$SL = h_1 – h_2 / (InL_2 – InL_1)$

Where, SL is the stream gradient index.

h_1 is the elevation of the first point.

h_2 is the elevation of the second point.

L_1 is the distance of first point from the source.

L_2 is the distance from the source of the second point

This semi-logarithmic profile explains more precisely the characteristics of the long profiles (Fig 3). The stream gradient index provides the information about the control of the lithology and structure on the river channel. According to Hack, wherever there is break on the long profile there is more lithological and tectonic control on the channel slope. The straight line is drawn on the profile on the semi logarithmic graph paper joining source and mouth of the river. This represents the graded profile. Any deviation from this line represents

the deviation from the graded profile. The data for the longitudinal profile is derived from the SOI toposheets, 47 E/11, 47E/15, 47 I/3, 47I/ 7 and 47I/8 covering the channel of river Mula from the source up to Mula Dam, at the scale of 1: 50, 000. The distance from the source and every successive contour crossing the channel is calculated manually. The distance against elevation is plotted in arithmetic graph paper. Since the profile does not show much variation in channel gradient, the same is plotted in semi log paper. Stream gradient index is prepared using Hacks method.

This is followed by field visit and observation and measurement of channel characteristic at the points where the SL index shows sharp changes.

Analysis and Interpretation of Long Profile

The profile on the semi-logarithmic graph shows two significant characteristics:

Overall convexity in the channel gradient from source up to the distance of almost 1.7 km from the source. Here the river is in above grade condition and is characterized by a steep channel segment. Erosion, that is, vertical down cutting is the main activity (Fig 3).

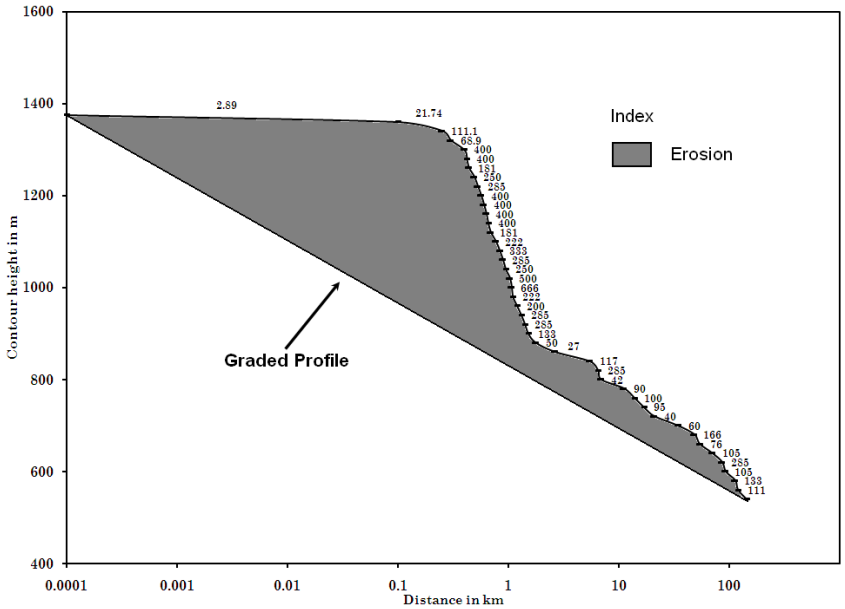
The profile of moderate to low convexity from the distance of 1.77 km up to 144 km downstream. Here too the river is on the above grade condition, but the activity may differ from the former. There is vast reduction on active down cutting and increase in transportation. The lateral erosion has limited scope due to the lithological factor as most of the time the river is restricted on the box shape channel. However, there are stretches where the river has been able to moderately widen its banks especially on meander bends and precipitous banks. However, the river rejuvenates at short reaches with intense erosion following the Knick points in some middle reaches (Fig 4).

The range of SL Index values range between 2.89 and 666.66 (Table 2). The values do not decrease but show variation with distance. In the source region, the values are lower but immediately at the distance of 0.3 km, the value increases to 111 and then decrease to 68, followed by sudden increase to 400. This irregular change in SL index to very high value and slightly lower value continues up to the distance of 1.77 km from the source. This means that for few tens of meters in the source region river flows in gently dipping surface, which is then followed by sudden steep falls at high index value and rapids at the slightly lower values. After the steep initial fall, the river flows with the gentle slope for next 2 km, the value suddenly increases to 258 at the distance of 6 km suggesting a knick point. For next 42 km from the first knick, the SL index values range between 42 and 100 with irregular gentle and slightly steep reaches. At the distance of 54 km from the source SL index value reaches 166. The site is identified as Bori in the field visit, which was characterized by the exposed rock section for about 150 m. At the distance of 92 km from the source region, the SL index value again increases to 285. This site is Ghargaon knick point. The last knick is shown on the profile at the distance of 120.50 km from the source with the SL index value suddenly increasing from 105.26 to 333.33. This site was identified as the gorge section downstream of Mula-Mandhol confluence, near Mandwe village.

Table 2 - SL Index values for River Mula

Contour height (m)	Length in km	SL Index	Contour height (m)	Length in km	SL Index
1375	0.0001	-	940	1.32	200
1360	0.1	2.89	920	1.42	285.71
1340	0.25	21.74	900	1.52	285.71
1320	0.30	111.11	880	1.77	133.33
1300	0.40	68.97	860	2.65	50
1280	0.42	400	840	5.5	27.40
1260	0.44	400	820	6.5	117.65
1240	0.49	181.82	800	6.95	285.71
1220	0.53	250	780	11.15	42.55
1200	0.57	285.71	760	13.95	90.91
1180	0.60	400	740	17	100
1160	0.63	400	720	20.95	95.24
1140	0.66	400	700	34.7	40
1120	0.69	400	680	48.30	60.61
1100	0.77	181.82	660	54.50	166.67
1080	0.84	222.22	640	71	76.92
1060	0.89	333.33	620	86.35	105.26
1040	0.95	285.71	600	92.85	285.71
1020	1.03	250	580	113.40	105.26
1000	1.07	500	560	120.25	333.33
980	1.10	666.67	540	144.75	111.11
960	1.20	222.22			

Fig 3 - SL Index of River Mula



Long Profile of River Mula

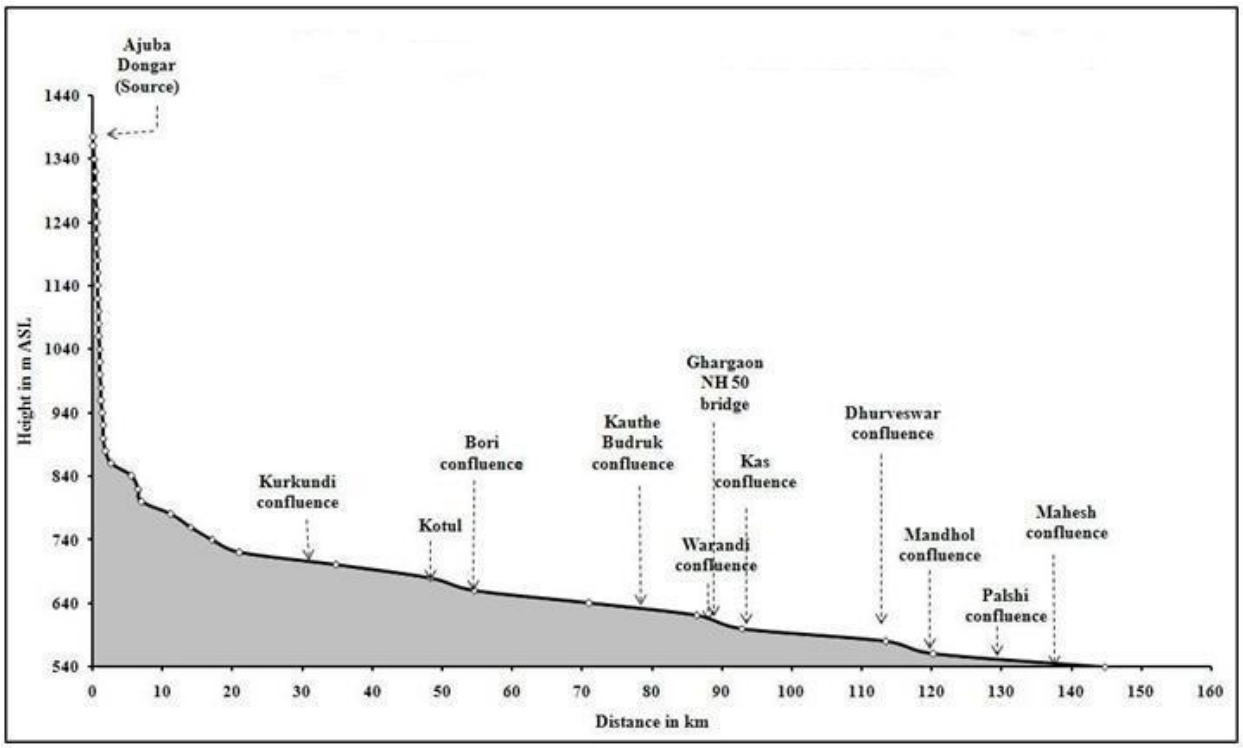


Fig 4

Characteristics of knick points

The stretch on river Mula between Bori (54 km from the source) and Mahesh Nadi confluence (86 Km) is noted during the field visit. The channel is confined to a box shape in general. The channel width increases almost commonly at the meander bends attributed to bank erosion, on the K.T weir sections, and the confluence zones. K.T weirs are locally referred to as Kolhapur type low height dam constructed across the river on the sections with rock exposure.

1) Bori section

Just downstream of Bori confluence river flows through almost flat rocky beds with miniature channel small potholes and grooves cut on the weaker section of exposed basalt. Discordant confluence (1.5 m) is the most notable feature of this knick point (Photo1). Discordant confluence occurs when the bed of the tributary mouth is higher than the mainstream bed at the confluence zone. Kennedy (1984) attributes this to differences in channel forming discharges and varying geology and sediment caliber of bed and the banks. Further Kennedy (1984), Best (1988), Best and Roy (1991), Biron et al. (1993, 1996) and De series et. al. (1999) has extensively studied the impact of bed discordance on change in flow and form variables at the river confluences following flume experiments and field observations. They noted significant deviation in

the behavior of flow variables and their resultant bed configuration compared to the symmetrical confluences. The bed discordance in the observed section can be ascribed to the rejuvenated corrosive power of the mainstream due to change in the flow variables at the knick point whereby the mainstream cuts the bed of the channel lower than its tributary. However the cross-sections could not be taken to study the geometry at this site.

Photo 1 Disordant confluence at Bori knick

2) Ghargaon section

Second most striking knick point is noted at Ghargaon section (92 km from the source). Here the K.T weir is constructed on the knick point and downstream of this weir channel bifurcates into two parts on the rocky exposure. Extensive observations on extent of degradation and bed materials have been made by Stevens (1938), Hathaway (1948), Bondurant (1950), Vetter (1953) and Galay (1988) on downstream degradation of high dams and barrages due to non-uniform release of flow. The water released from the weir is comparatively deficient in sediments than the sediment transport capacity, so it is likely to pick of sediments from bed and bank downstream.

However, as the observation reveals that the exposed knick point in this section reveals extremely resistant channel boundaries, the river would require high velocity, stream power and shear stress to create the existing channel form. Thus the change in slope at the knick point and low recurrence interval extreme floods is responsible for maintaining present channel form.

The right bank canal cuts deep and narrow gorge which is most probably formed due to the coalescence of many potholes (Photo 2). Numerous small to large potholes are abundantly displayed. This is an initial step in development of channel in channel physiography. Rajguru et al. (1995) describes this in the study of River Narmada and attributes to seasonal flow variations, high magnitude floods at interval and tectonic disturbances. The entire sequence of process is described by Shepard and Schumm (1974) on how erosion begins on a rocky bed and subsequently progresses from potholes and elongated groves to single deep channel. Another notable feature is the rock – cut paired terraces ranging from 1 m to 1.5 m on both the banks (Photo 3). This type of features is normally the result of local upliftment. However, this can also be the result of multi-scale discharges due to episodic rainfall. The river has cut the channel on the middle of solidified basalt slabs deposited on different lava flows clearly identified in the terraces.

Photo 2- Gorge section at Gargaon

Photo 3 – Terraces at Gargoan

3. Mandwe section

Cross – section taken on the channel 100 m above the rocky section measures maximum width 173 m; maximum depth is 5 m (measured from the HFL mark on the right bank), the cross-sectional area 852.6 m^2, and the width-depth ratio 1:30 (Fig - 5). However, as river channel flows through an unusual rocky stretch, the maximum width is restricted to 60 m, maximum depth 8 m, and the cross-sectional area 488 m^2. Slope of the channel increases at this section. The width-depth ratio is drastically reduced to 1:8 (Fig- 6). River cuts a single narrow meandering gorge with almost plain and smooth beds with accumulation of boulders at the corners. High above the bed, rock platforms are cut on either side of the high banks with rock arches similar to the coastal erosional features (Photo 5). Compared to highly eroded channel on exposed section of Ghargaon, this has smooth beds. This is possible result of water devoid of coarse material passing through this section only with suspended materials and result in polishing affect by fine sands. Secondly, big boulder accumulation at the corner of the rocky meander can be the product of hydraulic action of water on the bank walls.

However, Matthes (1947) attributes this type of features to macroturbulence where intense energy is spent on large scale eddies or vortexes. Though after long intervals and for short duration these are spectacular events where boulders are carried as bed loads and pebbles and cobbles and offcourse large quantity of sands are carried as suspended loads. After the rapid fall in discharge these heavy loads quickly settle and after complete subsidence fairly large boulders are found settled on bedrock surfaces. Baker (1988) states that such processes develops large erosional inner channels and variety of flute marks, polished surfaces, form facets and fine scale erosion pits and grooves on rock surfaces. However, the presence of rock arches and erosional features high above on the rock platform signifies local upliftment too.

4. Rock exposure before Mahesh confluence

Last but very unusual exposed rock on the channel is noticed upstream Mula - Mahesh confluence, 133 km from the source. Upstream from this rocky section river channel is wide and straight with gentle banks. Suddenly the

channel narrows down to width depth ratio 6.1 cutting a perfect deep box – shaped gorge very much resembling a section of artificial concrete canal. The maximum bank-full width is 80 m, depth 12.1 m, the cross-sectional area of 968 m^2 (Fig - 6). Both the banks are vertical with the pool of deep water even in the driest month. Closer examination on the slightly eroded section on the left bank displayed horizontal columnar basalts and very much resembled an artificial stone wall created with elongated columns of stones (Photo 7). Few meters downstream from this section channel widens with a slight turn with rock platforms and a small rock island on the middle of the channel connected by a narrow rocky bridge to the right bank. Past this section channel opens into a wide flood plain with braided meanders and permanent bars with vegetation resembling a part of North Indian alluvial river quite uncommon on River Mula (Photo 6). The maximum channel width is 580 m, depth 3.5 m, cross-sectional area 2030 m^2 (Fig - 8) .

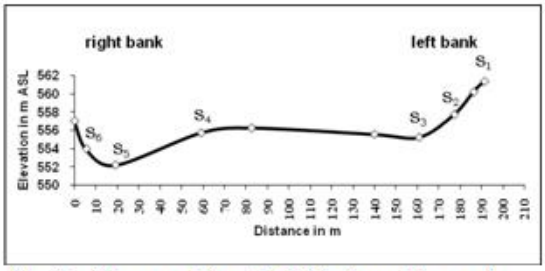


Fig 5 - Cross-section 100 M above the rock Exposure at Mandwe

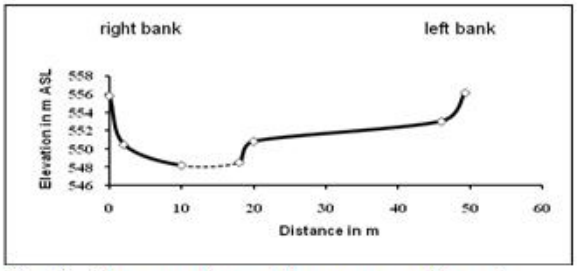


Fig 6 - Cross-section at the gorge section at Mandwe

Photo 4 - An upstream view from the Mandwe Knick

Photo -5 Upraised platform and rock arch at Mandwe Knick

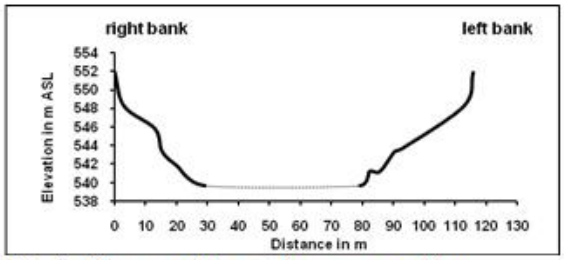


Fig 7 - Cross section at the gorge section upstream Mahesh confluence

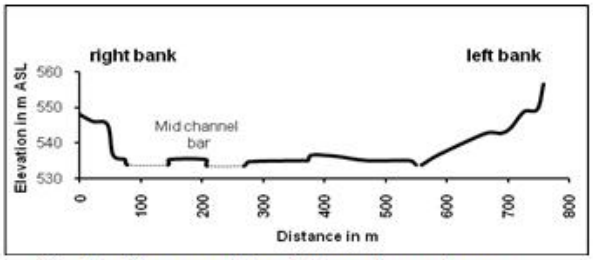


Fig 8 - Cross- section 200 m downstream

Photo 6 - Rock exposure at Mahesh followed by open floodplain

Photo 7 columnar basalts on the eroded section of bank wall

Findings and Discussions

The analysis and field observation of the longitudinal profile of River Mula in upland semi-arid Maharashtra revealed following precise characteristics:

1)144 km length of river Mula is still in a youthful stage with above grade condition. Downstream increase in the channel width is punctuated by the knick point sections at 54, 92, 120 and 133 km from the source. As the river has cut deep gorges, potholes and paired terraces on the layered volcanic strata, these provides strong reason to support post volcanic local upliftment of Deccan plateau as stated by Widdowson and Cox (1996).

2) The study tries to understand the channel processes operating on these breaks in longitudional profile. The Grargaon section conform the sequential evolution of single deep channel from pot holes and grooves as stated by Shepard and Schumm (1974). Similarly, the Section at Mandwe provided sufficient evidence to support the process of macroturbulence of Matthes (1947).

However, the reason for formation of rock platforms and terraces at certain sites also compels the observer to think about alternate processes related to attainment of channel equilibrium (on bed rock formed due to episodic volcanic flows) with low frequency multi – scale

discharges and process of weathering on the dry period between two extreme events.

3) Lastly, it was observed that the series of rock exposures and the constricted channel at these sites on the longitudinal profile of River Mula are of great social importance as they provide favorable sites for K.T weir construction. Local People highly value these sites because the resistant bed rock and channel walls provide excellent place to store the water for the local use in this drought prone area.

Conclusion

Although many studies have revealed the characteristics of long profile of the river, the present study is a humble attempt to unravel the ideal long profile developed on seasonal semiarid east flowing river of upland Maharashtra flowing from high rainfall zone towards rain shadow area. These channels reveal its own unique characteristics where the channel flowing over the coarse alluvium suddenly transforms itself into typical bed rock channel on patches with the display of youthful features even at 133 km from the source. However, it suddenly widens into meandering sinuous channel until this is punctuated by the next exposed patches downstream. These sections not only attract researchers but are also of great social significance.

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Identification of Rivers and Surrounded Streams from ASTER-DEM: A GIS Based Study of Koyna River and Surrounded Streams in Satara District of Maharashtra (India)

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ABSTRACT

River and streams are the requisites part of environment which sustain the surrounding environment and life form. In the few decades before the study of streams was based on visual interpretation of topographical maps, aerial photographs, satellite imageries as well as doing by manually surveying, field visits and local observations. This study methods accounting time consuming, resources losing and less accuracy. Now a day, these trends of study changed due to Remote Sensing (RS) and Geographical Information System (GIS) which mostly used in spatial planning with monitoring, mapping, and analysis of environmental parameters. The optical Remote Sensing helps for generate the Digital Elevation information of earth surfaces. On the earth surface, the presence of drainage lines and main river can be noticed and detect from the Remote Sensing's ASTER DEM (30 M resolution) data from stream segments and sharp bends in the river courses. In the present study, the mapping of Koyana River and surrounding streams is based on the GIS software and ASTER-DEM data. It was observed that the ASTER data provide more accurate results than the traditional methods, which will strongly useful and resourceful for the earth scientists, researcher, regional planner, education and spatial planning.

Introduction

Identification and mapping of River and related major streams is considered to be one of the foremost exercises for the earth scientists who are interested in the fields of water management, engineering, groundwater exploration, flood hazard management, etc. River system is the important unit of environment which is useful for the entire environmental unit. Here the Koyana River and its surrounded streams have been considered for the study. In most of the Rivers basin observed large geomorphological diversity, rough morphology, landforms and dense vegetation cover. There for the micro level study of rivers and its streams become a difficult task. There is much impreciseness possibility in traditionally research work. These problems could be minimized by using ASTER DEM data and its derivatives. River basin, streams, and landforms of basin can easily notice by visual interpretations from the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) DEM (Digital Elevation Model of Koyana River and surrounded region, (figure 1). The primary aims of research paper is to identify and extraction of Koyana River, its important streams, regional topography as well as geomorphological analysis of Koyana River from ASTER DEM.

Study Area

Present study area is the part of Satara district which is located in Maharashtra state of India (fig 1). The geographical extent of study area is 17° 11' 06" to 17° 53' 51" Northing to 73° 34' 21" to 74° 20' 39" Easting. The Koyna

River rises near Mahabaleshwar and is a tributary of the Krishna River in western Maharashtra, India. It rises near Mahableshwar in Western Ghats, having the length 130 km (81 mi). Unlike most of the other rivers in Maharashtra which flow East-West direction. The Koyna River is famous for the Koyna Dam and the Koyna Hydroelectric Project, there for it is known as the 'Life Line of Maharashtra'. The river meets the Krishna River, which is one of the three largest rivers in southern India by Karad. The river is just about average 100 meters in width and is slow-flowing. The distinct river or slightly its shape etc. can be observed on topographical maps, aerial photographs and ASTER DEM. Here, Rivers and major streams are visibly detect and extracted from ASTER DEM, (figure 2).

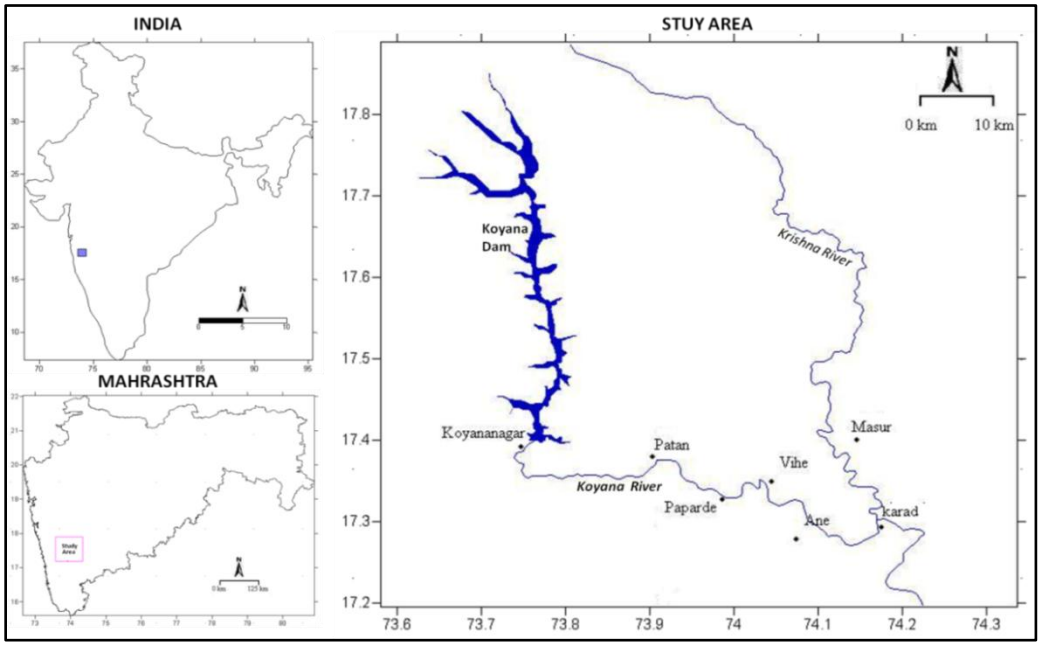


Figure 1: Location map of the study area showing the Koyana River & surrounded region

Objective

Further few objectives are considered here, such has, to use the Remote Sensing data (ASTER) and GIS teachings for identify and mapping of River channels and vicinity. Then, the extraction of Koyana River along with major streams by digitization techniques from ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) DEM data. Processing on ASTER DEM data in GIS software for acquire the topographical information, visualization and various results regarding Koyana River and vicinity. Generations of base maps for verity of applications and according to set of need, (figure 6).

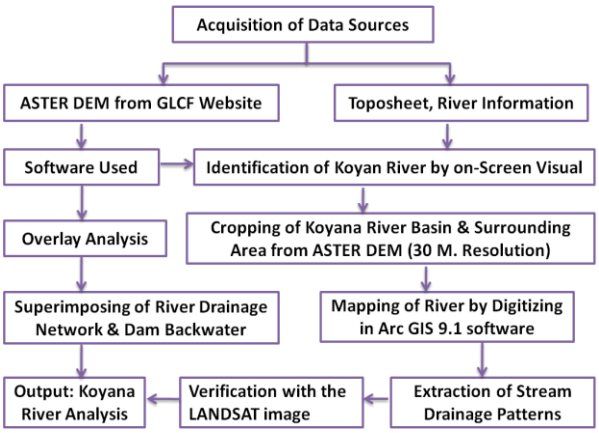
Methodology

In this study the methods have been used for River identification, streams detections, and its extraction with mapping which is based on the ASTER DEM data and its derivative maps like slope, aspect, shaded relief, etc, (figure 6). Here, the Koyana River and surrounded streams was identified on-screen by visual interpretation of the ASTER DEM. The following methodology was adopted for this study:

1) ASTER DEM data for middle India was downloaded from. http://www.glcf.org website.

2) Using the ArcGIS, Surfer-8, Global Mapper-v11.01 software the Digital Elevation Model (DEM) was constructed for the area for visual interpretations.
3) Then the drainage network of the Koyana River and its major tributary are digitized.
4) The derivatives of ASTER-DEM like shaded relief, slope, aspect and curvature maps were prepared in ArcGIS, Global Mapper-v11.01, Surfer-8 GIS Software.
5) Mapping map was extracted manually by digitizing all River and its tributaries that could be observed in the maps obtained from ASTER-DEM.

6) The delineated Mapping Rivers, streams was then superimposed on ASTER DEM in Global Mapper-v11.01 for verification as well as for ascertaining the occurrence of missed features.



Flow Chart 1:Flow-chart showing the methodology used for the study.

ASTER DEM Data (30 M. Resolution)

Due to the availability of ASTER data, there is opening the innovative and powerful research gateway in the spatial planning on 29 June 2009. ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) is an imaging instrument flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER data provides the comprehensive 3 dimension view of regions where the rivers basins can be easily identified as well as **easy-to-use topographic information of the any regions** with at 30 meter (98 ft) intervals resolution. This data has acquired from website www.glcf.org which is strongly represent the physiography of basin region. The clear cut flow lines of Koyana and surrounding streams, channel, and rivers are observed in ASTER DEM data.

Results

From the analysis and interpretation of the ASTER DEM data and its derivatives, the following results were obtained:

ASTER DEM data:

From the ASTER DEM data of the area, (figure: 3) it could be inferred that the general elevation of the Koyana Basin decreases from west to east. The highest elevation is 1300 m above sea level at a

point whose location coordinates are 17.9 º N and 73.7 º E. This point falls in the Upper basin of Koyana dam. The lowest point is, as expected, is seen where the Koyana meets to the Krishna (Karad). Thus, Koyana river flow extracted from ASTER DEM data easily.

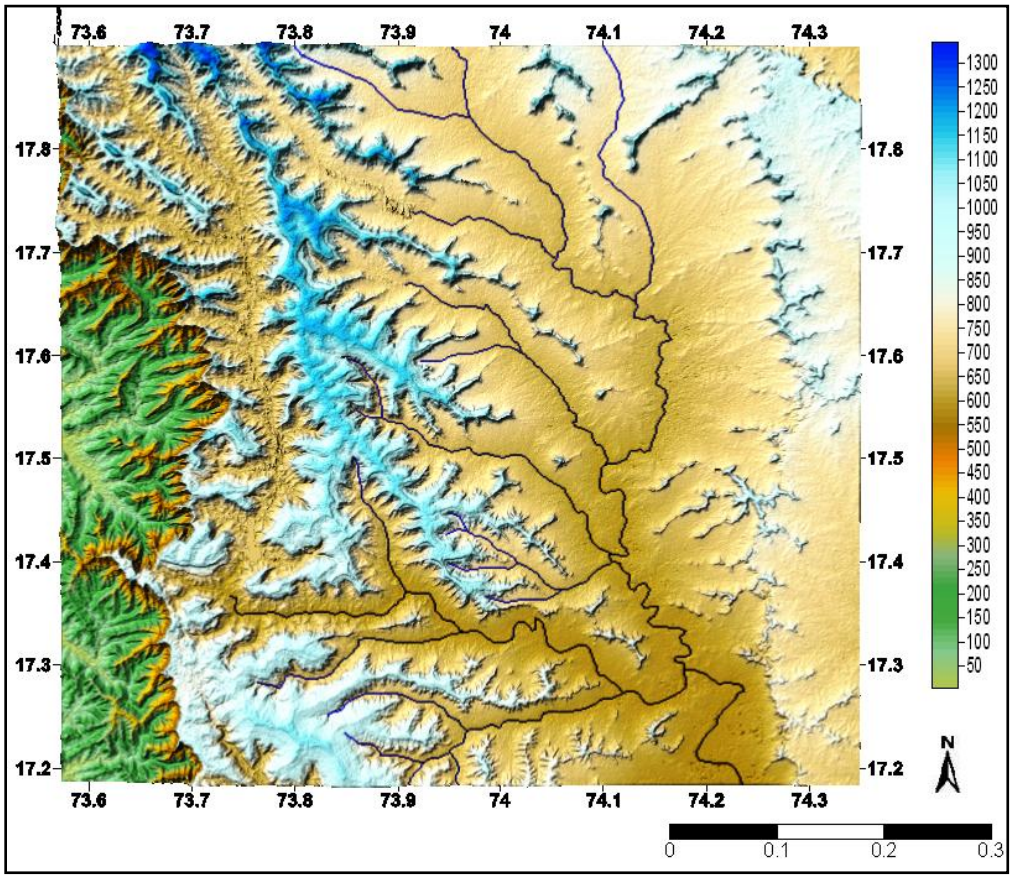


Figure 2: Digital Elevation Model of Study Area (ASTER DEM)

Drainage Network:

The drainage network map, (figure 3) of the Koyana River and surrounded major streams shows that the overall trend of the drainage basin is from northwest to southeast. This is in accordance with the elevation of the land surface which has the same trend as inferred from the ASTER DEM data, (figure 3). Almost streams in the study area meet to the Krishna River from right bank, because of these are flowing from western to eastern direction. Streams, River are originated in the western hilly region and joint to the main river Krishna, which is clearly observed from 30 meter resolution's ASTER DEM. There is development of various types of parallel Rivers basins in western directions.

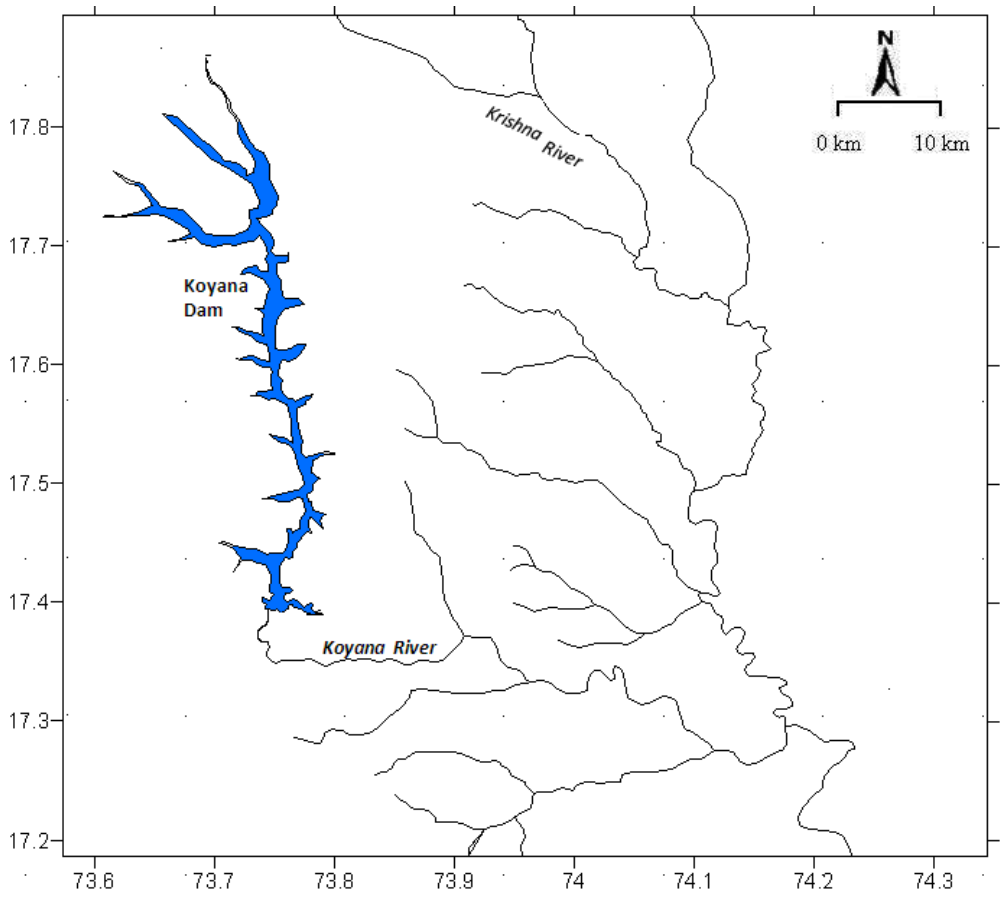


Figure 3: Koyana River and its Streams network

Slopes:

From the slope map of the Koyana Basin and surrounded regions it can be concluded that the western part of the study area has the highest slope angles. The slope angles in this region are above <15º. In the upstream areas some isolated pockets of steep slopes are seen. The downstream areas show very low values of slopes is 1-2º. About 60% of the basin area has slopes greater than 8º slope. In western direction of study area, western side of Koyana dam very steep slope is observed over the ASTER DEM. Overall slope from northwest to southeast direction, because all the streams and major Rivers flowing according to slope, (figure 4).

Physiography:

There is large variation in the present study area's physiography. The western part of study area consisting with lot of diversity in hilly regions. The upper basin of Koyana river is parallel to western Ghat and Arabian Sea there for Shivsagar Lake (Koyana dam) is parallel to the Arabian Sea in western Ghat. In the study area, maximum height is 1343 M. and minimum height is 4 Meter from Actual sea Level (MSL) noticed from ASTER DEM. Krishna River flowing from northwest to southeast direction in the study area. On the left bank of river one hilly range almost parallal to Krishna river, which direction is north to south. In the central part of study area observed the plain region of Krishna River and its tributaries. The contour interval is very close to one-another in western directions, it is indicate that, the rough topography along with undulating hilly nature of region, (figure 6).

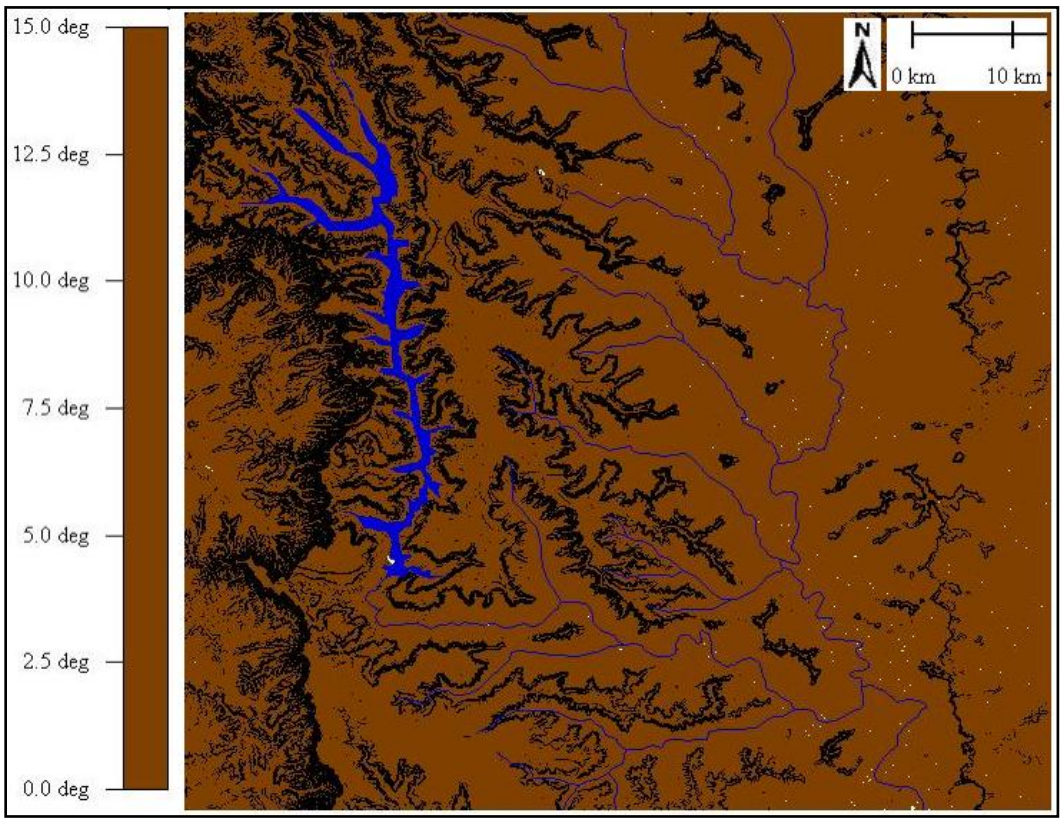


Figure 4: Slope map of study area (Degree)

Aspect:

Aspect is the direction of the slope. From the aspect map of the Koyana River and surrounded various basins it can be clearly seen that aspect or the general direction of the slopes in the study area is towards south and southeast. This fact serves as an evidence for the general direction of the major streams, Krishna river flow. There is a large fluctuation of Aspect in the western part, due to hilly regions and various ridges; most of the basins of rivers are parallel to one another. However, the Koyana river basin is parallel to Western Gaht and Arabian Sea, which is the large basin in this region.

Koyana River Profiles:

Here, from ASTER data various Profiles of Koyana river generated from source region to confluence place at Karad, (figure 5). From this profile noticed that River basin area extended in downstream portions of the Koyana River. Nearby eight profiles generated from ASTER data in GIS software for basin length, slope analysis. In the downstream part of Koyana River, mostly plain regions of the Koyana and Krishna Rivers.

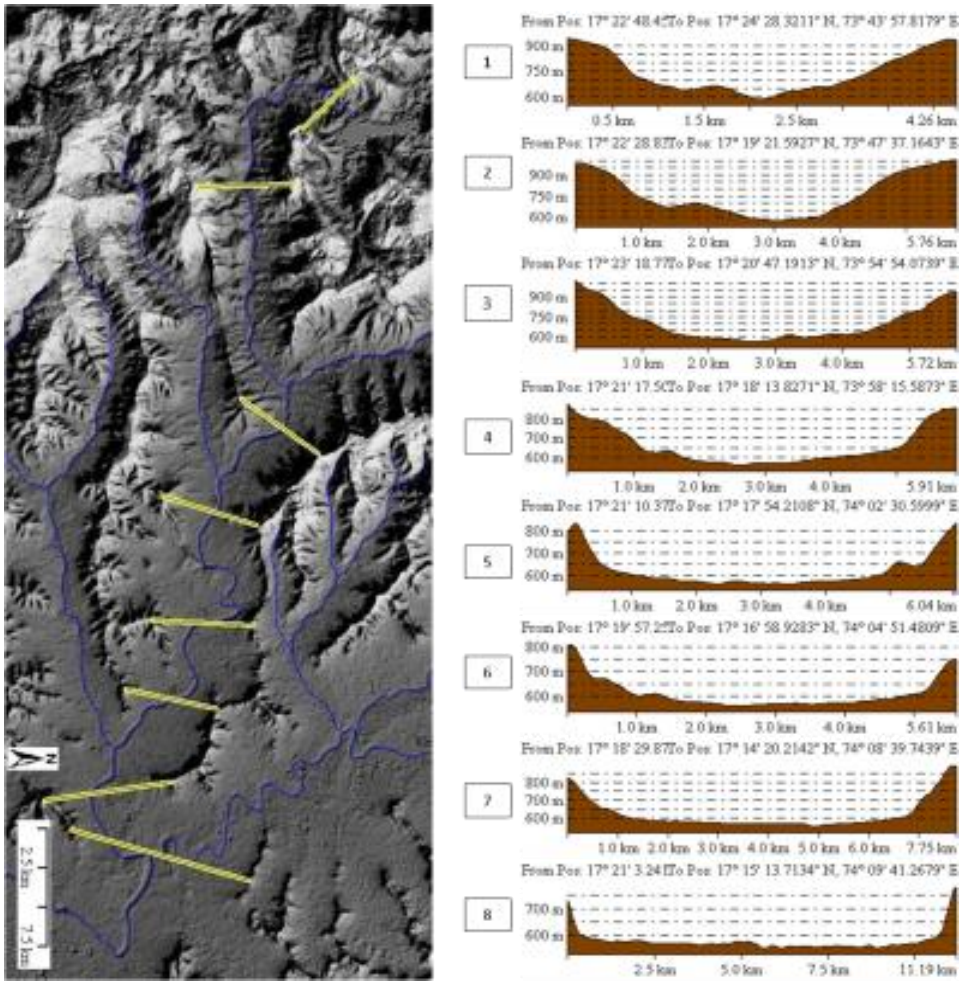


Figure 5: Koyana River horizontal Profiles from source region to confluence place

GIS Analysis of Study Area:

As campers to traditional techniques, advance GIS and RS techniques are more supportive for River basin and streams analysis. It took very short time for results generations along with accuracy, (figure 6). From the study area's ASTER DEM further few views also generated which is useful for visual interpretations and related spatial planning of river basins; such has dam constructions, canal delineation, flood line marking, watershed management etc. The capability of GIS software is minimized the time, resources and increases the quality of work along with high preciseness. In the present study area observed highly physical diversity, especially in the western part. Similarly there in plain region of variues streams and rivers in middle part of Study area, Koyana Dam located in the western part in the Koyana River basin, which has north to south directions, (figure 6).

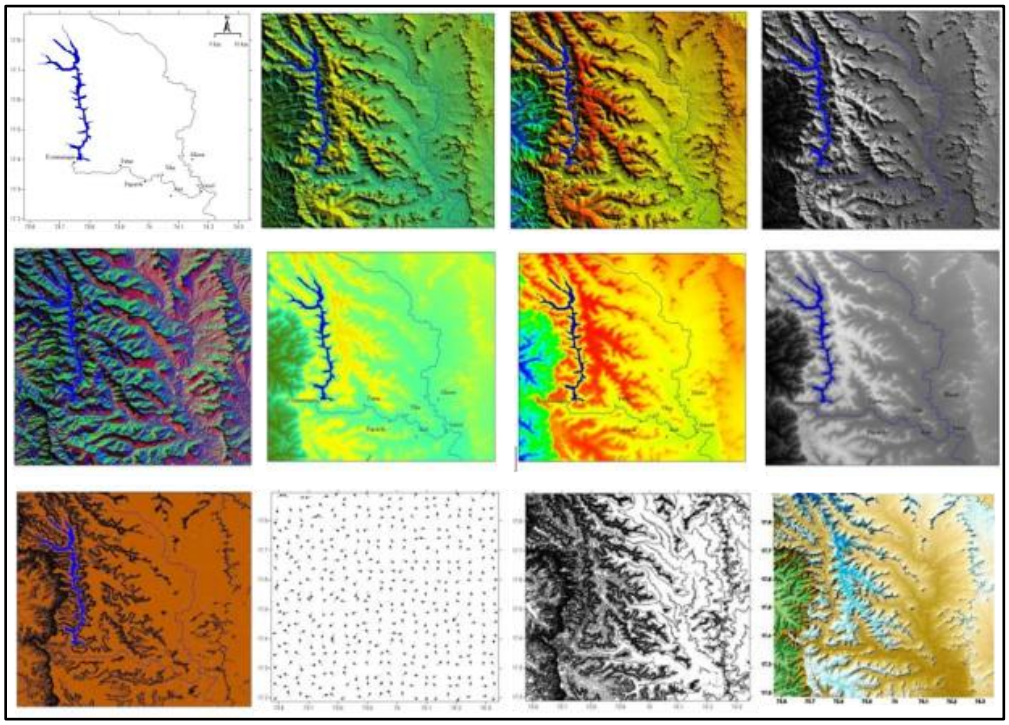


Figure 6: Various base maps of Study area such has, DEM Map, Shaded relief map, flow map, vector map, Aspect map, and contour map

Discussion:

Thus, it can be stated beyond doubt that Remote Sensing data, especially ASTER DEM and GIS is a very efficient tool in the process of identification and mapping of River and its major streams. In this case-study of the Koyana Basin and streams, it has become clear that the ASTER-DEM which contains only the elevation data, can give better results than the conventional methods in which the topographical maps and satellite imageries are usually employed. The upper-stream section of the Koyana Basin shows the highest slope and less meandering nature. However, this method of River and Stream identification is plagued by the fact that ASTER data has a resolution of 30 m. So, for micro-level River basin, shape, size, length, slope identification, this method may be very useful. This suggests that many minor rivers, streams may be detect and analysis with the ASTER DEM and GIS software tool very accurately. However, there is also perform the verification of rivers, streams from Topographical maps, Google Image data, satellite image, there for chances of error has been somewhat minimized. Finally, it can be said that in spite of some limitations, ASTER-DEM and GIS software's can be extremely useful in the future studies and management of Rivers, Streams and in other fields of earth sciences.

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Fluoride Contamination in Ground Water and Related Health Problems: A Study of Geo-Environmental Issues in Rural India

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Abstract

The problem of high fluoride concentration in groundwater resources has become one of the most important toxicological and geo-environmental issues in rural India. Excessive fluoride in drinking water causes dental and skeletal fluorosis, which is encountered in endemic proportions in several parts of the world. The present study will highlight the nature of health conditions of rural people of India as well as West Bengal related to the fluoride concentration in groundwater resources. The main objective of the present study is to identify the nature of fluorosis, its extent and to suggest to its remedial measures. The findings of the present study are that the problem of high fluoride concentration in groundwater resource has become one of the most important toxicological and geo-environmental issues in different parts of India. The findings also show that the excessive fluoride intake and its related diseases can be checked by providing defluoridated water for drinking purpose, restrict use of fluoride rich food, treatment of the disease, use of rain water and proper health education.

Introduction

The study of fluoride is one of the most important geo-environmental issues in developed as well as developing nations. Fluoride contamination in the groundwater is a natural phenomenon, influenced basically by the local and regional geography as well as hydro geological conditions. Fluoride is most concentrated within tissues such as bone, dentin, enamel, thyroid gland and skin of animals. It is the ionic form of fluorine, and is instrumental in protecting bone and tooth enamel from loss of constituent minerals. Excessive intake of fluoride results in skeletal and dental fluorosis (Czarnowski *et al.* 1999). However the present study embraces the fluoride content in groundwater and its impact on human health. The paper proceeds to describe the extent of fluoride contamination in India as well as West Bengal with emphasis on its preventive measures.

Objectives

The objectives of the study are as follows:

- To know the sources of fluoride contamination in ground water
- To show the extent of groundwater contamination of fluoride in India and West Bengal
- To assess the impact of fluoride contamination
- To present the preventive measures of fluoride contamination

Database & Methodology

The present study is primarily based on secondary data collected by the author. To assess the sources of fluoride concentration various research works have been followed such as Chand(1998), Gupta and Deshpande (1998), Meenakshi *et al.*, (2004). To know the extent of

fluoride contamination author has consulted the reports of the Indian Ministry of Water Resources, Public Health Engineering Department, Government of West Bengal (2004) and WHO (2010).The works of Garg & Singh(2007) & Ghosh, et al.,(2008) have also been taken into consideration. In this case 10 states of India with their affected districts and percentages have been highlighted. Concentration of fluoride in West Bengal is mentioned in mg/L for 13 districts.

The health impacts of fluoride have been studied by the reports of WHO. However various research works of Susheela (2001), Weast and Lide(1990), Luther *et al*,. (1995), Lu *et al.,* (2000), Patra *et al.,* (2000) have also been highlighted to reflect the health impacts of fluoride. To measure the impact of fluoride concentration in drinking water and its effects on human health the range of fluoride concentration has been selected from< 0.5 mg/L to >10.00 mg/L.

Examining the WHO Report (1984), and works of Gupta (1999) and Teotia et al, (1985) author has presented several preventive measures for ground water contamination of fluoride. However, based on the available consulted literatures a literature review has been made for clear understanding of the present study.

Literature Review

The study on ground water contamination of fluoride in India is an important topic of geo- environmental study. The problem of fluorosis has been known in India for a long time. The disease earlier called mottled enamel was first reported by Vishanathan (1935) to be prevalent in human beings in Madras Presidency in 1933. Mahajan (1934) reported a similar disease in cattle in certain parts of old Hyderabad state. However, Shortt (1937) was the first to identify the disease as fluorosis in human beings in Nellore district of Andhra Pradesh.

Wodeyar and Sreenivasan (1996) in their work describe the occurrence of fluoride in the groundwater and its impact in the Peddavankahalla basin, Bellary district of Karnataka. Agrawal et al.,(1997) in their study focuses elaborately on the fluoride and fluorosis in Rajasthan. Gupta & Deshpande, (1998) in their study assess the depleting groundwater levels and increasing fluoride concentration in villages of Mehsana district of Gujarat. They also show the impact of fluoride on the economy and health. Chand (1999) in his work mentions the fluoride and its impact on human health. Gupta (1999) points out the environmental health perspective of fluorosis in children.Apart from these some other regional studies on fluoride in Assam, Karnataka, Maharastra and Haryana have also been carried out by Das et al, (2003), Latha et al, (1999) and Babu et al, (2004), Meenakshi et al., (2004) respectively. Ghosh,et al.,(2008) in his 'Status of Environment of West Bengal- A Citizen's Report' highlights the nature of fluoride contamination in West Bengal.

The present study also embraces the works of some non Indian scholars. Czarnowski et al.,(1999) in his study mentions the impact of water borne fluoride on bone density. Lu et al., (2000) points out the effect of high fluoride water on intelligence in children. Teotia et al., (1985) in his work covers the bone static and dynamic histomorphometry in endemic fluorosis.

Sources of Fluoride in ground water

The main sources of fluoride in groundwater are the fluoride bearing minerals in the rocks and sediments from which it get weathered and/or leached out and contaminate the water. When water percolates through rocks it leaches out the fluoride from these rocks. Usually the surface water is not contaminated with high fluoride, whereas ground water may be contaminated with high fluoride because the usual source of fluoride is fluoride rich rocks. In most cases of natural geogenic presence of fluoride in groundwater are the fluoride bearing minerals such as Apatite and Hornblende. Groundwater, when exposed for long periods to such minerals leaches out some minerals, fluoride being one of them. The rocks rich in fluoride are:

- Flurospar or calcium fluoride (CaF_2) (Sedimentary rocks, lime stones, sand stones);
- Cryolite- (Na_3AlF_6) (Igneous, Granite);
- Fluorapatite- Ca3 (PO)2 Ca (FCl)2

Concentration of fluorides is five times higher in granite than in basalt rock areas. Similarly, shale has a higher concentration than sandstone and limestone. Alkaline rocks contain the highest percentage of fluoride (1200 to 8500 mg/kg) (Chand, 1998). However the cause of fluoride in groundwater can be geogenic as well as anthropogenic. Fluoride enters the human body mainly through the intake of water and to a lesser extents by food. The foods which are rich in fluoride include fish and tea (EPA, 1997). Long time exposure of such water to the underlying rocks causes high concentrations up to 19 mg/l in some areas (Gupta and Deshpande, 1998). Presence of high Fluoride in groundwater is therefore strongly linked to increasing exploitation of groundwater. For many rural areas where hand-pumps and tube-wells are the only source of safe drinking water, this contaminant has emerged to cause a serious crisis threatening public health.

Although there are several sources of fluoride intake, it is roughly estimated that 60% of the total intake is through drinking water. This is the most available form of fluoride and hence the most toxic. Drinking water is considered as the major contribution to fluoride entering the human body. According to WHO standards, the fluoride in drinking water should be within a range that slightly varies above and below 1 mg/L (Meenakshi *et al.*, 2004). In temperate regions, where water intake is low, fluoride level up to 1.5 mg/L is acceptable. The Ministry of Health, Government of India, has prescribed 1.0 and 2.0 mg/L as permissive and excessive limits for fluoride in drinking water, respectively.

Extent of Contamination

India is one among the 23 Nations around the globe where health problems have been reported due to excessive fluoride in drinking water. An estimated 62 million people in India in 17 out of 28 states are affected with dental, skeletal and/or non skeletal fluorosis.

It is well known that the excess fluoride intake is responsible for dental and skeletal fluorosis. The problem of fluorosis has been known in India for a long time. The disease earlier called mottled enamel was first reported by Vishanathan (1935) to be prevalent in human beings in Madras Presidency in 1933. Mahajan (1934) reported a similar disease in cattle in certain parts of old Hyderabad state. However, Shortt (1937) was the first to identify the disease as fluorosis in

human beings in Nellore district of Andhra Pradesh. The Indian Ministry of Water Resources informs that several districts of 10 states are affected by high Fluoride concentrations (greater than 1 mg/l) in groundwater (Table 1). However, this picture is far from being complete. Several districts of northern Gujarat like Mehsana and Patan, Dungarpur and Banswara in southern Rajasthan, and some districts in western Madhya Pradesh have now been found to have high fluoride concentrations and newer areas are emerging from Assam (Das et al, 2003), Karnataka (Suma Latha et al, 1999; Wodeyar and Sreenivasan 1996) and Maharashtra (Babu et al, 2004). The endemic states with the percentage area affected are given in Table 1.

Table- 1 Indian states with area affected by fluoride poisoning

State	Affected Area (%)	Affected Districts
Andhra Pradesh	50 - 100	Cuddapah, Guntur and Nalgonda
Gujarat	50 - 100	Banaskantha, Kutch & Amreli
Haryana	30 - 50	Hissar, Kaithal & Gurgaon
Kerala	< 30	Palaghat Krishna, Ananipur, Nellore, Chittoor.
Orissa	< 30	Bolangir, Bijapur, Bhubaneshwar and Kalahandi
Punjab	30 - 50	Amritsar, Bhatinda, Faridkot, Ludhiana & Sangrur
Rajasthan	50 - 100	Nagaur, Pali, Sirohi, Ajmer & Bikaner
Tamil Nadu	50 - 100	Chengalput, Madurai
Uttar Pradesh	50 - 100	Unnao, Agra, Aligarh, Mathura, Ghaziabad, Meerut & Rai, Bareli
West Bengal		Purulia , Birbhum, Hugli , Malda, Dakshin Dinajpur, Burdwan , Pachim Medinipur

West Bengal has also high concentration of fluoride. High fluoride content in groundwater was first reported in 1997 around Nasipur village in Nalhati-I block of Birbhum district. Here the fluoride concentration has been reported to be as high as 10-16 mg/1 causing deformity in bones, fluorosis, dental caries, etc. The contaminated water was reported from tube wells tapping groundwater from basaltic rocks at around 90 m depth. In West Bengal the total population exposed to fluoride contamination is about 6.34 million spreading over 1073 villages of 131 blocks and 1 municipality of which about 4 million people are at risk residing at 63 blocks (Ghosh et al., 2008).Table-2 shows that out of the 13 districts the concentration of fluoride is found to be high in Purulia, Malda, Hugli, Dakshin Dinajpur, Pachim Medinipur and Burdwan districts

Table- 2 Concentration of fluoride above 1.0 mg/l

Districts	Concentration of fluoride in mg/1
Koch Bihar	1.40
Jalpaiguri	2.20
Darjiling	2.02
Uttar Dinajpur	2.50
Dakshin Dinajpur	5.18
Malda	8.0
Hugli	6.28
Purba Medinipur	1.16
Pachim Medinipur	4.42
Bankura	1.90
Purulia	8.5
Burdwan	4.03
South 24 Parganas	1.80

Health Impacts and Fluoride

To a certain extent fluoride ingestion is useful for bone and teeth development, but excessive ingestion causes a disease known as Fluorosis. Fluorosis is a crippling disorder due to entry of fluoride in the body, which affects every organ, tissue, cells in the body, and results in health complaints having overlapping manifestations with several other diseases like gouts and osteoporosis. In short, it causes Dental Fluorosis, Musculo-Skeletal Fluorosis. Fluoride damages the Pineal Gland, which secretes melatonin hormone in the brain. It also affects the reproductive systems and intelligence (Susheela, 2001). Many symptoms of Fluorosis are somewhat alike with other diseases such as Arthritis, osteoporosis etc.

It is generally accepted that fluoride stimulates bone formation (Richards *et al.,* 1994) and small concentration of fluorides have beneficial effects on the teeth by hardening the enamel and reducing the incidence of caries (Fung *et al.* 1999). It plays an important role on the formation of dental enamel and normal mineralization in bones but can cause dental fluorosis and adversely affect the central nervous system, bones, and joints at high concentrations (Agarwal *et al*., 1997).

According to WHO standards 1.5 mg/l of fluoride is a safe limit in drinking water for human consumption. People in several districts in Rajasthan are consuming water with fluoride concentrations of up to 24 mg/l. Fluorosis continues to be an endemic problem. Children in the age group of 0 to 12 years are most prone to fluorosis as their body tissues are in formative / growth stage during this period.

At lower levels (<2 mg/ml) soluble fluoride in the drinking water may cause mottled enamel during the formation of teeth, but at higher levels other toxic effects may be observed (Weast and Lide, 1990). Severe symptoms lead to death when fluoride doses reach 250-450 mg/ml (Luther *et al,*. 1995). It has been found that the IQ of the children living in the high fluoride areas (drinking water fluoride > 3.15 mg/ml) was significantly lower (Lu *et al.,* 2000). Ingested fluorides are quickly absorbed in the gastrointestinal tract, 35-48% is retained by the body mostly in skeletal and classified tissues, and the balance is excreted largely in the urine. Chronic ingestion of fluoride rich fodder and water in endemic areas leads to development of fluorosis in animals e.g. dental discoloration, difficulty in mastication, bony lesions, lameness, de-ability and mortality (Patra *et al.,* 2000).

Table 3 Concentration of fluoride in drinking water and its effects on human health

Fluoride Concentration (mg/L)	Effect
Nil	Limited growth and fertility
< 0.5	Dental caries
0.5 - 1.5	Promotes dental health, prevents tooth decay
1.5 - 4.0	Dental fluorosis (mottling and pitting of teeth)
4.0 - 10.0	Dental fluorosis, skeletal fluorosis (pain in neck bones and back)
> 10.00	Crippling fluorosis

Non Skeletal Manifestations

Neurological manifestation

- Nervousness & Depression
- Tingling sensation in fingers and toes
- Excessive thirst and tendency to urinate frequently (Polydypsia and plyurea):
- The Control by brain appears to be adversely affected.

Muscular manifestations

- Muscle Weakness & stiffness
- Pain in the muscle and loss of muscle power

Radiological Presentations

- Osteosclerosis
- Periosteal bone formation
- Calcification of interosseous membrane, ligaments, capsules, muscular attachments, tendons.
- Exostoses
- Osteophytosis
- Associated metabolic bone disease

Clinical Presentation

- Heel pain
- Painful and restricted joint
- Movements
- Deformities in Limbs
- Hunch back

In Extreme Cases

- Paralysis,
- Mucular wasting,
- Premature aging

Urinary tract manifestations

- Urine may be much less in volume
- Yellow red in colour
- Itching in the region of axilla.

Allergic manifestation

- Very painful skin rashes, which are vascular inflammation prevalent in women and children.
- Pinkish red or bluish red spot, round or oval shape on the skin that fade and clear up within 7-10 days.

Gastro - intestinal problems

- Acute abdominal pain
- Diarrohea
- Constipation
- Blood in Stool
- Bloated feeling (Gas)
- Tenderness in Stomach
- Feeling of nausea
- Mouth sores

Prevention of Fluoride Contamination

Excessive fluoride ingestion by human beings can be prevented by using the following three approaches:

Health education
Treatment of the disease,
Preventive measures.

Health Education

Creating awareness about the disease

Creating awareness about the disease should be in form of graphic presentation of the final consequences of the disease to the extent possible. If required live presentation of the patients, who are suffering from the severe form of the disease, in areas where the gravity of problem has not reached to that extent. It may be of use, to demonstrate the most severe extent of the disease and to motivate them to use the preventive or therapeutic measures.

Creating awareness about the sources of the fluoride

The creation of awareness will help in implementing the need based preventive measures in the affected community.

Treatment of the disease

Vitamins C and D, and, salts of Calcium, Magnesium or Aluminum are prescribed in an attempt to reverse these effects (WHO Report, 1984). Adequate calcium intake is directly associated with a reduced risk of dental fluorosis. Vitamin C ingestion also safeguards against the risk of fluorosis. Studies conducted in Rajasthan under Rajasthan DST sponsored studies indicated that fluorosis could be reversed, at least in children (Gupta, 1999) by a therapeutic regimen (Calcium, Vitamin C and Vitamin D) which is cheap and easily available. The choice of the reported therapy was logical. The presence of calcium in gut directly affects the absorption of fluoride ions and will also improve serum calcium levels (Teotia et al, 1985). Vitamin D in low doses enhances calcium absorption and retention without causing hypercalcemia and thus directly affects the absorption of fluoride ions. It also inhibits the excessive release of parathyroid hormone thereby preventing excessive activation of osteoblasts thus preventing hyperosteoidosis and osteopenia. Ascorbic acid controls collagen formation, maintains the teeth structure and is also essential for bone formation. These structures are adversely affected by higher fluoride intake.

Preventive measures

Providing defluoridated water for drinking purpose

Removing excess fluoride from drinking water using different techniques such as Nalgonda method is an important defluoridation measure. This defluoridation method is based on the combined use of alum and lime in a two-step process. Methods of deflouridation recommended so far are aimed at bringing the fluoride levels to the WHO standards.

Changing the dietary habits

Deflouridation of drinking water alone shall not bring the fluoride level to a safe limit. It would be necessary to overcome the toxic effects of the remaining fluoride ingested through other source. This can be done by effecting minor changes in the diet and dietary habits of the population compatible with their social system and available resources. The main aim should be to

- Restrict use of fluoride rich food
- Avoiding use of fluoride rich cosmetics
- Use of food rich in calcium, vitamin C and proteins

Water harvesting (alternative water source)

Fluoride not only affects the people but it also affects the animals. Therefore it is desirable that the animals should also be provided with fluoride free water for maintaining their longevity. Defluoridation of drinking water for animals will be too costly and not feasible, and therefore the only solution of this problem is water harvesting. The water harvesting technologies should be aimed not only to provide fluoride free water to human beings but also to animals. Rainwater storage can be a major source of fluoride free drinking water for the animals. This three pronged attack can prove to be a blessing for the population especially for the younger generation living in fluoride rich areas having no choice except to drink the water contaminated with fluorideand suffer the inevitable consequences including permanent deformities.

Findings

The problem of high fluoride concentration in groundwater resource has become one of the most important toxicological and geo-environmental issues in different parts of India. It is silent killer. The major sources of fluoride in groundwater are the fluoride bearing minerals such as Apatite and Hornblende, Flurospar or calcium fluoride (CaF_2) (Sedimentary rocks, lime stones, sand stones), Cryolite- (Na_3AlF_6) (Igneous, Granite) and Fluorapatite- Ca3 (PO)2 Ca (FCl)2. Drinking water is considered as the major contribution to fluoride entering the human body. According to WHO standards 1.5 mg/l of fluoride is a safe limit in drinking water for human consumption. But excessive fluoride in drinking water causes dental, skeletal fluorosis and other Non Skeletal Manifestations. Again very low amount of fluoride in drinking water causes limited growth and dental caries. The present study also shows that excessive fluoride intake and its related diseases can be checked by providing defluoridated water for drinking purpose, restrict use of fluoride rich food, treatment of the disease, use of rain water and proper health education.

Conclusion

The study of fluoride contamination of ground water has not been carried out everywhere in India. There are a number of rural areas in India where this problem is acute but due to lack of study the people have been suffering from fluorosis diseases. Therefore proper scientific study of fluoride contamination of ground water should be adopted in order to keep rural health physically sound and mentally strong.

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"To Make Large Scale Digital Toposheet Using GIS And Remote Sensing Tools."

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Abstract

The application of GIS is growing rapidly in every field of sciences. The toposheet is primary source of the GIS field with the help of that we can generate the various types of primary, Secondary data. The large-scale Toposheet of southwest coastal part of Ratnagiri districts made by SOI Pune through the own survey for the purpose to study of "Disaster Management". To make a DEM of the area of south west coast of Ratnagiri districts from the elevation data of digitized the contours taken from the large scale toposheet and overlay the Google Earth image. The digitize layers such as River, Road, Power line and Settlement when the added to the DEM gave a realistic view of the study area.

Introduction

"Geographical information system (GIS) is a powerful set of tool for collecting, storing, retrieval, transforming and displaying spatial and non-spatial data from the real world" GIS components are divided in to four parts. They are Hardware, Software, Data and Human Ware etc.

The earth surface has many different forms such as Mountains, Plains, Rivers and etc. the topographical form Changes place to place. The representation of the topographic feature information on sheet with respect to scale is called as the topographic map and that information in the digital form is called as the Digital Toposheet. Toposheet is Primary source of information to the GIS field through which generated the primary spatial and non spatial information that useful for various Analyses like as construction of roads, to build dam, city planning, village planning etc. The elevation information represent the toposheet that can understand the various surface relief on the flat sheet paper according that elevation we can do various planning. We make digital toposheet using different plates such as Black, Blue, Border, Green, Red plates etc. The main purpose of to make a digital toposheet is that we store many toposheet in any system. And user-friendly, suppose user want only road and settlement layer we give him that much information when toposheet present in digital format.

Digital Elevation Model can be defined, as 'Any Digital representation of the continuous variation of relief over the space is known as the Digital Elevation Model (DEM)'. Or the continuous variation of relief over a space is called as terrain model. The DEM also help us to understand the 3D view of topographical features. Information about terrain relief and all type of Landforms is important to many

applications such as military can use security purpose and weapon, civil engineering department use for road construction, dam construction and much more and also various government department use the DEM for Soil analysis, disaster management analysis, city, village and regional planning etc.

Study Area: -

The Study area covered Jaitapur village area in Rajapur Tahsil of Ratnagiri District. It is totally costal Area which lies between Latitude 16^0 34' 30"N to 16^0 36' 30"N Latitude and Longitude is $73^0$19' 00" to 73^0 21' 00"E Longitude.

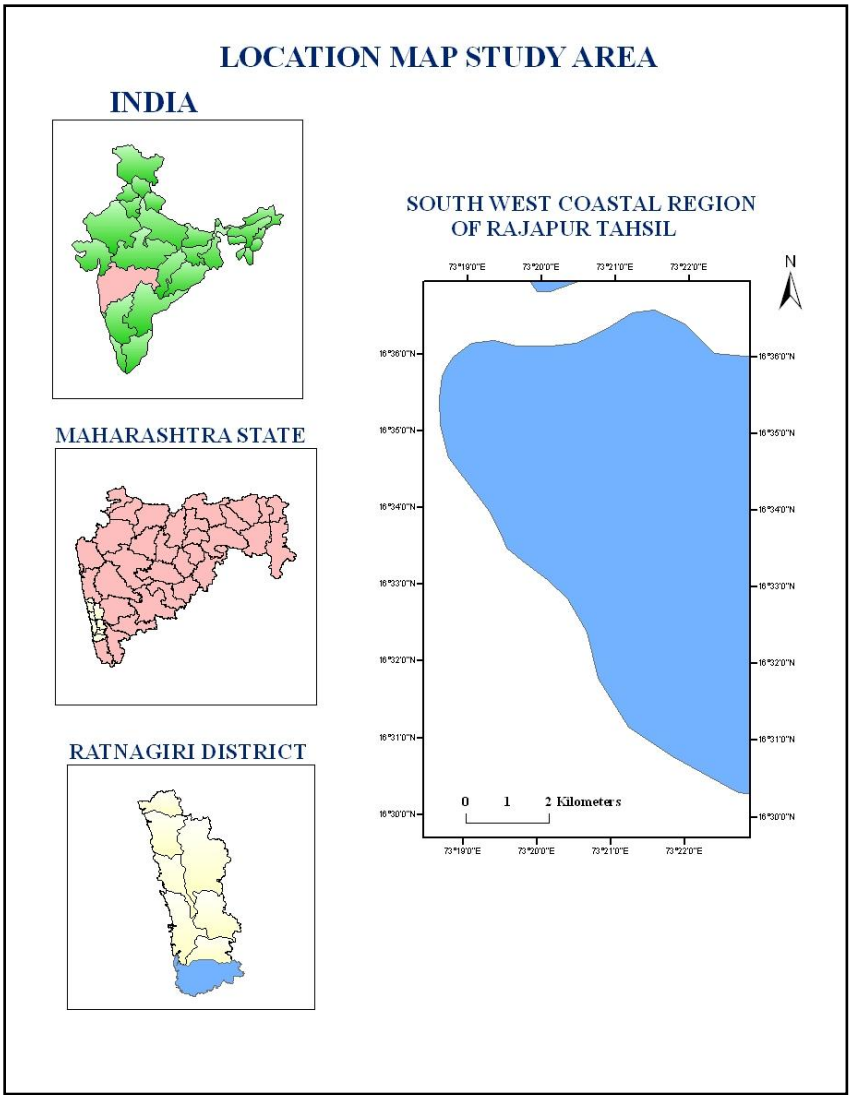

Fig.1.

Objectives

To create large scale Digital Topographical data base on Everest ellipsoid and Polyconic projection in Micro Station Software and transformation in to WGS-84 ellipsoid Universal Transverse Mercator (UTM) projection.

Data used

a) Survey of India (Pune 06) Prepared Special Toposheet of Ratnagiri districts of coastal area through which the own survey in year 1990, that toposheet scale is 1:2000 and contour interval is 0.50 Meters. Total study area extend is 16˚ 34’ 30” to 16˚ 36’ 30”N Latitude and 73˚ 34’ 30” to 73˚ 19’ 00” E Longitude above total Latitude & longitude extend area covered to the 15 Toposheet.

b) Google Earth Free Download image

Methodology: -

1). A 1:2000 Scales of 16 Toposheet covered very small area of the Ratnagiri Districts of coastal Area. It is very large scales Toposheet one toposheet extend are 0˚ 00’ 30” × 0˚ 00’ 30” (1/2 second by 1/2second) and total study areas extend is 16˚ 34’ 30” to 16˚ 36’ 30”N Latitude and 73˚ 34’ 30” to 73˚ 19’ 00” E Longitude was scanned in 15 parts in jpeg format by using A4 size scanner.

2). The scanned images were converted in .rle (Run length Encoding) format with the help the Micro Station and IGEVEC because Micro Station and IGEOVEC Software Easily visualize the .rle format Raster image.

3). The Polyconic projection is made with the help of Micro Station Geocord Software because most of toposheet are prepared in Polyconic projection.

4). The .rle Raster format image set in the Polyconic projection with the help of warping processes in Micro Station and IGEOVEC Software.

5). The .rle raster format toposheet made then digitized into different plates such as Black plate, Blue plate, Red plate, Green plate, Contour plate, Name plate and Border plate in the Micro Station and IGEOVEC Software.

6). All plate layers ware merge together with the help of merge process in the Micro Station and IGEOVEC Software then we have got final digital toposheet.

7). The transformation of the digital toposheet from the Polyconic projection in to the UTM 84 (Universal Trance marketer) with the help of Micro Station Geocord Software.

8). 15 Toposheet were plate wise mosaiced by using the merge process in Micro Station and IGEOVEC Software.

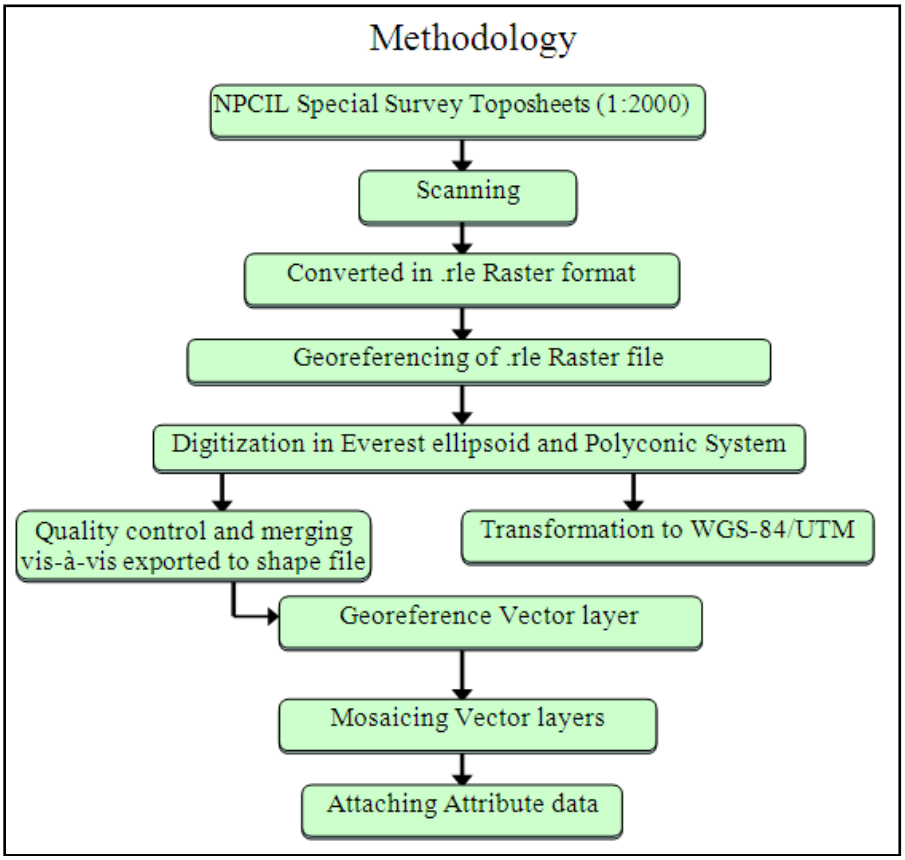

Fig .2

Making large scale digital toposheet using Polyconic projection

Micro Station is one of the software which is related to the making digital Toposheet. It's including IGEOVEC and IRASB software. IRASB software supported to Raster and Micro Station is supported to the Vector but IGEOVEC it is supported to both Vector as well as Raster. It is totally command-based software. According to feature code it is automatically taking that feature colour, shape, pattern, text, style and thickness. IGEOVEC is supported semi digitization only for contour because contour is the continuous line feature.

I/GEOVEC (interactive geographic vectorization)

I/GEOVEC are an interactive, stand-alone data conversion and collection product for geographic vectorization of map features and utility outside plant items. It streamlines heads-up data capture/conversion from scanned binary map documents using raster line following and feature coding. A binary raster file displayed in I/RAS B can be digitized selectively or completely as you identify line work for

automatic vector tracing as Micro Station elements. Where line following is not appropriate, I/GEOVEC provides a comprehensive set of heads-up digitizing commands for efficient on-screen data collection with I/RAS B. I/GEOVEC accepts Intergraph format raster files and produces Micro Station design files, which may be bulk-loaded into Intergraph mapping application databases. Feature data is segregated by level and symbology and tagged with feature names, and codes are stored in user links and optionally tagged with attribute values. Feature names, codes, and attributes are stored in external files, allowing non-Intergraph databases to be built with I/GEOVEC, provided the user is responsible for loading the database.

I/RAS B (Interactive Raster Binary)

I/RAS B is a raster editor software package that provides all the tools necessary to import raster data from a scanner, edit, and create new raster data. Raster data in I/RAS B is displayed on the screen simultaneously with the current Micro Station drawing. I/RAS B and Micro Station data are separate from each other and neither one affects the other in any way, even though they are displayed on screen simultaneously.

Editing a raster data file does not affect a CAD drawing displayed in Micro Station, and drawing objects with Micro Station has no effect on I/RAS B raster data, unless the .dgn to Raster option is enabled. If you wish to work only on a raster file in I/RAS B, without looking at a corresponding design file in Micro Station, you can load a blank file into Micro Station, so that only raster data from I/RAS B is displayed on the screen. Raster data can be collected through a scanning device, such as ANA Tech Eagle scanner, created from scratch with software such as I/RAS B, or imported from various formats (e.g. TIFF, CALS). Once collected or created, raster data can be edited as needed for archiving, plotting, or for use with other applications. Using Micro Station and the I/RAS B Snap to Raster function, it is also possible to trace over raster data, referred to as heads-up digitizing, thus capturing the data in vector format. Digital toposheet means topographical features in vector format or in digital format that is point, line, polygon, description of attitudes numerical information and symbology. Toposheet can be defined as it is a itself map that include all contained, it is also showing the permanent physical feature and cultural feature with related attribute. According to Robinson (1984) Topographical map can be defined as " it is a map whose objectives is to portray the spatial associative of a selection of diverse geographical phenomena. Toposheet is our primary source of the spatial and non-spatial information. GIS and other computerize field are growing very fast that computerize field want to the spatial and non-spatial in soft or vector data format due to the reduce time, cost and manpower etc.

Digital Toposheet

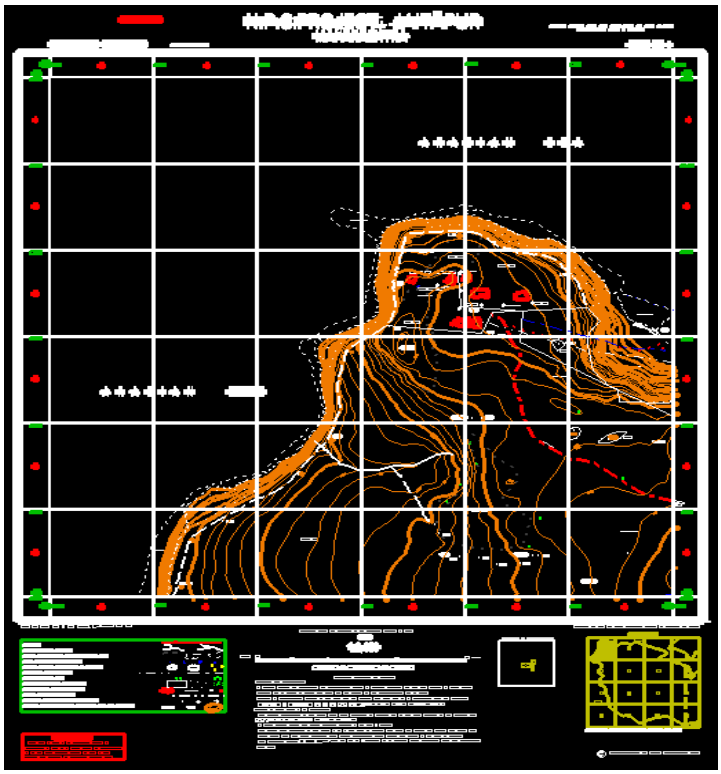

Fig 3.

Structure of digital toposheet: -

The basic structure of the digital toposheet is the data storage in various plates like Black plate, blue plate, Red plate, green plate, contour plate, Name plate and Border plate.

Above that all plate contained the point, line, polygon data in one layer but the various levels, According to that levels we can obstructed only point, line, polygon and Name layer those are user want. According to feature code and color the following plates are created for different layer

BLACK PLATE: -

It represents those features are in black colour on Toposheet such as Point likes spot heights, BMs etc. Line like unperennial Rivers, Telephone line, power line and Polygon like cultivation boundary, scrub area boundary, Quarry, Village, Taluka, District, State and international boundary etc.

Black Plate

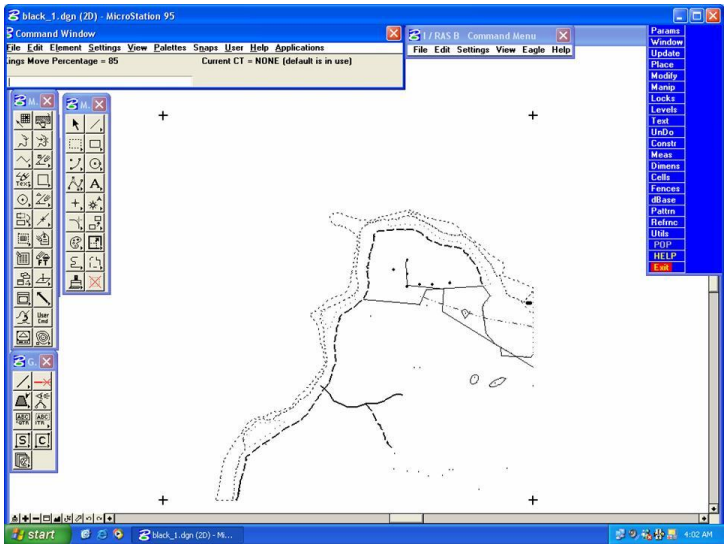

Fig. 4

BLUE PLATE: -

Blue plate only represents those features appear in blue colour on the Toposheet like Point features are Spring, Tube well etc, Line features are Perennial stream or river, Canals, High water line, low water line, Polygon feature are Various Coastal Sand area limit etc

BORDER PLATE: -

Border Plate represents outer border of the Toposheet and store the various text in that upper side of the Toposheet Central heading, District heading, State name, Sheet Number, Restricted, surveyed year, and down side of Toposheet Symbol box, scale bar, contour and scale information, copy right etc.

CONTOUR PLATE:

Brawn Plate represents those features appear in Brawn colour on the Toposheet like Line and Polygon features are contours, Stony Waste area boundary etc.

GREEN PLATE**:**

Green Plate represents those features appear in Green colour on the Toposheet like Point features are various trees in that Palm, casuarinas, cactus, bamboo, high grass, grass and other small or big trees, Polygon feature are Various forest boundaries in that protected forest, Restricted forest Boundaries etc.

NAME PLATE:

Name Plate represents the various text and figure in that BMs height, relative, spot, and heights figures. Village, Tahsil, Cities Names and open scrub, dense forest, Protected forest names etc.

RED PLATE:

Red Plate represents those features appear in red colour on the Toposheet like point Features are various Huts, House, Bridges symbols, Line features are various types road

like Metalled, Unmetalled, Cart track etc, and Polygon Feature are Compact house boundary etc.

Blue Plat

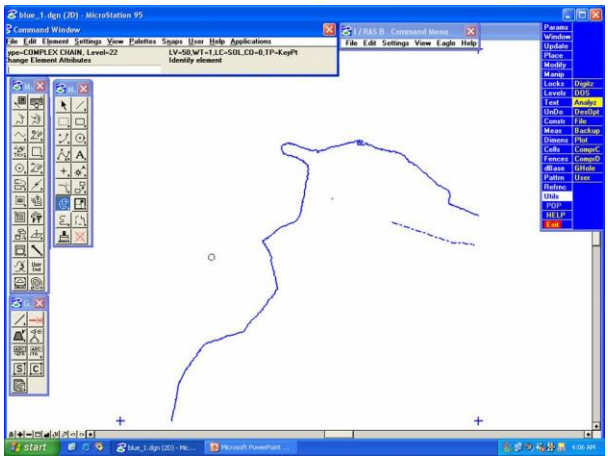

Fig 5

Border Plate

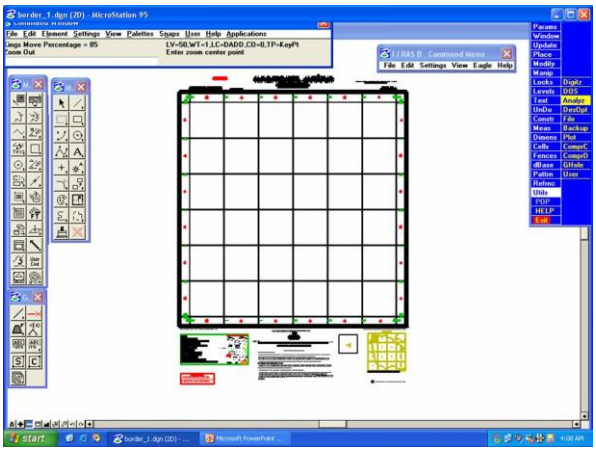

Fig 6

Contour Plate

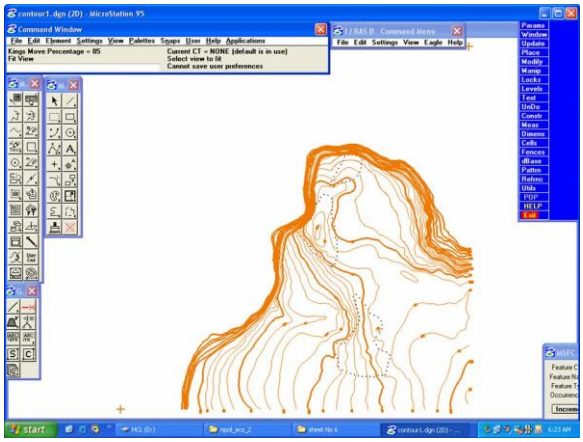

Fig. 7

Green Plate

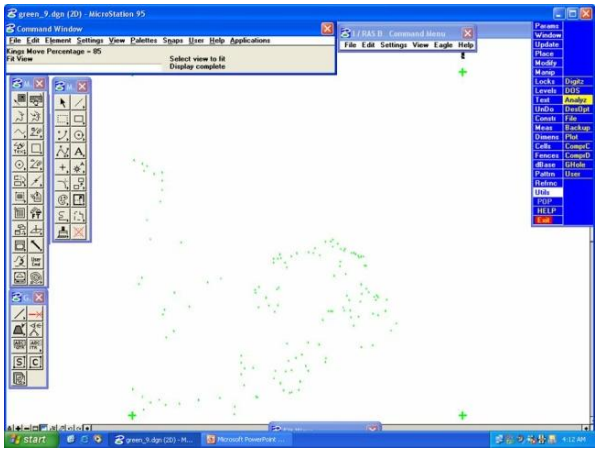

Fig. 8

Name Plate

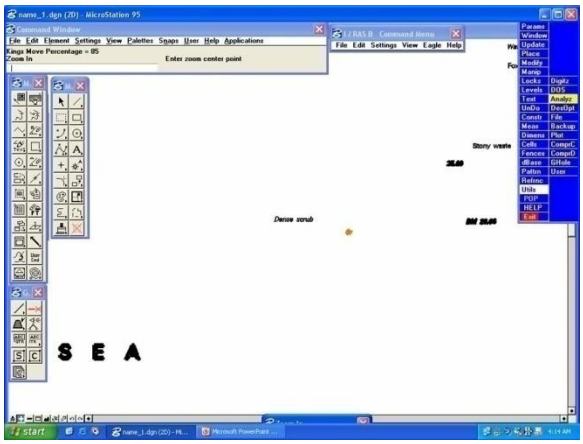

Fig 9

Red Plate

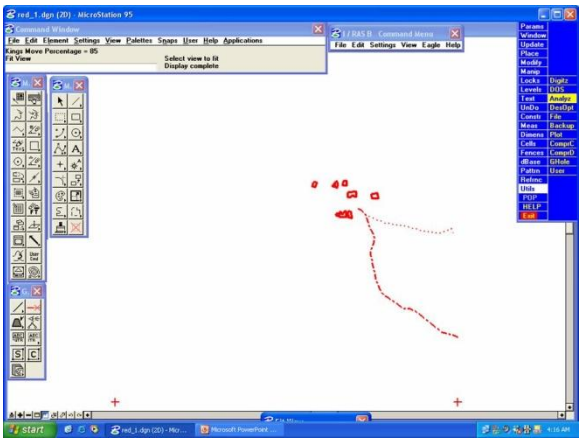

Fig 10

Projection and transformation using Micro Station Geocordinator

Micro Station GeoCoordinator is powerful cartographic software designed exclusively for Micro Station. Micro Station GeoCoordinator turns Micro Station into a powerful map projection manager. It allows us to assign Coordinate Systems to individual maps, read coordinates from any assigned projection system and convert Micro Station data from one Coordinate System to another. We can also generate grids based on any Coordinate System. These complex transformations are handled quickly and easily with Micro Station GeoCoordinator. And because it is a perfect fit with Micro Station. Micro Station GeoCoordinator can be used effectively by almost anyone in the Micro Station community. City planners, foresters, highway engineers and surveyors can make easy comparisons between old maps and new ones. Cartographers, oil engineers and mining companies can evaluate data gathered from many different jurisdictions. Micro Station GeoCoordinator gives us the freedom to define custom projections to fit any situation.

Mapping involves taking curved surfaces and flattening them out in a highly precise manner for a particular purpose. While the distortion introduced for each particular map may be minimized, the coordinates contained are not compatible with any other map using a different projection or even simply different parameters within the same project. Micro Station GeoCoordinator allows Micro Station users to make maps compatible by transforming design files between an incredibly wide variety of projections and coordinate systems

Projection

Technique of converting curved surfaces to a flat surface Unit are linear (meters, feet) all projections have lines of zero distortion. A wisely selected projection will minimize the

distortion for the local area. If maps use more than one variety of projection, we will have to transform one or the other to be on the same projection in order for the data to be compatible.

Polyconic Projection

1. It can be suitably used to represent regions like North America.
2. It is represented in the millions sheets.
3. It is applied for large-scale maps and topographical maps.

Using Micro Station GeoCoordinator we get following Polyconic Projection that .dgn file is following

Polyconic projection to Micro Station

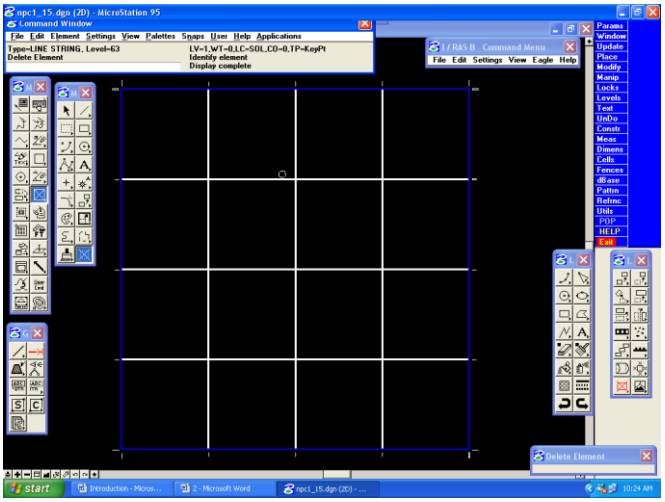

Fig 11

Universal Transverse Mercator (UTM)

It is a series of 120 Coordinate Systems established by the U.S. Army in the late 1940's. These Coordinate Systems are based, as the name implies, on the Transverse Mercator projection. Each zone is six degrees wide and is numbered. Zone 1 covers 180° to 174 ° west longitude with a central meridian at 177 ° west. Zone two covers the region between 174° and 168° west and has a Central Meridian at 171° west longitude. In a similar manner, the entire northern hemisphere is covered by a system of 60 zones. The latitude of origin is the equator the linear unit is the meter.

Universal Transverse Mercator projection to Micro Station

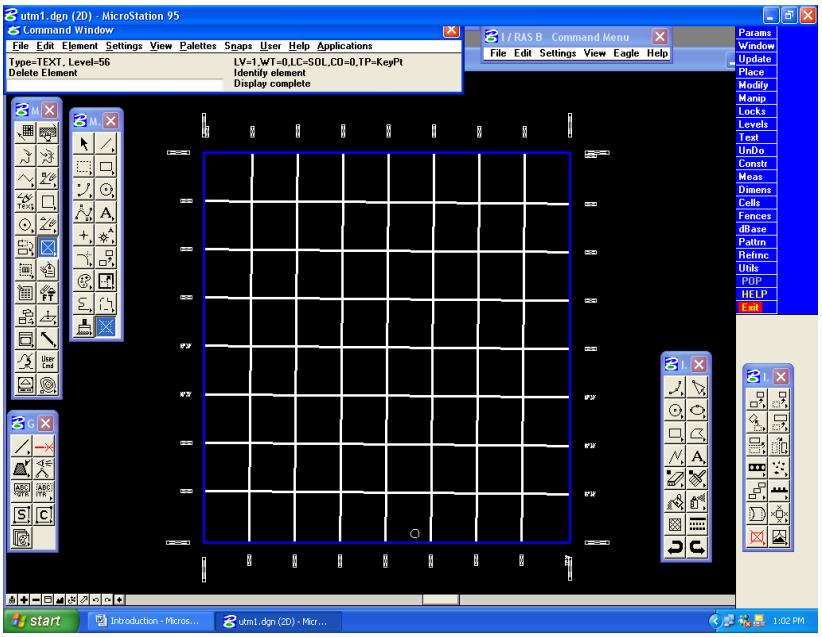

Fig. 12

Result and Discussion

The input for the project was the hardcopy map of 16 special topographical sheets is 1:2000 scale generated under a project survey by survey of India. The 16 sheets were first converted into Raster format using an A_0 size scanner then it converted into the .rle (Run Length encoding) format. The .rle files of sixteen sheets were georeferenced to Everest ellipsoid and Polyconic Projection systems as the hardcopy maps were originally created in the same system.

Using the Georeference .rle files vector maps is Digital Topographical Databases of all sixteen-map sheets were created using Micro station and IGEOVEC cad software. Since these digital maps were not suitable for GIS analysis gets converted in to shape file. All sixteen toposheets were merged to be necessarily attributes were attached.

Using the contour slope file an accurate DEM of the area was created. The other vector layers of different features were easily developed on to it is 3D virtual GIS viewer of ERDAS Imagine software. Image downloaded from the Google Earth also were georeferenced in order to drape it on to the 3D surface created. So that it became highly interpretable.

Different 3D analysis were done such as water flooding in the area etc. topographic analysis such as Slope map, Aspect map, Hill Shade map, View Shade analysis etc were also carried out. The product so generated and attached in different chapters.

Virtual object such as trees and 3D building also crated on the model to give the model a realistic look. An animated movie also was created so as to enable the administrative and planners a throughout look of the area from different angles.

Since the contour interval was 0.5 M DEM realistic was highly accurate offering very tiny differential analysis. The vector map created with attribute was also subjected to the query building using the ArcGIS 9.1 Software.

The project was indeed wholistic approach for different 2-D, 3-D and semantic analysis using the modern tools and software.

Conclusion

The topographic map is primary data source of the GIS, the topographic map represent the 3d view on flat sheet. The large-scale digital topographic maps more helpful for to study the disaster management and military purpose.

DEM and overlay Google Earth image gives us to the realistic view as they appear in real world is applicable in various fields such as disaster management, military purpose and telecommunication etc.

The elevation data taken from toposheet and contour interval 0.5 meters there fore accuracy of DEM was increased. Water layer very useful for the how to topography submerge if water level will be increase and that water layer applicable for to study the Disaster management purpose

Digital toposheet after Transformation in to Universal Transverse Mercator (UTM) with WGS 1984

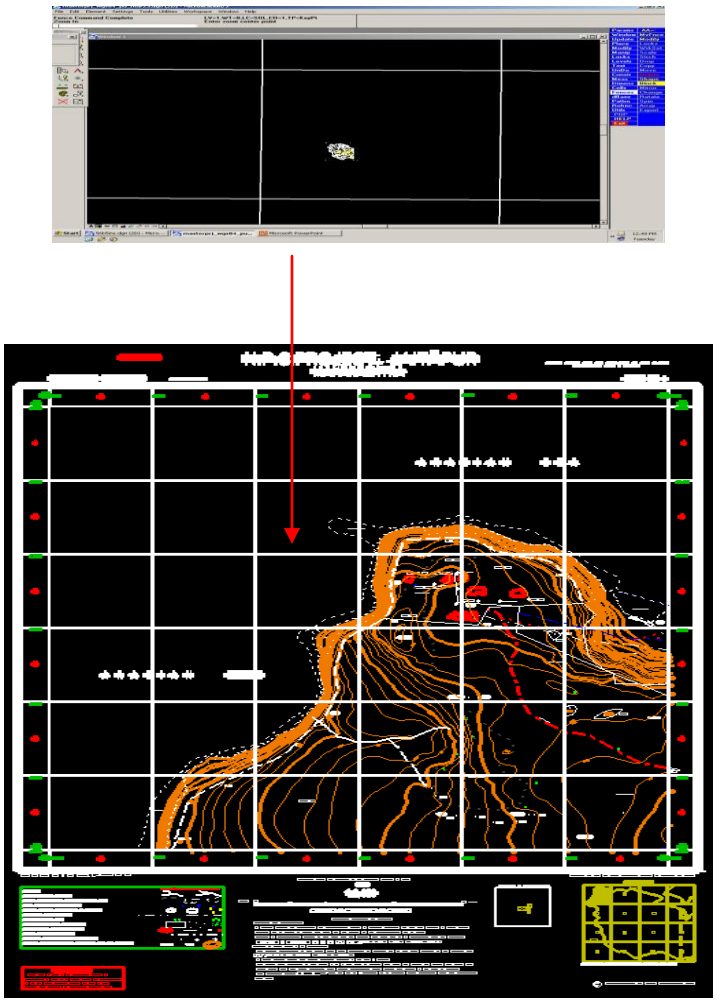

Fig 13 Digital toposheet after Transformation in to UTM WGS 1984

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www.GoogleEarth.com

Role of Remote Sensing and GIS in Integrated Rural Development Planning

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ABSTRACT

Planning is a basic human activity that involves thinking ahead and organizing to achieve the objectives. The function of the planning system is to regulate the development and use of land in the public interest and to reconcile current requirements with the need to protect the natural and historic environment. Spatial analysis applications, especially at the micro level, are a natural progression from land management applications, as the maps are directly used or derived from cadastral survey data and the land profile and usage information is available in land registers. With the use of Remote Sensing & GIS, the spatial impacts of alternative plans can be evaluated to assist planners, administrators and the people in selecting the most appropriate plan. At the implementation stage, GIS can used to evaluate development proposals, development control, zoning, and approval of subdivision schemes and impact studies of large-scale development projects. The program goals are to improve agricultural techniques to ensure rice security, to provide extension services, to encourage cash crop production to enable villagers to purchase rice to make up for shortages, to clear land for paddy production, and improve irrigation, fishing, and watershed management.

Introduction

Planning is a basic human activity that involves thinking ahead and organizing to achieve the objectives. The function of the planning system is to regulate the development and use of land in the public interest and to reconcile current requirements with the need to protect the natural and historic environment. It is possible to conceive planning as having several goals - the ultimate goal and layers of proximate goals. The first striking characteristic of planning is that it is *a **process.*** However centralized, it actually represents a number of tiers of decision-making. Planning must also have a distributive bias from the point of view of distributing the gains of planning and distributing the ownership and control of the material resources of the community by regulating the economic system of the national (or local) economy. Micro level planning generally involves ground study and evaluation of data of a specific area of interest. For e.g., rural development schemes, irrigation, ground water development, town planning, mining, Road logistics etc. require a study of maps and data pertaining to small zones. Spatial analysis applications, especially at the micro level, are a natural progression from land management applications, as the maps are directly used or derived from cadastral survey data, the land profile and usage information is available in land registers. GIS is most suitable tools for capturing data from diverse sources such as the census, government departments,

topographic maps, aerial photographs, cadastral maps, remotely sensed data from satellites, land records, and local surveys etc. It is therefore, an excellent tool for management of large bodies of spatially extensive data with all the advantages of a computer environment; precision, consistency, and absence of computational error. The inventory, analysis and mapping capabilities of GIS have wide applications in urban and regional planning, ranging from data retrieval and site selection to project monitoring and programming (Marble and Amundson 1988, Levine and Landis 1989).It is used in information retrieval, development control, mapping (Newton and Crawford 1988, Zwart and Williamson 1988), site selection (Dangermond *1983,* Smith and Robinson *1983),* land suitability analysis (Lyle and Stutz 1987, McDonald and Brown 1984), and programming and monitoring (Yeh 1990). Planning also uses data from other non-GIS databases and data from surveys. Its degree of usefulness and applications varies at different stages of the planning process.

With the use of GIS, the spatial impacts of alternative plans can be evaluated to assist planners, administrators and the people in selecting the most appropriate plan. At the implementation stage, GIS can be used to evaluate development proposals, development control, zoning, and approval of subdivision schemes and impact studies of large-scale development projects.GIS have emerged as very powerful technologies because they allow geographers to integrate their data and methods in ways that support traditional forms of geographical analysis, such as map overlay analysis. But they also make possible new types of analysis and modeling that are beyond the capability of manual methods, including visualizing alternative futures. With GIS it is possible to map model, query and analyze large quantities of data all held together within a single database.

Three main resource for which planning is done are: soil, water and energy. Sound planning requires keeping track of the current status of the soil, water and energy resources and its changes with time; i.e. a meaningful plan should maintain both static and dynamic information of these resources in a watershed. A spatial distribution of resources of watershed /village visualised at different points in time are also required.

Study area –

The study area is two villages i.e. Muktapur & Brundabanbiharipur in Ranapur block of Nayagarh district of Odisha lying between longitude 85°24’10.474”E.to 85°25’14.145”E. and latitude 19°57’23.798”N. to 19°59’9.728”N.covered by toposheets no 74e5NE with a scale of 1:25,000 . Fig.1.

Objective

1. Maintain Natural Resource database of the study area.

2. To map all the thematic information by interpreting the Satellite imageries and also from cadastral sheets.

3. Micro level studies on soil and water resources with people's participation.

4. To propose developmental plan for protection, conservation and improvement of the land resources.

To prepare a sustainable plans to protect and enhance the water resources.

5. To suggest a sustainable cropping pattern for the watershed utilizing the available the land and water resources.

Methodology

- Microwatershed boundary delineation from SRTM Data with reference to stream order.
- Collection of cadastral sheet from settlement office
- Scan , Digitization & Mosaic the collected Cadastral sheets
- Ground control point collected from field for Geo-referencing the cadastral sheets
- Geo-reference the Cartosat II Satellite image
- Preparation of Existing Landuse, conservationmeasures,soil,land capability & slope map with reference to Cadastral sheets and Cartosat II Satellite image
- Preparation of action plan map of Land and water resource.

Location Map of Study Area

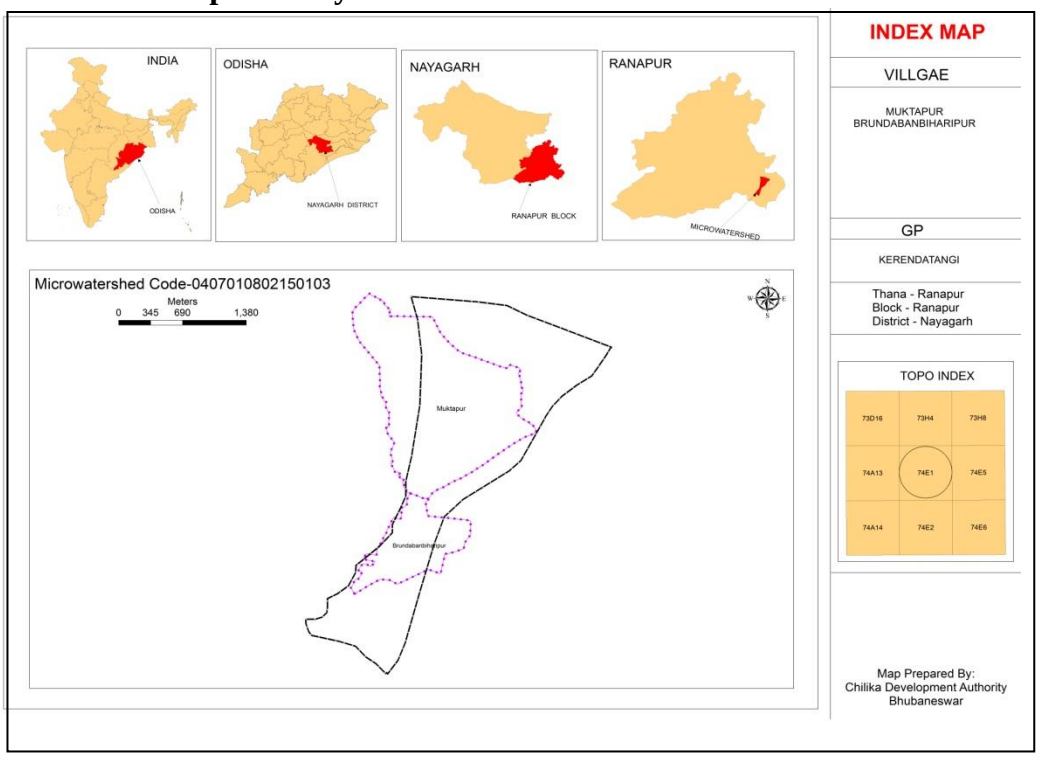

Fig.1.

RESULTS AND DISCUSSION:

The individual thematic maps were studied in order to make the spatial assessment of the relative variations of the resource potentials and a wide range of terrain conditions. This analysis helps in understanding the peculiar nature of the study area viz., the waterlogged conditions, wastelands, land degradation etc. This analysis helps in better understanding of the cause and effect in respect of not only problems / limitations and also at the same time understands the potentials of the study area. A number of spot observations were prepared, covering the entire area that consists of various land forms, soils, nature of ground water, depth of the ground water table, present land use etc. At each spot, the land characteristics / parameters as mapped in the respective theme maps along with the present land use along with the existing irrigation facilities and cropping pattern were recorded. The availability of improved varieties of crops, trees, scrubs and grasses and advantages of interdependency of agriculture, live stocks and other practices such as integrated farming systems etc. were taken in to consideration.

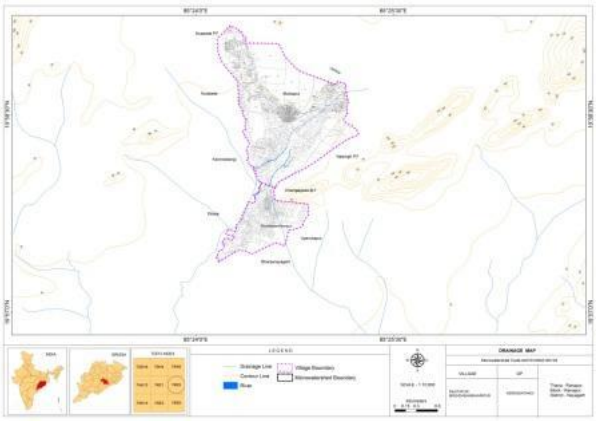

Fig.2.

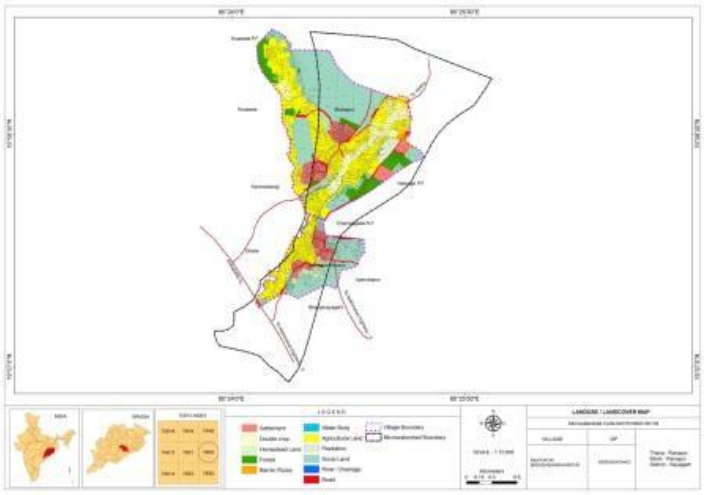

Fig.3

Table 1: showing the LU/LC area in Hector

No	Land use Type	Area in HA.	Study Area (%)
1	Settlement	23.8	8.23
2	Double crop	18.1	6.26
3	Homestead land	9.2	3.18
4	Forest	18.2	6.29
5	Barren rocky	1.4	0.48
6	Water body	0.05	0.01
7	Agricultural land	99.8	34.52
8	Plantation	3.5	1.21
9	Scrub land	103.3	35.73
10	River/ Drainage	1.1	0.38
11	Road	10.6	3.66

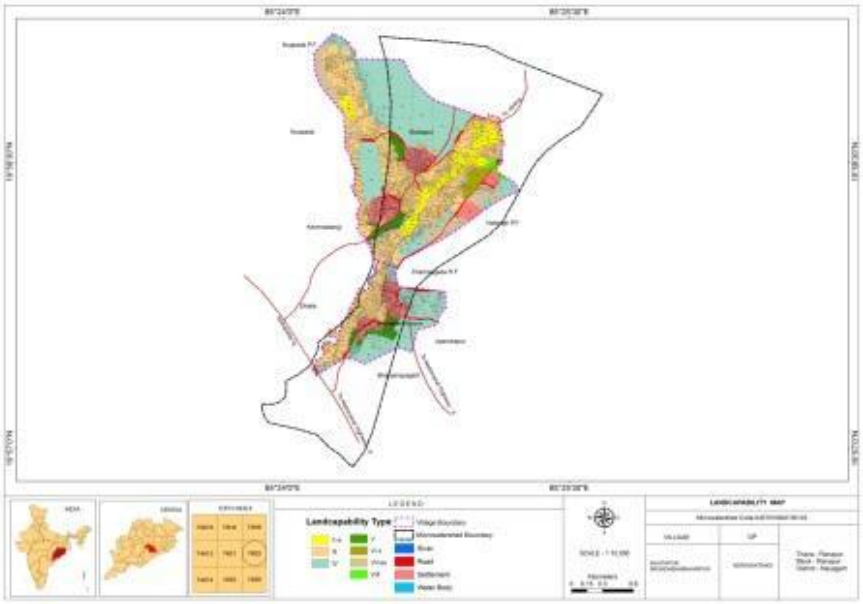

Fig. 4

The approach used for evaluation of rural development factors as said above are with remote sensing and GIS techniques. Interpretation of Land use/ land cover map for evaluating land utilization, Hydro geomorphology map for ground prospects, slope map for terrain properties and drainage map for drainage characteristics of watershed which are prepared with the help of satellite imagery and toposheets. To get the accurate ground control point, delineations of certain features like road network, water bodies, canals, settlements etc., from the toposheets are used for exact matching with those on the satellite imagery, this led to the preparation of base map. Drainage, slope, maps are prepared from the toposheets and land use / land cover; hydro geomorphology maps are prepared with satellite imagery and toposheets.

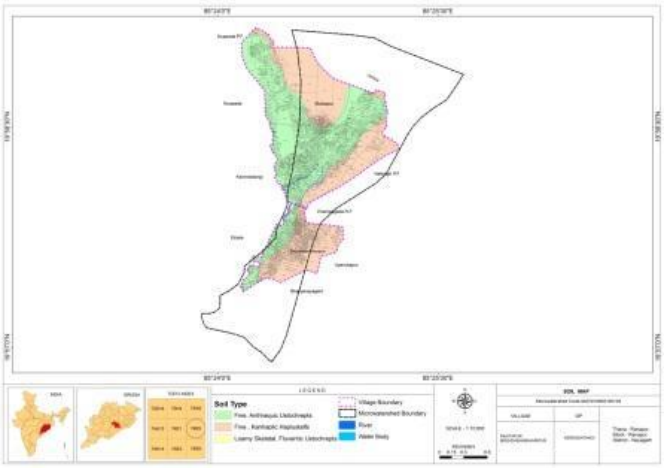

Fig. 5.

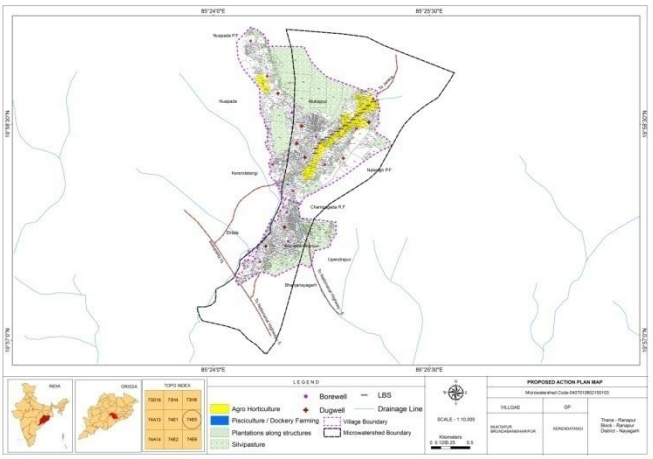

Fig. 6

Action plans for land and water resources development are interpreted from the land, water maps which are prepared by overlying the thematic maps. Ground Water Prospects map is generated by overlying the Hydro geomorphology and slope map. Similarly, Land resources map is generated with land use / land cover, slope maps and Water resources development map is generated using slope and drainage maps. To evaluate the crop/agriculture, by studying the existing cropping patterns and the available water resources in the study area with a view of available natural resources using above study for the extraction of feasibility condition for its development. Depending on the soils, climate, local practices by the people, socio- economic conditions of the people and also keeping in view of long term market prospects, cropping patterns are determined based on crop water requirement in view of water availability. To compute the crop water requirement by analyzing the meteorological data to optimize irrigation water requirement in order to use existing water for effective irrigation production. Suitable cropping patterns for a command area are recommended with the help of the above study. This map is also used as a guide map for ground truthing.

The action plan items includes sites for Agro horticulture, Plantation, Agro Silvipasture, Horizontal Drainage system, Vertical Drainage system, Bio drainage, Pisciculture / Dockery farming, Soil Conservation measures, Loose boulder structure, Dugwell & Borewell etc.

The total population of the study area is 1510 numbers and the availability of educational facilities are two primary schools and two minor schools but there is no high school available for higher study of students of those villages. Students are going a long distance for higher education .for that problems many students are free from higher studies.

Rural Economic Development

There are two approaches to market integration: bring the markets to the people (i.e., investing in road upgrades and related infrastructure), or bring the people to the markets (i.e., resettlement). This latter approach is embodied in the Focal Sites program, which concentrates infrastructure and social service investment in a small number of areas. The program goals are to improve agricultural techniques to ensure rice security, to provide extension services, to encourage cash crop production to enable villagers to purchase rice to make up for shortages, to clear land for paddy production, and improve irrigation, fishing, and watershed management.

Table 2: showing the village wise area.

NO	VILLAGE NAME	AREA IN Ha.	% OF AREA
1	Muktapur	229	79
2	Brundabanbiharipur	60	21

Socio Economic Conditions:

Table 3: village wise population of the study area

NO	VILLAGE NAME	POPULATION	MALE POPULATION	FEMALE POPULATION
1	Muktapur	748	366	382
2	Brundabanbiharipur	472	242	230

Table 4: Details of educational facilities

NO	VILLAGE NAME	PRIMARY SCHOOL	MINOR SCHOOL
1	Muktapur	1	1
2	Brundabanbiharipur	1	1

Conclusions

This study helps to get the digital data of the total village infrastructure facility, road network, according to their importance. If we analyze any road we can get the total information in the form of tabular attribute data, length of the roads, details along the roads. We can get the distance between any two settlements, infra structure facilities to the villages, and as a future extension, with the details available we can get the shortest route among the network and to know the location of available infrastructure facility. This is required for site suitability analysis for future development. Not only the road network and infrastructure details we can obtain the full details of the village as it is a Decision support system of the village level micro planning. For example we can get the socio-economic data like demographic details (household wise), economic status of the villager, details of farmer categories, transportation and live stock etc. For implementing these action plans some policy should follows-

1. Concentrate on contiguous sites defined by the threats to the landscape, chances of success and cost-effectiveness of the investment, where landscape and economic improvement will be self-evident.
2. Include all stakeholders in watershed management rather than only the poor farmers in

the target areas, as is the current practice among most development organizations.

3. Select preventive rather than curative activities, and base them on land use capacity and income generating potential for maximum cost-effectiveness.

4. Treat farmers, large and small, as informed clients to whom development organizations are accountable and who are capable of deciding what is good for them in the light of their resources, priorities and values.

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Vegetation Cover in Drought Prone Area: A Case Study of Village Hingni in Solapur

Dr. Arjun H. Nanaware, Arjun P. P. Satpute A. S. & Dighe D. J.

Abstract

Vegetation means total plant cover. A Human life without plants is quite unthinkable on the surface of the life forms, are greatly influenced by plant kingdom. Man gets food, fuel, fiber, timber, drugs, nuts, tan materials, rubber and various others thins from plants. The number of vehicles and industries are increasing day by day and it resulted in to increase of co_2. The plants are controlling temperature of atmosphere of Earth by consuming of co_2, Therefore attempt is made here to find out actual area under trees at micro level. The paper is based on primary data sources. For which field survey has been made, during the field survey the radius of each tree is measured by tape and field notes are prepared. Systematic sampling method is applied. To find out area under trees, the Geometrical equation i.e. area of circle = πr^2 technique has been utilized. The study reveals that the village Hingani (Pa.) has only 0.03 per cent of total geographical area is under vegetation cover in the village.

Introduction:

Forest means a dense growth of trees and underbrush covering a large tract. (Webster,s Collegiate Dictionary, 2004) Forest means a large area of land covered with trees and undergrowth. it is generally more extensive than woodland; consists of either natural or artificially planted vegetation with tall mature trees, which are often of commercial value and is dense growing forming a continuous canopy (Dictionary of Geography, 1984. Vegetation means total plant cover. (Webster,s Collegiate Dictionary, 2004). A plant is living thing that grows in the earth and has a stem, leaves and roots. A Human life without plants is quite unthinkable on the surface of the life forms, are greatly influenced by plant kingdom. Man gets food, fuel, fiber, timber, drugs, nuts, tan materials, rubber and various others thins from plants (Khan, 2007).

Trees are natural umbrella for ground surface because these protect the ground surface from erosion caused by falling raindrops and control radiation balance of the earth and the atmosphere by consuming increased amount of CO_2 released from ever increasing human volcanoes and thus prevent the earth from becoming too hot. It may be pointed out that forests intercept falling raindrops and thus spilt them and reduce their kinetic energy. Intercepted rainfall reaches the ground surface slowly in the form of 'AERIAL STREAMLETS' through the leaves, branches and stems of trees. Thick leaf litters on the ground surface after decomposition provides humus content to the soils and also makes the soil friable (Singh, 1998).

Air pollution can be minimized by the plants, Plants purify the air and produce oxygen which is a vital respiratory gas. Hazardous effects of temperature are minimized and thus thermal pollution can be controlled. Plants absorb sound waves and reduces sound pollution. Plants are the living places of birds, where they get protection, food and shelter

(Bharucha,2005). According to estimate of FAO of United Nation India have only 20 per cent area under forest, while in Maharastra it is 16.46 per cent. It is less than standard value because India is the world's largest consumer of fuel wood. The number of vehicles and industries are increasing day by day and it resulted in to increase of co_2. The plants are controlling temperature of atmosphere of Earth by consuming of co_2, Therefore attempt is made here to find out actual area under trees at micro level

Study Area

The Village Hingani (Pa.) lies in Southern part of Barshi Tahshil of Solapur District. Which is a part of drought prone area of Maharashtra. Absolute location of village is 18^0 5' 53''North latitude and 75^0 49' 55'' East longitudes. The geographical area of village is 22720 hectors, out of that 90.75 per cent is under cultivation. The village has hot and dry climate, with an average annual rainfall of 665.84 mm. The village has surface irrigation facility of Hingni (Pan) Medium Project.

Objectives:

The main objective of present paper is to study plant diversity and find out area under trees in the village Hingani

Data collection and methodology:

The paper is based on primary data sources. In order to meet these objectives the relevant information and data regarding types of trees and area under trees collected and used for the year of 2009-10 are based on the Primary sources. For which field survey has been made to obtain primary data. During the field survey the radius of each tree is measured by tape and field notes are prepared. During field survey 77 farmers were surveyed out of 155 land holder, which constitute 49.67 percent of total land holders. Systematic sampling method is applied; every second land holder is assessed. It has been helped to understand types of trees and area under trees. Information also collected from Talathi office. Collected rough data are processed. To find out area under trees it assumed that trees are generally circular in shape therefore to calculate the area under trees, the Geometrical equation i.e. area of circle = πr^2 technique has been utilized. On basis of these calculation the result and conclusions are drown.

Discussion:

Diversity of plants (Trees Only)

In the village Hingani (Pa.), 32 various types of trees are observed at the time of field survey. The names of the trees are given in the table-1, and these are Neem, Mango, Tamarind, Babul, Coconut, Sandal, Jujube, Javaplum, Guava, Aamla, Balck radish, Drumstick tree, Religiosa, Eucalyptus, Sweet sop, Teak, Pimparni, Palas, Country fig, Banyan tree, Almond, Khair, Foreign tamarind , Limbara, Ashoka, Pomogranate, Chickoo, Saundad, Shelvat, Castor Oil tree, Palm and Lemaon .

Ranking of trees:

The table -1 indicates that there are 32 trees observed in village Hingani (Pa.), and each of these having their special importance. Neem is the major tree of the region and it ranks first in number,141 Neem trees are

observed in the study area and its percentage is 28.6 to the total number of trees in the village, because it grows naturally and not necessary to plant it. It has thick bark therefore it have high drought resistance power. It is not harmful for other trees as well as crops. It is used for making furniture as well as fuel and medicine.

Coconut is not suitable in drought prone area yet it is second ranking tree in this village, because it is grown by watering due to the village Hingani have medium irrigation project. There are 71 trees are observed in this village and its percentage is 14.40 to the total number of trees in this village. It is not harmful to the other trees and it important in economic point of view crops therefore farmers grow it purposely.

The babul ranks third in number of trees and their percentage to the total number is 12.98 in village, 64 trees of babul are observed in this village. Babul is commonly observed tree in drought prone region everywhere. It is thorny tree and it has thick and rough bark therefore it has high drought resistance power but it is harmful to other trees and crops also. Because of its harmfulness to other trees and crops farmers are not in favour of preserving babul trees as like the above trees like Neem, and Coconut. It's wood is good for furniture and agricultural equipments. Furthermore it is useful as a medicine plant.

Mango is very important tree of study area and it ranks fourth in number and, like Neem it is not harmful for other trees and crops it provides sweet fruits. The tree is important in the economic point of view due to it is fruit trees. It also called king of fruits; therefore farmer grows it purposefully in their farms. There are 145 Mango trees in this village. It's percentage to the total number of trees is 11.36. It has low drought resistance power.

Table -1 type and number of trees in village Hingni (pa.)

Sr No	Name of trees	Number of trees	% to Total Number of trees
1	Neem	141	28.60
2	Coconut	71	14.40
3	Babual	64	12.98
4	Mango	56	11.36
5	Jujube fruit	23	4.67
6	Tamarind	23	4.67
7	Almond	15	3.04
8	Javaplum	13	2.64
9	Banayan tree	11	2.23
10	Religiosa	7	1.42
11	Teak	7	1.42
12	Ashok	6	1.22
13	eucalyptus	6	1.22
14	Country fig	6	1.22
15	Sandal	5	1.01

16	Drumstick tree	5	1.01
17	Guava	4	0.81
18	Sugar apple	4	0.81
19	Chikoo	3	0.61
20	Lemon	3	0.61
21	Castar oil tree	2	0.41
22	Amala	2	0.41
23	Black radish	2	0.41
24	Limbara	2	0.41
25	Palas	2	0.41
26	Pimparni	2	0.41
27	Saundad	2	0.41
28	Shelvat	2	0.41
29	Pomogranate	1	0.20
30	F. Tamarind	1	0.20
31	Khair	1	0.20
32	Palm	1	0.20

Source: Compiled by researcher based on field survey

Tamarind and Jujube-fruit both are fifth ranking trees in the village Hingani. The number of Tamarind and Jujube-fruit of each are found at 23 in the village during field survey and its percentage to the total number of trees is 4.67.Tamarind is very important tree in the economic point of view therefore farmers grow it purposefully. It also has high drought resistance power therefore these are found more in number. Almond is sixth ranking tree of the village, 15 trees are observed in the village and its percentage to the total number of trees is 3.04 per cent. Almond was planted by farmers by watering due to it's attraction and thik shadow. Javaplum is seventh ranking trees in the village. There are 13 trees of Java plum and percentage is 2.64. It is fruit trees. These trees requires very low amount of water. It is a favorable fruit of summer season and important from economic point of viewas well as it is a medicine plant, therefore it is planted by the farmers.

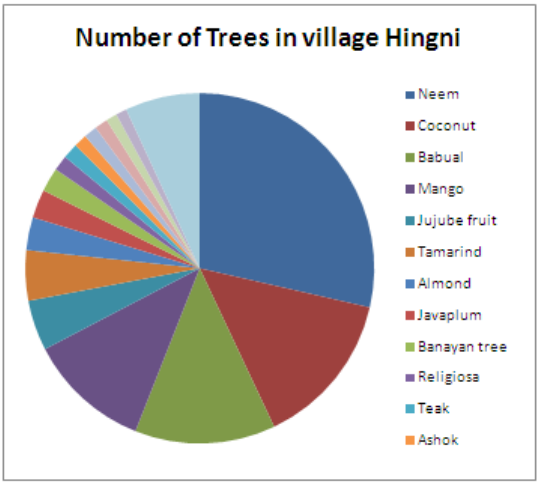

Fig.1.

Banayan tree is eigthth ranking trees in the village. There are 11 trees of Banayan tree and it,s percentage is 2.23 to total number of trees. It is one of the bigger trees and give more oxygen and thick shadow. It have religious impotant. Religiosa and Teak both are 9th raking trees in the village. There are 7 trees of Religiosa and it,s percentage is 1.42 to total number of trees. It have religious impotant. It is one of the bigger trees and give more oxygen and thick shadow. The percentage of Teak is also 1.42 to total number of trees. It is not suitable for this climate but farmer plants it deliberately due to its important from economic point of view. Considering number of trees Ashok, Eucalypltus and Country fig each are ranking 10th in the village Hingani (Pa.) and their percentage of each is 1.22 to total number of trees. Ashok and Nilgiri grows deliberately, while Eucalypltus grow naturally. Eucalypltus have religious important and it give more oxygen than other trees. Sandal and Drumstick tree both are is 11th ranking tree of the village, and their percentage is 1.01 percent of each. Both are economically important. Drumstick tree are planted while Sandal grows naturally. it is more suitable for the climate of the village. Sandal is valuable tree, because of its volubility it does not remain for longer period because of thievery. Thievery is only one cause of less number even though it is most suitable for this climate Some minor numbers of trees are observed in this village which is fruit and other trees e.g. Guava, Sugar apple, Chikoo, lemon, Amala, Castor oil tree, Black radish, Limbara, Palas, Pimparni, Saundad, Shelvat Pomegranate, Foreign tamarind, Khair and Palm these are very less in number and their percentage is less than one percent to total number of trees. All of these have very high drought resistance power and lives longer. Out of them fruit trees are planted and other trees grows naturally and most suitable to the area.

Area under different trees:

The table -2 and diagram-2 indicates that Neem, Mango, babul, coconut, Banayan tree and Tamarind acquires maximum area collectively i.e. 79.68 per cent of total. Neem is the major tree of the village. It acquires highest area i.e. 28.28 per cent of total area covered by different type of trees. Mango ranks second and its percentage to the total land covered by all trees is 15.07. Considering area under trees babul ranks third, it's share is 13.58 per cent of total area under trees

Table-2 Area under different trees in Village Hingni (Pa.)

Sr No	Name of trees	Number of trees	Area in SQ M	% to total area under trees
1	Neem	141	17171.25	28.28
2	Coconut	71	4675.4	7.70
3	Mango	56	9151.97	15.07
4	Babual	64	8246.61	13.58
5	Jujube Fruit	23	1736.88	2.86
6	Tamarind	23	4558.93	7.51
7	Almond	15	1327.9	2.19
8	Javaplum	13	2059.14	3.39
9	Banayan tree	11	4572.84	7.53
10	Religiosa	7	1794.79	2.96
11	Teak	7	270.23	0.45
12	Ashok	6	43.77	0.07
13	Eucalyptus	6	437.33	0.72
14	Country fig	6	538.89	0.89
15	Sandal	5	198.66	0.33
16	Drumstick tree	5	220.36	0.36
17	Guava	4	633.49	1.04
18	Sugar Apple	4	450.52	0.74
19	Chikoo	3	104.1	0.17
20	Lemon	3	205.38	0.34
21	Castor Oil tree	2	25.12	0.04
22	Amala	2	274.56	0.45
23	Black radish	2	150.84	0.25
24	Limbara	2	88.23	0.15
25	Palas	2	244.45	0.40
26	Pimparni	2	659.8	1.09
27	Saundad	2	211.51	0.35
28	Shelvat	2	157	0.26
29	Pomogranate	1	40.69	0.07
30	F. Tamarind	1	339.62	0.56
31	Khair	1	113.04	0.19
32	Palm	1	13.84	0.02

Source: Compiled by Researcher based on field survey

While Coconut and Banayan tree occupy 7.70 and 7.53 per cent of total area under trees. Tamarind acquires 7.51 to the total land covered by all trees.

The share of Jujube, Java plum, Almond and Religiosa are ranging in between 2.19 to 3.39 per cent of total area under trees. The Jujube, Java plum, Almonds are the fruits trees as well as provides timber & furniture wood. Pimparni and Guava acquires 1.09 and 1.04 percent of total area covered by different trees in the village respectively. In spite of the above explained trees there are 20 different types of trees observed in the village and occupies less than 1per cent of total land covered by all type of trees.

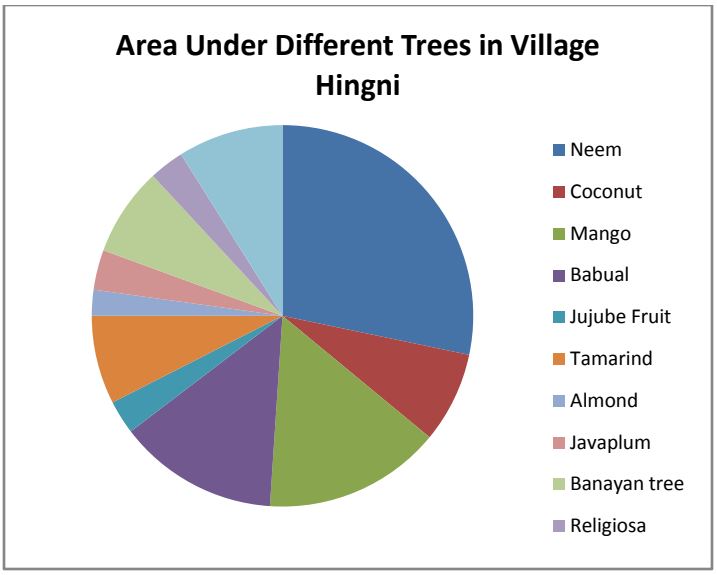

Fig. 2.

Concluding remarks:

The fore going analysis reveals that there are 32 types of trees which provide fruits, wood for furniture, and agriculture equipment and building materials. The study of ranking trees indicates that the trees those having high drought resistance power are higher in numbers i.e. Neem, Babul, Tarmarind, and Banayan tree. Mango and Coconut ranks second and 4th only due to it is economic important. Mango is popular tree known as king of fruits its higher rank is due to irrigation facility. The study of area under trees reveals that high share Neem is mainly due to it's drought resistance power, while high share of mango is result of its popularity in farmer due economic important. The study of vegetation cover reveals the share of Neem, Mango, Babul, Tamrid, Coconut and Banayan tree is high in area under trees, while Palm, Khair, Black radish, Shelvat and limbara occupies very low area, because of their less importance. The trees acquiring less than 1 per cent will disappear in future. The village Hingani (Pa.) has only 0.03 per cent of total

geographical area is under vegetation cover in the village. As compared to the state and country it is also very low. It is also too much below the standard value therefore how we can expect sufficient rainfall, sufficient ground water and over all environmental balance. Therefore there is dire need to increase area under vegetation to maintain environmental balance. Therefore it is suggested that to make awareness in the farmers to grow such species that naturally growand which have high drought registance power i.e. Neeem, Babul and Tamarind .

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"SOIL, WATER, AND CROP RELATIONSHIP OF OSMANABAD DISTRICT A GEOGRAPHICAL ANALYSIS"

Tatipamul R.V & Dr. Shinde.N.G

Abstract

This paper studies Soil, Water and Crop relationship of Osmanabad District with their environmental conditions and Tahsil wise variations. Soil is the main base of Agriculture. There are many factors affecting on to Agriculture, i.e. Geology, Terrain, Slope, Climate, and human population. Soil structure and soil texture affecting on cropping pattern and crop types. Soil quality, soil properties influence on the crops production. Farmers usually grow crops which is suitable to soil first then market. Water is also playing major role in soil and crop relationship. Osmanabad district comes under drought conditions. Rainfall is irregular and irrigation facilities are insufficient. District shown some major crops concentration i.e. Jawar and Cotton etc. Osmanabad district geographically comes under in drought condition. Increasing attention on cash crops plantation and increasing food Production which requires more water and chemical fertilizer are affecting to reduce soil fertility. Increasing population pressure affecting on intensive use of soil with high yielding varities as well as chemical fertilizer.

Introduction

Osmanabad is one of the district of Marathwada region of Maharashtra and famous for Tuljabhavani temple at Tuljapur. The district has a geographical area of 7512 sq. km. It has a total population of 14, 86, 586 as per 2001 census. The district forms part of Godavari Basin and Manjra Sub basin. Manjra, Sina, Terna, Bori, Benitura, Banganga are the main rivers flowing through the district.

This paper studies Soil, Water and Crop relationship of Osmanabad District with their environmental conditions and Tahsil wise variations. Since independence remarkable progress has been taken place in Agriculture in India. Sources of irrigation, rainfall, soil, farm size, farmer's economic condition playing vital role in the Agriculture. There are many factors affecting on to Agriculture, i.e. Geology, Terrain, Slope, Climate, and human population. Soil is the main base of agriculture in any region. Soil structure and soil texture affecting on cropping pattern and crop types. Soil quality, soil properties influence on the crops production. Farmers usually grow crops which is suitable to soil first then market. Water is also playing major role in soil and crop relationship. Osmanabad district comes under drought conditions. Rainfall is irregular and irrigation facilities are insufficient. District shown some major crops concentration i.e. jawar and cotton etc. Now days population increasing day by day it's badly affect on the environment. Osmanabad district geographically comes under in drought condition. Increasing attention on cash crops plantation and increasing food Production which requires more water and chemical fertilizer are affecting to reduce soil fertility.

Soil is a natural body consisting of layers (soil horizons) that are primarily composed of minerals which differ from their parent materials in their texture, structure, consistency, and color , chemical, biological and other characteristics. It is the unconsolidated or loose covering of fine rock particles that covers the surface of the earth. Soil is the end product of the influence of the climate (temperature, precipitation), relief (slope), organisms (flora and fauna), parent materials (original minerals), and time.

Crops refer to plants that are grown on a large scale for food, clothing, and other human uses. They are non-animal species or varieties grown to be harvested as food, livestock fodder, fuel or for any other economic purpose (for example, for use as dyes, medicinal, and cosmetic use). Major crops include sugarcane, pumpkin, maize (corn), wheat, rice, cassava, soybeans, hay, potatoes and cotton. While the term "crop" most commonly refers to plants, it can also include species from other biological kingdoms. For example, mushrooms like shiitake, which are in the fungi kingdom, can be referred to as "crops". Based on the growing season, the crops grown in India can be classified as kharif crop and Rabi crops.

Water The most important use of water in agriculture is for irrigation, which is a key component to produce enough food. Irrigation takes up to 90% of water withdrawn in some developing countries and significant proportions in more economically developed countries. Fifty years ago, the common perception was that water was an infinite resource. At this time, there were fewer than half the current numbers of people on the planet. People were not as wealthy as today, consumed fewer calories and ate less meat, so less water was needed to produce their food. They required a third of the volume of water we presently take from rivers. Today, the competition for the fixed amount of water resources is much more intense, giving rise to the concept of peak water. This is because there are now nearly seven billion people on the planet, their consumption of water-thirsty meat and vegetables is rising, and there is increasing competition for water from industry, urbanization, and bio fuel crops. In future, even more water will be needed to produce food because the Earth's population is forecast to rise to 9 billion by 2050. An additional 2.5 or 3 billion people, choosing to eat fewer cereals and more meat and vegetables could add an additional five million kilometers to the virtual canal mentioned above.

An assessment of water management in agriculture was conducted in 2007 by the International Water Management Institute in Sri Lanka to see if the world had sufficient water to provide food for its growing population. It assessed the current availability of water for agriculture on a global scale and mapped out locations suffering from water scarcity. It found that a fifth of the world's people, more than 1.2 billion, live in areas of physical water scarcity, where there is not enough water to meet all demands. A further 1.6 billion people live in areas experiencing economic water scarcity, where the lacks of investment in water or insufficient human capacity make it impossible for authorities to satisfy the demand for water. The report found that it would be possible to produce the food required in future, but that continuation of today's food production and environmental trends would lead to crises in many parts of the world. To avoid a global water crisis, farmers will have to strive to increase

productivity to meet growing demands for food, while industry and cities find ways to use water more efficiently.

Objective: -

The main objective of the study is to showing the Soil, water and crop relationship in the Osmanabad district. Osmanabad district having the variety of soil types, disparity in crop production. Sources of irrigation, Ground water resources, irrigation impact on agriculture land are the specified objectives of the study.

Sources of Data and Information:-

The entire research paper is based on secondary data. The secondary data and information have been taken from the Director, District irrigation department of Osmanabad, District Agricultural Office etc. Through the literature available, Survey and field knowledge of soil geology scenario in Osmanabad district has been used to supplement the quantitative and qualitative analysis of the present study.

Methodology:-

Topographical maps are used for physiographic study. Land use data collected from socio-economic abstract, Osmanabad district and District Census Hand book are referred to collect related information. After collecting the data it has been organized, tabulated, & then analyzed. Whenever necessary the maps and the graphs have been prepared to help the analysis.

Study Area

Osmanabad is district in the state of Maharashtra in India. The district headquarters is located at Osmanabad. Temple of goddess Tuljabhavani at Tulajapur is famous in India. The district occupies an area_of 7512.4 km² of which 241.4 km² is urban area and has a population of 1,486,586 of which 15.69% were urban (as of 2001). Osmanabad district lies in the southern part of state. It lies on the Deccan plateau, about 600 m above sea level. Parts of the Manjara and Terna flow through the district. The district is located on east side of Marathwada region within the range latitude 17.35 to 18.40 degrees north, and latitude 75.16 to 76.40 degrees east. In Osmanabad District generally the rainy season starts from mid-June and continues till the end of September. The climate is humid in October and November and dry and cool from mid-November to January. From February to June the climate is dry and becomes increasingly hot. During summer the temperature of Osmanabad district is low compared to other districts of Marathwada region. The average annual rainfall in the district is 730 mm. Temperature Max.: 42.1 °C; Min.: 8 °C, but now days there is growth in temperature up to 44°C. There are eight talukas (Tahsil) in Osmanabad district. i.e. Osmanabad**,** Tuljapur, Omerga ,Lohara, Kallamb, Bhoom, Paranda, Vashi.

LOCATION MAP OF THE STUDY AREA

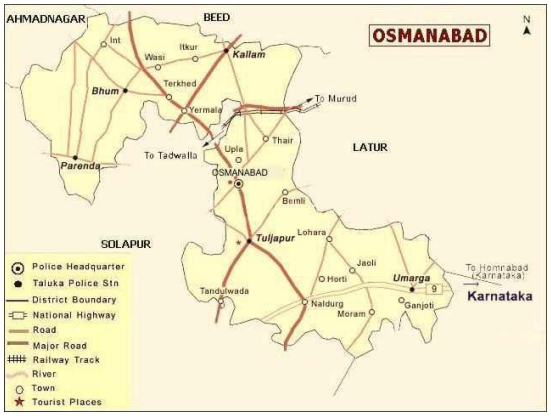

Fig. 1.

Table:-1 Annual Rainfall Data (1998-2007)

Sr No	Tahsil	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
1	Osmanabad	1278.4	591	948.8	614.9	679.2	431.4	741	857	673.6	979.4	**779.47**
2	Tuljapur	1408.8	598.4	864.4	684.7	651.2	498.2	882.4	874.2	857	821	**814.03**
3	Paranda	925.8	479.1	633.1	474.2	398.5	266	598	508	554	631.8	**546.85**
4	Bhoom	1242.1	735.8	816.2	475	702.6	473	684.7	690	746	832.7	**739.81**
5	Kallam	1416.2	873	827.2	596.3	668	576	915.5	1049	760	746.8	**842.80**
6	Omerga	1206.5	610.2	975.2	484.8	633.4	621	666.9	954.4	642	678.1	**747.25**
7	Lohara	556.6	NA	677.4	642.8	626.4	461.8	604.5	817.4	652	705.4	**574.43**
8	Washi	1200.6	NA	746.8	552.6	605.6	383	696.9	747.6	782.6	797.5	**651.32**
	Average	**1154.3**	**485.93**	**811.13**	**565.66**	**620.6**	**463.8**	**723.7**	**812.2**	**708.4**	**774.1**	**711.99**

Role of Climate and Rainfall in Soil and Crop relationship

The climate of the district is characterized by a hot summer and general dryness throughout the year except during the south-west monsoon season, i.e., June to September. The mean minimum temperature is 8.5°C and means maximum temperature is 42.5°C. The normal annual rainfall over the district varies from 600 mm to about 850 mm. It is minimum in the western parts of the district around Paranda (629 mm) and increases towards east and reaches a maximum around Osmanabad (840 mm). The average annual rainfall ranges from 546.85 mm (Paranda) to 842.80 mm (Kallam).

Soil Map of Osmanabad

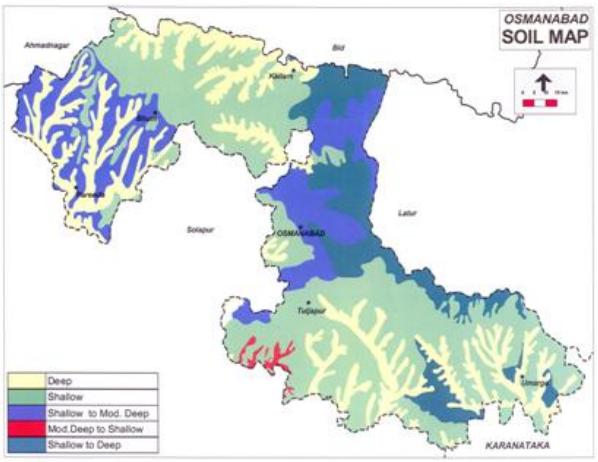

Fig.2

Data Interpretation:-

According to soil types and their relationship with crop as under.

Correlates of Soil, Water, and Crop relationship:-

1) **Soil, Water and crop relationship in the Rain fed Situation**
   - A) **Medium deep to deep black soil with assured rainfall**: - This type of soil is suitable for pigeon pea, sorghum, Black gram, soybean, and sunflowers.
   - B) **Shallow soils with assured rainfall: -** It is suitable for Pearl millets, Soybean, Black gram, sorghum pigeon pea.
   - C) **Medium deep to deep black soils with low rainfall:**- It is suitable for pigeon pea, sorghum, Black gram, soybean etc.
   - D) **Shallow soils with low rainfall**:- It is suitable for pigeon pea, sorghum, Black gram and Pearl millets etc.
2) **Soil , water and crop relationship in Irrigated situation**
   - A) **Medium deep to deep black cotton Soil with assured rainfall**: - This type of soil is suitable for sugarcane, Turmeric, Vegetables crops, Mango etc.
   - B) **Shallow soils with assured rainfall: -** It is suitable for grape, Kagzilime.
   - C) **Medium deep to deep black soils with low rainfall:**- It is suitable for wheat and Onion.
   - D) **Shallow soils with low rainfall**: - It is suitable for wheat only.
3) **Soil , Water and crop relationship in Non release of water in canals under delayed onset of Monsoon in catchment**
   - A) **Medium deep to deep black cotton Soil with assured rainfall**: - In this situation sugarcane replaced by cotton, turmeric replaced by safflower and vegetable crops replaced by Pigeanpea.
   - B) **Shallow soils with assured rainfall: -** In this situation grape, Kagzilime are grown without any change.
   - C) **Medium deep to deep black soils with low rainfall:**- in this situation sugarcane, Turmeric, Vegetable crops replaced by cotton, Safflower and pigeanpea respectively.
   - D) **Shallow soils with low rainfall**: - in this situation no change will occur.

Conclusion:-

According to climatic condition, role of monsoon, soil, water and crop relationship changes. Soil, water, and crop relationship is interrelated to each other. In Osmanabad district the soil profile is complex. In the Rain fed situation Pigeon Pea, Sorghum, Black gram, Soybean is grown in the district. Medium deep to deep black cotton Soil with assured rainfall type of soil is suitable for sugarcane, Turmeric, Vegetables crops, Mango etc. Medium deep to deep black soils with low rainfall type region is suitable for wheat and Onion. In Osmanabad

District the Soil, Water and Crop relationship with their environmental conditions and Tahsil wise variations are found.

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Geographical Assessment of Sugarcane Crop in Solapur District (M.S)

Dr. Govindrao U. Todkari, Dr.Virbhadra C. Dande

Abstract

Sugarcane forms the basic materials for sugar industries. If production of this crop increased it could facilitate, not only the development of agro based industries but also boost our export of sugar and thereby improve of our economic position by earning foreign exchange. The total cropped area of Solapur District is 1065000 hectors in 2005. Among them only 8.63 percent area under sugarcane crops. Therefore, the spatial distribution of sugarcane is uneven and last two decade large change observed in District. So the present paper tries to assess the temporal change and spatial pattern of sugarcane cultivation and to suggest optimum suggestion for sugarcane cultivation in study region.

Introduction

Sugarcane is a major garden crop in the district. The cultivation of sugarcane has been steadily increasing because of the opening of sugar factories in this district and also due to the availability of increasing irrigation facilities. Sugarcane is mainly an irrigated crop and is grown all over the district in deep black soils. The sugarcane cultivation has considerably increased in the canal areas since the opening of the Nira Canals, Bhima-Sina river joint canal in district. Sugarcane is a twelve-month crop and is planted in the month of January. The treading system is usually followed with the poorer canes or in poor soil and it requires manuring after ten or twelve days of planting. The trodden cane sprouts a month after planting, but the plough cane, being deeper set, takes a month and a half to sprout but suffers less from any changes in climate, supply of water, etc., and reaches greater perfection. Sugarcane is either eaten raw or is made into sugar or gur. The development of irrigation facilities and techniques the Sugercane cultivation area increased in Solapur district. The present paper assess the spatial pattern of Sugercane cultivation and area changes during investigation period.

The sugarcane plant is classified under the genus ‘saccharum’ the word being derived from the Sanskrit word ‘sharkara. It is locally called as ‘Oos. It is the main source of sugar in India and a premier cash crop. It is grown mainly in the irrigated area in the study region. It holds the top most position in the economy of the district. It is used for making white sugar.

Objective

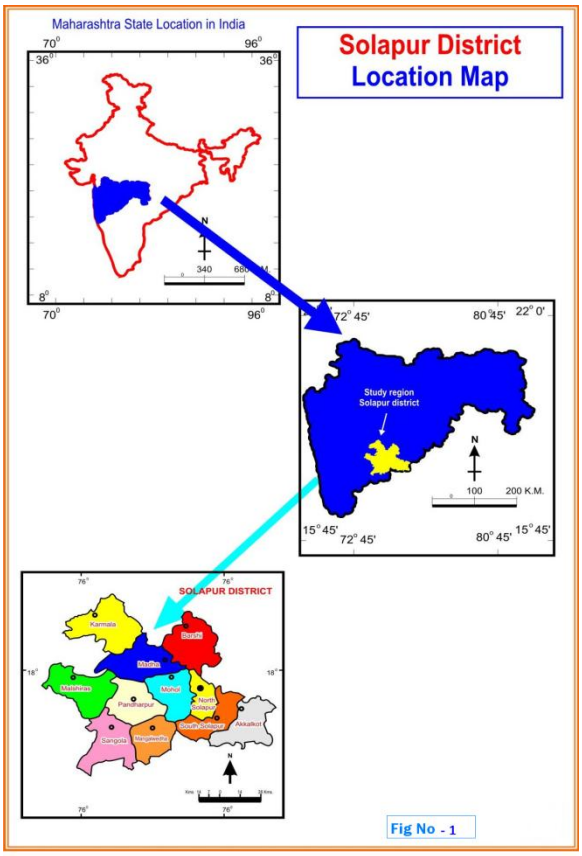
1. To assess the spatial pattern of sugarcane cultivation in Solapur District.
2. To find out the temporal changes in study region during investigation period.

Study Area

The present study deals with the geographical perspectives of the agriculture in Solapur district. The Solapur district is bounded by 17º05' North latitudes to 18º 32' North latitudes and 74º42' east to 76º15' East longitudes. The total geographical area of Solapur district is 14895Sq. K.m. divided into eleven tahsils. Climate of the district is dry. The daily mean maximum temperature range between 30º C to 35º C and minimum temperature range between 18ºC to 21ºC. The highest temperature is 47º C recorded in the month of May. The average annual rainfall is registered 510 mm. The soil of the district essentially derived from the Deccan trap. The soil of the district can broadly classify into three groups shallow, medium and deep soil.

Data base and Methodology

Present study mostly relies on the secondary data is collected through District statistical Department of Solapur and District socio-economic abstract of Solapur District. The total district (11 tahsils) has selected for investigation in the year of 2004/05. The sugarcane area have measured from 1990/91 to 2004/05. The suitable cartographic technique



was adopted to depict map to find out spatio-temporal variation of sugarcane in Solapur district of Maharashtra.

Discussion

Sugarcane is one of the most important cash crops, grown in the region under study. The cultivation of sugar cane has been steadily increasing because of the opening of number sugar factories in the district and also due to the increase in the irrigation facilities. Sugarcane is only irrigated crop and is grown all over the district in deep black soils. The local variety of sugarcane is known as *pundya* and is grown throughout the district. It is a soft cane and is mainly used for chewing and extracting juice for drinking. Improved varieties such as C.O.-740, C.O.-419 and C.O.-775 have been introduced by the department of agriculture in the district. These varieties give a better yield. They are hard and cannot be easily crushed on the wooden mills. The *brix* is higher than the local, varying from 20 inches to 22 inches. Top sets cannot be used for fodder as these varieties are of flowering type. Generally the whole cane is cut into layers for planting in furrows, three to four feet apart. There are 17 sugar factories in the study region.

Environmental Requirements :-

It is a water loving tropical crop and therefore, requires high temperature, maximum moisture and well developed irrigation facilities. The temperatures ranging between 20°c to 32°c is favourable for sugarcane cultivation and it requires 700 mm to 1200 mm rainfall. The optimum growth of the crop depends on the soil condition. It grows best on medium to deepblack soil, regur soil and alluvial soil. Water logging or alkalinity makes soils unfit for this crop. Presently, sugarcane is facing "mava" disease in the study region.

Spatial Distribution

Sugarcane is a major garden crop in the district. The cultivation of sugarcane has been steadily increasing because of the opening of sugar factories in this district and also due to the availability of increasing irrigation facilities. Sugarcane is mainly an irrigated crop and is grown all over the district in deep black soils. About 6.95 percent of the net sown area of the district was under sugarcane in 2004-05. The distribution of sugarcane in the study area is widespread. It depicts the regional variation of the area under sugarcane which ranges from 2 to 22 percent of the net sown area. The tahsils of Pandharpur and Malshiras record over 18 percent area followed by Mohol, Sangola, Akkalkot and South Solapur tahsils with 5 percent to 10 percent area under sugarcane. And the rest of the tahasils have very little proportion (below 5 %) of area the under sugarcane.

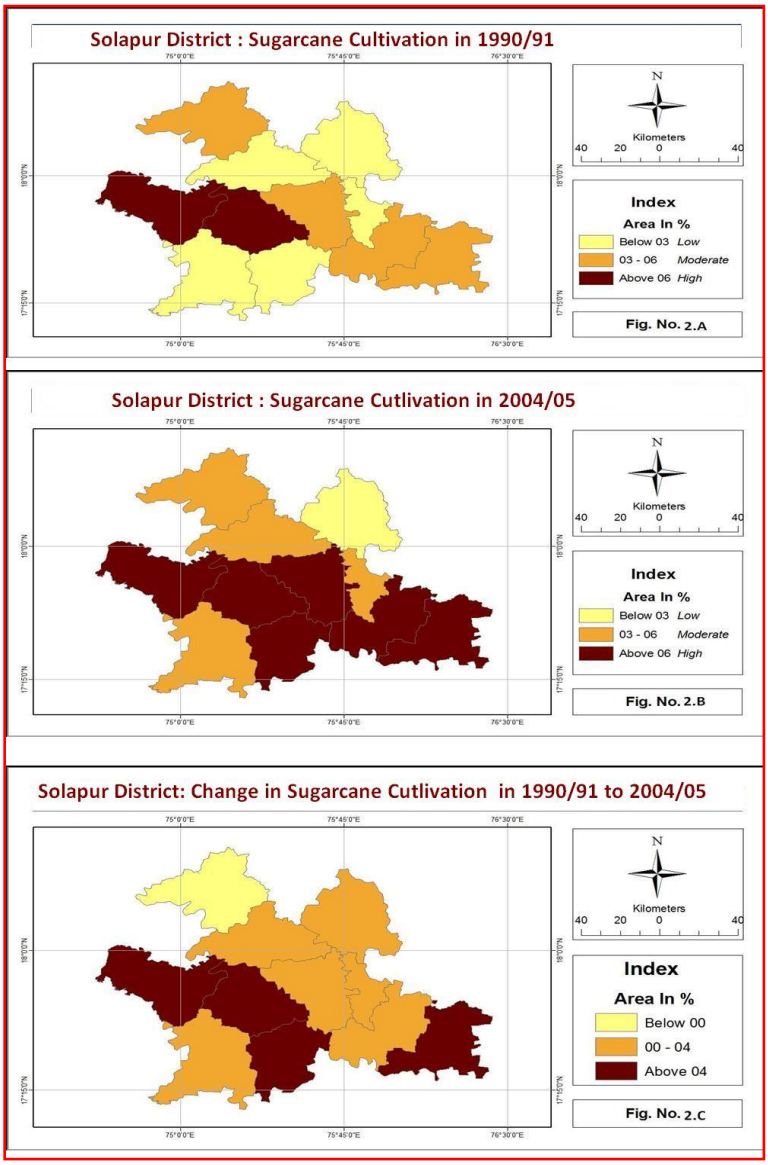
Table No 1. Percentage of Sugarcane Area to total agriculture area.

Tahsil	1990-91 (hectors)	%to agri. area	2004-05 (hectors)	%to agri. area	Change - 990-91 to 2004-05
Karmala	450	3.62	2783	3.14	-0.48
Madha	2513	2.00	3337	3.05	+1.05
Barshi	1441	1.23	2272	2.64	+1.41
N Solapur	890	1.59	1250	3.07	+1.48
Mohol	3705	3.40	5684	6.29	+2.89
Pandharpur	11468	11.70	19331	20.78	+9.08
Malshiras	11732	13.38	17949	18.62	+5.24
Sangola	3331	2.94	4706	5.76	+2.82
Mangalwedha	2134	2.33	8690	9.13	+6.80
S Solapur	3006	3.23	5775	6.98	+3.75
Akkalkot	4620	4.07	9595	9.69	+5.62
District	65316	4.39	1065000	8.63	+4.24

Source:- Socio-economic abstract of Solapur district 1990-91 &2004-05

Temporal Analysis

The pattern of change in sugarcane cropping in the region is also observed in study region. Sugarcane is a crop which exhausts the soil and, therefore, it is not grown in the same field from year to year but is rotated in alternate years with food-crops. The area under sugarcane has been increased significantly during the period under investigation and this is mainly due to the increased irrigation facilities in recent years in all the tahasils of the district. One tahsil (Pandharpur) record above 9.08 percent while Malshiras, Mangalwedha and Akkalkot tahsils have recorded an increase from 5 to 7 percent. The remaining tahsils have increased the sugarcane area to small extent (below 4 %) except Karmala Tahsil. In Karmala Tahasil sugarcane has decreased owing to shallow soil , rough topography and lack of irrigation facility.


Solapur District : Sugarcane Cultivation in 1990/91
75°0'0"E
75°45'0"E
76°30'0"E
18°30'0"N
17°15'0"N
N
Kilometers
40 20 0 40
Index
Area In %
Below 03 Low
03 - 06 Moderate
Above 06 High
Fig. No. 2.A
Solapur District : Sugarcane Cutlivation in 2004/05
Index
Area In %
Below 03 Low
03 - 06 Moderate
Above 06 High
Fig. No. 2.B
Solapur District: Change in Sugarcane Cutlivation in 1990/91 to 2004/05
Index
Area In %
Below 00
00 - 04
Above 04
Fig. No. 2.C

Conclusion

Sugarcane is a major cash crop in the district. The cultivation of sugarcane has been steadily increasing because of the opening of sugar factories in this district and also due to the availability of increasing irrigation facilities. Sugarcane is mainly an irrigated crop and is grown all over the district in deep black soils. It depicts the regional variation of the area under sugarcane which ranges from 2 to 22 percent of the net sown area. The tahsils of Pandharpur and Malshiras record over 18 percent area followed by Mohol, Sangola, Akkalkot and South Solapur tahsils with 5 percent to 10 percent area under sugarcane.

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Ground Water Potential Mapping Using Geo-Spatial Technology: A Case Study of Sidhewadi Village of Sangli District

Subhash Chavare, S.D. Koli, Dr. S. D. Shinde

Abstract:

Ground water is easily the most important component and constitutes about two thirds of the fresh water resources of the world. In the present study, the modern geo-spatial technologies, namely remote sensing and GIS were used in the identification of ground water potential zones in the Sidhewadi village in Sangli district at micro level. The Sidhewadi village falls in drought prone area, so its need to delineate the potential zone for the sustainable ground water management and development. Satellite images (Landsat) along with other thematic data sets such as geology, slope, land use/ land cover, drainage density, and soil have been utilized about the study area and assigned weight and rank to each layer and multi criteria overlay analysis has been carried out using ArcMap software to find out the potential zones. Accordingly, it classified as highly potential, moderately potential, low potential and very low potential etc.

Keywords: Ground water, Geo-Spatial Technology, Multi -Criteria Overlay Analysis

Introduction:

Water is the most important renewable natural resources since it is required for agriculture, industry, and domestic purposes. The remote sensing data combined with field survey data can provide a unique and hybrid database for mapping of groundwater potential zones. The recent technologies like Remote Sensing and GIS helps us by giving a quicker and cost effective analysis for various applications with accuracy for planning and sustainable development.

Geo-spatial technology for Analysis of Groundwater Potential Zone Mapping

A GIS is a composite of computer based decision support tools for the integration of spatial data from different sources and for the analysis, manipulation, and display of these data. It is therefore, an excellent tool for the management of large bodies of spatially extensive data with all the advantages of a computer environment precision, consistency, and absence of computational error. The GIS applications as a long-term goal in the realization of a new strategy in land suitability analysis primarily assumes the collecting, systematization, and analysis of topographic, pedological, and hydro-meteorological data. The recent technologies like Remote Sensing and GIS helps us by giving a quicker and cost effective analysis for various applications with accuracy for planning and sustainable development.

This study was undertaken to delineate groundwater potential zones for irrigation and domestic purposes in the Siddhewadi village, using remote sensing data and GIS techniques.

Objective:

The objective of present study is to delineate groundwater potential zones of Siddhewadi village using remote sensing and geographical information systems (GIS).

Study Region:

- Siddhewadi village is situated nearly 20km North-East of Tasgaon City in Sangli district.
- On the bank of Agrani river, a small tributary of the river Krishna at 17° 8' North latitude and 74° 47' East longitude.
- The average height of the region is 460-meter M.S.L, maximum and minimum temperature is 38° c and 15° c respectively with average annual rainfall of 300 mm. In 2001 the village had a population of 4332, spreading over an area of 2181.4 hectares.

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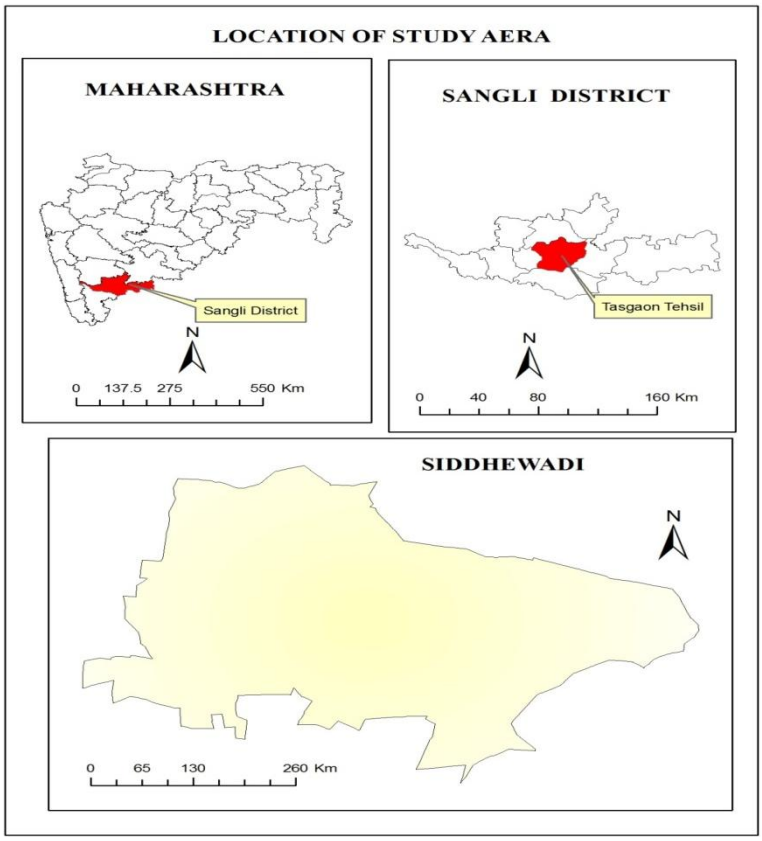

Fig.1 Location of Study Area

Database:

- **Satellite Data**
- The satellite data used in the study is acquired from Landsat ETM+ in the form of geo-coded false color composite (FCC).
- SRTM elevation data
- The feature are distinguished using the interpretation key tone, texture, size, shape, and association are used to interpret land use pattern.
- **Ancillary Data**
- The Survey of India (SOI) toposheets 47K/16 of 1:50,000 scale to prepare base map, drainage and water body layer and for field work and ground truth verification.

Thematic Layer	Map Weight	Individual Features	Ranks
Land Use/ Land Cover	0.30	Agricultural Crop Land	40
		Built up Land	0
		Forest	40
		Waste Land	20
		Water bodies	-
Slope	0.20	0-3 %	50
		3-5%	30
		5-8%	15
		8-21%	5
Soil Texture	0.20	Deep Black	45
		Medium Black	35
		Shallow Black	20
Geomorphology	0.20	Alluvial Plain	30
		Highly/ Moderately Dissected Plateau	25
		Denudational Hills	20
		Denudational Slope	7

Table. 1 Weightage and Ranks Assigned

Methodology:

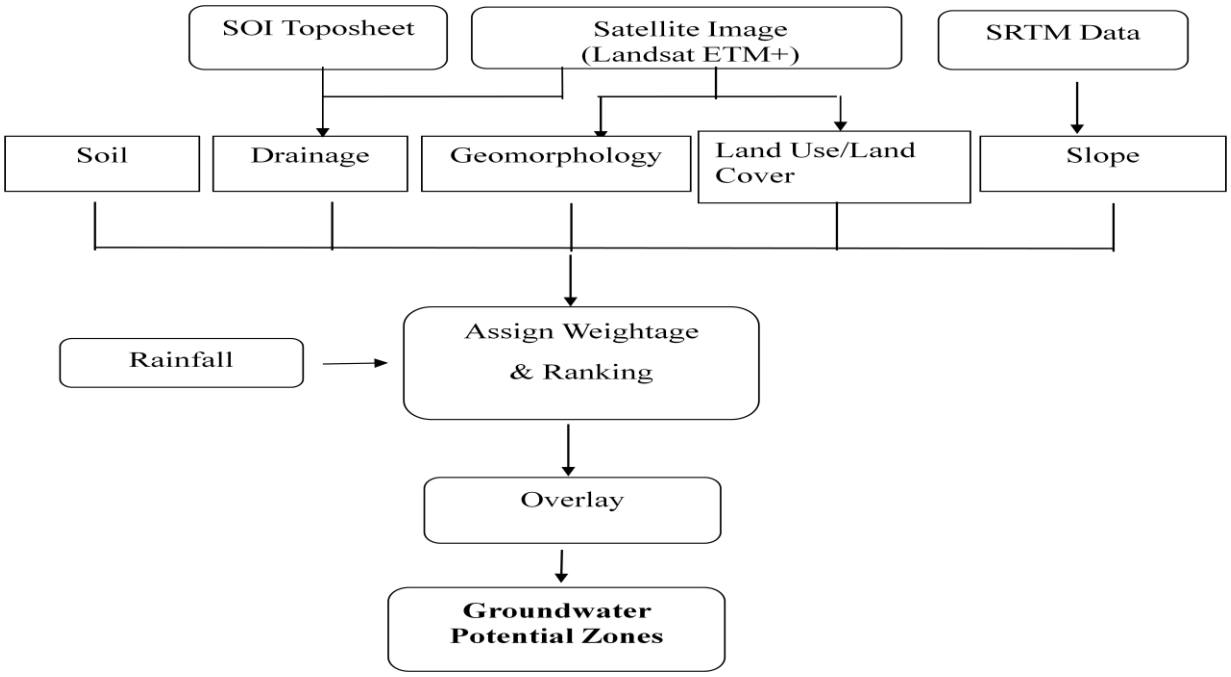

Fig. 2 Methodology

Result and Discussion:

Thematic Layers

The study is based on various thematic layers such as drainage, soil, soil depth, slope, soil erosion, land capability, geomorphology, and land use / land cover. These thematic layers were prepared using various spatial and non spatial databases and analyzed using various GIS and digital image processing software's like ArcGIS Desktop 9.2 and ERDAS 9.2 respectively. GIS based approach for the suitable site selection gives effective solution where different thematic layers are overlay using GIS techniques. Appropriate ancillary data is used for generation of respective thematic layers.

Ground Water Potential Zones:

The integration and analyses of various thematic maps and image data proved useful for the delineation of zones of groundwater potential. The ground water potential zones are high potential, moderate, low and very low potential. The western part of the study area is under the moderate potential zone, and south eastern part having very low potential.

Conclusion:

In the Siddhewadi village nearly 40 per cent area is highly potential for the groundwater. Remote sensing and GIS techniques are effective tools for mapping of groundwater potential zones using various thematic parameters for the proper planning and sustainable water resources development.

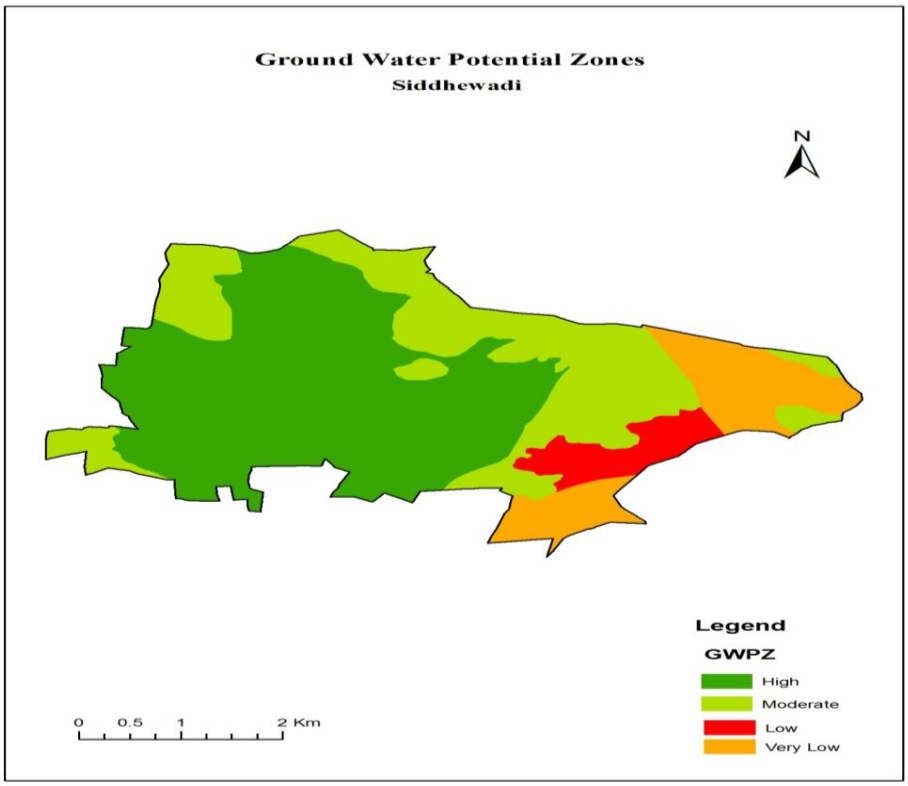

Fig. 3
Ground Water Potential Zones

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