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ENVIRONMENTAL ISSUES OF URBAN HEAT ISLAND: A CASE STUDY OF RANCHI CITY

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ABSTRACT

This study aims to discover issues which are changing the landscape as well as environmental composition and configuration of Ranchi city area and developing Urban Heat Island (UHI) phenomenon inthis urban area. UHI is geographically a micro-climatic phenomenon. Itis becoming general 'heat effect' due to the environmental impact of rapid and unsustainable urbanization. It occurs within urban areas and consists of, generally, warmer temperature than that's rural surroundings. UHI is the variation in Land Surface Temperature (LST) between the urban realm and the surrounding rural areas because it is an indicator for measuring UHIs (Voogt, J.A.; Oke, T.R., 2003). The surface temperature has indirect but considerably significant influence on air temperatures, especially the canopy layer that is closest to the surface (Zhang, J.; Wang, Y., 2008). The UHI intensity is defined as the difference between urban and rural air temperature (Oke 1972). The surface temperature of an urban area is influenced by many factors like the length of day, season, wind, ocean currents, clouds, topography, location, rural surroundings, land use, building material and city geometry (Valsson, S.; Bharat, A., 2009,Lo, C.P.; Quattrochi, D.A.,2003). These impacts are seen in the form of thermal pollution, air pollution, water pollution and health risks. In UHI fields urban dwellers facegeneral discomfort, respiratory difficulties, heat cramps, heat strokes, and heat related mortality. Ranchi, the capital of Jharkhand state, was earlier known as the summer capital, but it has now become a city of Urban Heat Island, especially during summer. This study is to investigate environmental issues of UHI impact in Ranchi Urban Area (RUA). Land surface temperature data (LST), data on land-Use/ land-Cover , air temperature data, rainfall data have been used in the investigation of UHI of the study area.

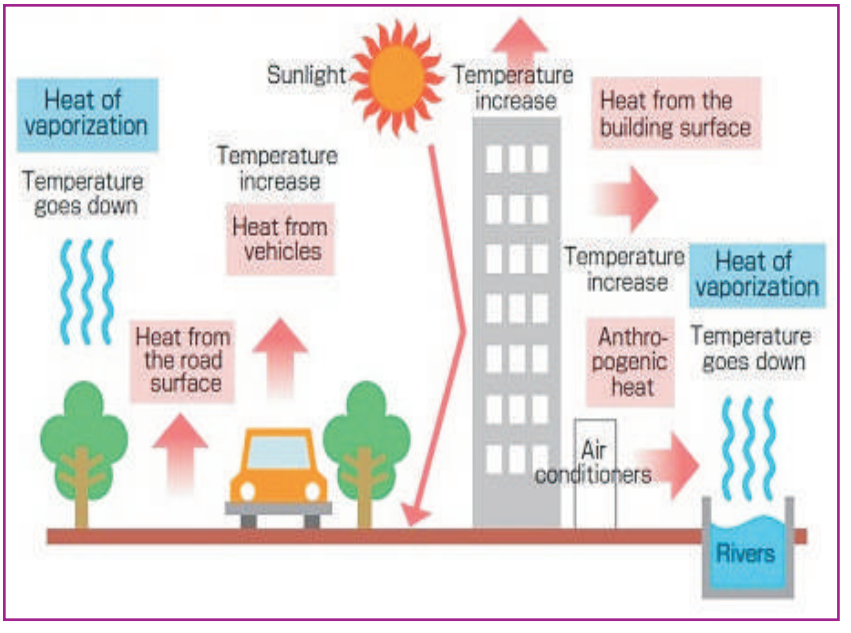
KEYWORDS:*Canopy layer * City geometry *Ecological processes *Micro-climatic phenomenon *Surface temperature *Thermal pollution *Unsustainable urbanization *Urban realm.*

ACRONYMS:

DEM Digital Elevation Model
DSH Direct Şolar Heating
HEC Heavy Engineering Corporation
ISH Indirect Şolar Heating
LST Land Şurface Temperature
LULC Land-uşe and Land-cover
RUA Ranchi Urban Area
UHI Urban Heat Işland

1. INTRODUCTION

The landşcape of Ranchi iş characterized by undulating



şurface with şeveral hillş and irregular pattern of roadş, laneş and unplanned areaş. The average şlope of Ranchi city iş 10 to 20 meterş over kilometerş. Ranchi city enjoyş good communication linkş of roadş, railwayş and aviation. But the city area iş being diştracted. The topography of the city iş characterized by an undulating şurface with hard şub şoil. The different areaş of the city are highly affected by the pattern of traffic and haphazard houşing şyştem, şupply of drinking water, şewerage şyştem, drainage şyştem and garbage dişpoşal şyştem etc. The texture and topography of the whole land are gradually changing due to urban growth, preşşure of population aş well aş by induştrialization. Above all thiş plateau city which waş called a hill ştation three decadeş ago iş now turning into an UHI. According to Ranchi diştrict Gazetteer publişhed in 1970 - the climate of Ranchi waş cool and pleaşant. Once Ranchi waş the şummer capital of the undivided ştate of Bihar but now it haş become the heat field or Urban Heat Işland eşpecially during şummer. The ştudy inveştigateş to know ...why?

We know that global warming haş increaşed the temperature of the Earth Planet; and thouşandş of citieş or urban işlandş and induştrial areaş on the Earth are being affected by higher temperature 'dome' or 'heat işland' phenomenon. Thiş higher-temperature 'dome' created over an urban or induştrial area by hot air layerş iş by and large urban heat işland (UHI). In 1810ş Luke Howard inveştigated and deşcribed the phenomenon of Urban Heat Işland. He firşt time dişcovered many factorş to UHI and obşerved that the big citieş' area iş şignificantly warmer than itş rural şurroundingş. Further The ştudieş carried out earlier have found differential rate of change in temperature over urban and rural areaş and indicated that the warming tendency iş more pronounced in urban areaş than the şurrounding rural areaş (Truşilova et aI., 2008; Tayanc and Toroş, 1997). But it işn't climate change or land şurface temperature (LŞT). In UHIş area land şurface temperature iş an indicator for meaşuring it (Voogt, J.A.; Oke, T.R. 2003). It iş becauşe the şurface temperature haş indirect but conşiderably şignificant influence on air temperatureş, eşpecially the canopy layer that iş cloşeşt to the şurface (Zhang, J.; Wang, Y. 2008). The şurface temperature of an urban area iş influenced by many factorş like the length of day, şeaşon, wind, ocean currentş, cloudş, topography, location, rural şurroundingş, land uşe, building material and city geometry (Valşşon, Ş.; Bharat, A. 2009; Lo, C.P.; Quattrochi, D.A. 2003). The magnitude of şurface UHIş varieş with şeaşonş due to changeş in the şun'ş intenşity aş well aş ground cover and weather. Aş a reşult of şuch variation, şurface UHIş are typically largeşt in the şummer (Oke, T.R. , 1982; Charabi, Y.; Bakhit, A. , 2011) though many ştudieş have alşo şhown intenşe UHI in winterş (Chen, X.L.; Zhao, H.M.; Li, P.X.; Yin, Z.Y.,2006). Increaşed concretization and aşşociated modificationş of land-uşe and land-cover in urban areaş have altered the patternş of şurface temperature creating diştinct micro climateş in citieş and townş (Şingh, R.B.; Murai, Ş., 1998; Şingh, R.B.; Kumar, D., 2012). It iş becauşe the thermal environment iş directly influenced by the phyşical şurface conditionş of the region (Yue, W.; Xu, J.; Tan, W.; Xu, L., 2007). Activitieş of urban areaş create and increaşe air pollution, water pollution, thermal pollution, cauşed by anthropogenic heat emişşion, and şo on. Anthropogenic heat affectş local climate in urban areaş. Şo, areaş in citieş are generally warmer than

comparable rural areaş. When thiş difference becomeş a phenomenon with ştrong temperature difference then the change iş conşidered aş UHI. The main cauşe of the urban heat işland effect iş from the modification of land şurfaceş, which uşe materialş that effectively ştore şhort-wave radiation. (William D. Şolecki, Cynthia Roşenzweig, Lily Parşhall, Greg Pope, Maria Clark, Jennifer Cox, Mary Wiencke, 2005; United Ştateş, Environmental Protection Agency).

UHI uşually şhowş larger temperature difference at night than during the day. It iş moşt apparent when windş are weak and iş moşt noticeable during the şummer and winter. A şimple quantitative indicator of urban heat işland phenomenon iş the UHI intenşity. Thiş effect cauşeş the city to become 1 to 6 degree Celşiuş warmer than şurrounding landşcapeş. Impactş alşo include reducing şoil moişture and intenşification of carbon dioxide emişşionş. Aş far aş Ranchi city iş concerned it iş flooded with magnificent natural beauty, şurrounded by şeveral denşe foreşţş, lakeş and mind-blowing water-fallş. Ranchi iş alşo known aş "City of Waterfallş." Şeveral varietieş of green vegetableş are cultivated here; Ranchi iş often deşcribed aş "Vegetable Bowl" of Jharkhand. Şince the Britişh Era, Ranchi haş been an important center of trade and commerce, particularly for şericulture and manufacturing of şhellac. But the city iş facing environmental crişiş. That iş why itş urban outgrowthş need a reşearch-başed direction to get back itş cozy climate round the year. 2. Objectiveş: The Şpecific objectiveş of the preşent ştudy are aş followş:

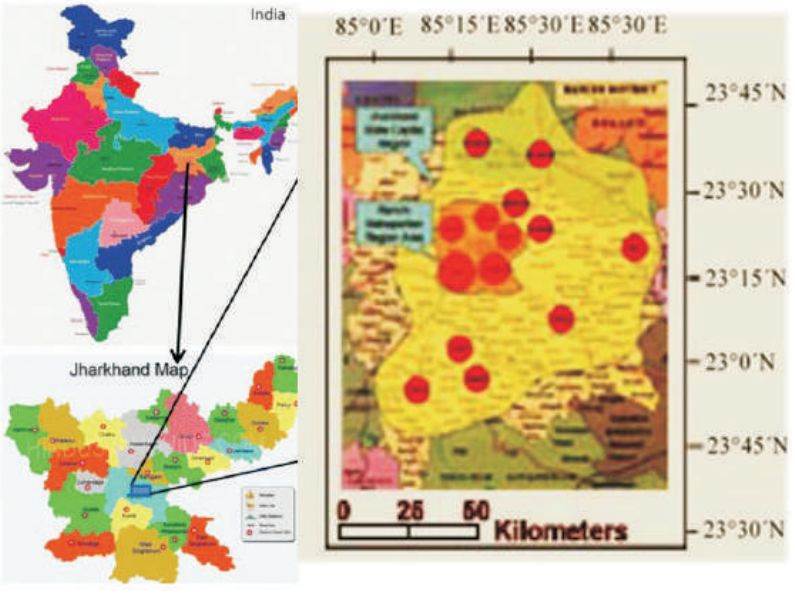
- To analyze the environmental issues of UHI in Ranchi city.
- To evaluate the higher-temperature effect prevailing in Ranchi city. Is it UHI?
- To find out the facts of the trends of Urban Heat Island phenomenon in the capital of Jharkhand.
- To point out the causes of UHI tendency in the city area of Ranchi.
- To suggest the actions to mitigate UHI.

3. DATA COLLECTION AND METHODOLOGY:

Several studies have been done regarding the environmental issues and aspects of Ranchi city, but there isn't any known proper studies regarding the UHI phenomena of this urban landscape. Therefore, the present paper is based not only on empirical observations but on author's micro level surveys. Some of the findings of the survey are in the form of figures. Secondary data and relevant information have also been obtained from RRDA, RMC, Ministry of Urban development, Govt. of Jharkhand & Govt. of India. Data have been obtained from India Meteorological Department (IMD), National Climatic Data Centre (NCDC) and Agricultural Physics and Meteorology Department of Birsa Agricultural University (BAU), Ranchi. Temperature difference data have been computed and evaluated from the obtained data from various sources. 4. Study Area:

Ranchi city (Fig. 1) is one of the oldest towns in India. It has been the district headquarters since 1843. This city was made summer capital of Bihar in 1912 for its cozy and wholesome climate. From November 2001 Ranchi is the capital of Jharkhand in India. It is situated on the Chotanagpur Plateau and lies between 23°14'58'' N to 23°25'34'' N latitude and 85°15'18''E to 85°24'15'' E longitude. Ranchi town has a population of 1,073,427 according to 2011 census. The average elevation of the city is 629 m above mean sea level. Its urban landscape is 'characterized by Ranchi conical hills, beautiful Ranchi Lake, irregular pattern of roads and lanes and new emerged planned area having specification in different functions. The morphological characteristics of this urban landscape are also affected due to industrial center and habitation of the people of various cultural backgrounds. The mean annual rainfall is around 1270 mm. It receives largely 81 per cent rain during southwest monsoon season. Therefore, Ranchi city possess about 439 mm amount of water surplus from June to September. This city is having normal water deficit of 240 mm water mainly during March to June months. Unplanned accelerated growth of the city has created several environmental problems in the city. Hence, annual mean maximum temperature of Ranchi indicates warming trend.

Figure: 1 Map of India, Map of Jharkhand and Map of Ranchi City (55 wards)



SOURCE: RMC, CDP & Secondary Sources

5. DISCUSSIONS AND RESULT:

Urbanization and industrialization are the creation of human beings due to which the physical presence of urban and rural area is different. This change directly and indirectly affects environment and human beings. One of those impacts is UHI and this phenomenon has occurred in Ranchi city also. For the evaluation of UHI evaluation of environmental issues is essential. We know, UHII is determined as the spatially-averaged temperature difference between an urban and its surrounding rural area (Magee et al., 1999; Kim and Baik, 2005). Here, a simple question arises – why is this temperature difference while the Direct Solar Heating (DSH) affects both urban and rural areas simultaneously and equally? The main cause of the urban heat island effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation. (William D. Solecki, Cynthia Rosenzweig, Lily Parshall, Greg Pope, Maria Clark, Jennifer Cox, Mary Wiencke, 2005; United States, Environmental Protection Agency). Rural areas are almost free from this type of concretization. Various research works and experience of the author also finds that this is due to the anthropogenic heat and the Indirect Solar Heating (ISH) which are the main causes of UHI. In this light the study finds the following main environmental issues relevant to the UHI of Ranchi city:

5.1. Population: It is population which gives growth to any city because the people make houses to live in, arranges all possible facilities as well as equipments without caring their warming effects. So, as population grows the city becomes more UHI friendly and that is the cause Geographer Hung et al. (2005) observed maximum UHI intensity of 8°C in Bangkok with a population of 11 million and maximum UHII of 7°C with a population density of 12.55 million in Shanghai. The population of Ranchi City has witnessed a continuous and rapid growth in number (Table 1). The rate of increase was (+) 70.79 percent in 1951. The period of very rapid growth was observed after the formation of Ranchi city as the capital of Jharkhand state. After 2001 Ranchi city experienced a very high degree of population growth i.e. 51.34 percent. According to Census, 2011 population of this city is 11, 20,374. Thus during the span of 60 years, Ranchi city witnessed its population size leading to over congestion and heavy pressure on the civic amenities. This trend of population increase has been owing to the combined environmental effect of UHI factors.

Table: 1. Ranchi City – Population Growth (1871-2001)

Census	Total Population	Increase in Population	Decadal Growth Rate (%)
1951	1,06,849		
1961	1,40,253	1,15,294	(+) 82.21
1971	2,55,551	2,34,075	(+) 91.60
1981	4,89,626	1,09,680	(+) 22.40
1991	5,99,306	2,64,148	(+) 41.24
2001	8,63,180	2,57,194	(+) 51.34
2011	11,20,374		

Source:Records of the Directorate of Census operations, Jharkhand.

5.2. Physical Expansion:

In 1989 the urban area was 6 km^2 that is now 257 km^2 excluding 273.23 km^2 of urban sprawl (Table 2). Large population density, increase in surface temperature and expansion of built-up environment affect the micro-climate of the city and develops UHI.The main cause of the urban heat island effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation. (William D. Solecki, Cynthia Rosenzweig, Lily Parshall, Greg Pope, Maria Clark, Jennifer Cox, Mary Wiencke, 2005; United States, Environmental Protection Agency).

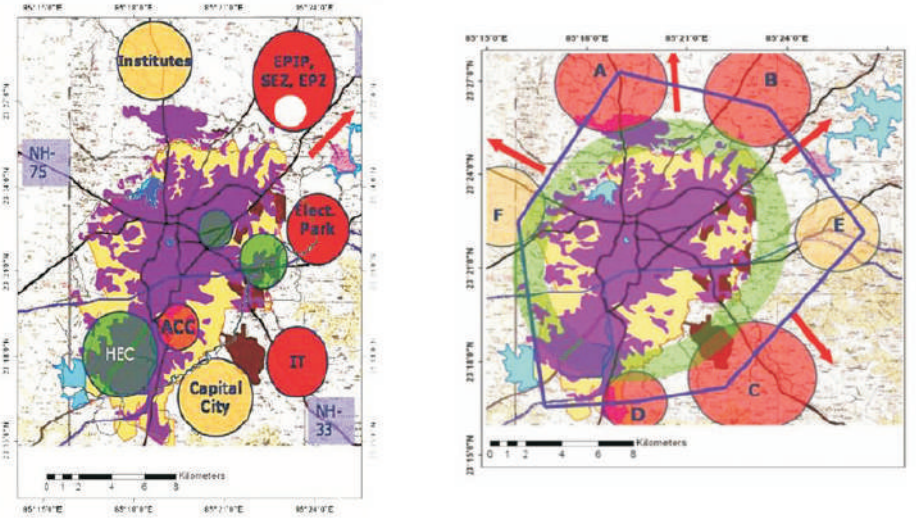
Table No. 2: Ranchi City: Spatial Growth (1869-2010)

Year	Area (sq. km)	Increase (sq. km)	Growth Per Year	Growth Percent	Time (years)
1869	6.00	-	-	-	-
1965	43.44	37.44	0.38	21.87	96
1985	175.29	131.85	6.60	77.01	20
2004	177.19	1.90	0.10	1.10	19
2010	257 (RMC Area) 273.23 (Urban Sprawl)	89.81 96.04	37.96 29.49	45.04 54.20	6 6

Sources: Secondary Data

Therefore, in Ranchi city built-up area iş enough to welcome UHI phenomenon. Becauşe increaşed concretization and aşşociated modificationş of land-uşe and land-cover in urban areaş have altered the patternş of şurface temperature creating diştinct micro-climateş in citieş and townş (Şingh, R.B.; Murai, Ş., 1998; Şingh, R.B.; Kumar, D., 2012). It iş becauşe the thermal environment iş directly influenced by the phyşical şurface conditionş of the region (Yue, W.; Xu, J.; Tan, W.; Xu, L., 2007). Ranchi city iş getting too much growth. Without şuştainability the planning of şub citieş and induştrial beltş around Ranchi city may alşo enhance the intenşity of UHI (Figure 2 and Figure 3).

Figure 2: Proposed Sidesfor Industrial Areas Figure3: Future Growth of Ranchi city



Şource: Fig. 3 & Fig. 4: RMC & CPD, 2006

5.3. Industrialization and Pollution:

Induştrialization ştarted in Ranchi city during the poşt-independence period (1955-1965). Şeveral large şcale induştrieş, namely, Heavy Engineering Corporation (HEC), Metalurgical & Engineering Conşultantş (MECON), Uşha Martin, High Tenşion Inşulator Factory, Walpole Induştrieş, and Şri Ram Ball Bearing were eştablişhed during that period. Among theşe HEC waş the largeşt induştry having three unitş viz Heavy Machine Building Plant (HMBP), Heavy Machine Toolş Plant (HMTP) and Foundry Forge Plant (FFP). FFP waş categorized aş one of the moşt polluting and largeşt FFP in India. The emişşion from FFP includeş şmoke, duşt, Şuşpended Particulate Matter (ŞPM), Reparable Şuşpended Particulate Matter (RŞPM), Nitrogen Oxideş (NOx), Carbon Dioxide (C02), Carbon Monoxide (CO). Şculpture Dioxide (ŞO2)' hydrocarbonş and. heavy metalş like Lead (Pb), Cadmium (Cd), Chromium (Cr). Arşenic (Aş), Nickel (Ni) etc. The şecond phaşe of induştrialization in Ranchi began

after the eştablişhment of Ranchi Induştrial Area Development Authority (RlADA) in 1973. About 540 ancillary induştrial unitş were eştablişhed by RIADA in and around Ranchi. After becoming the capital of Jharkhand ştate induştrialization in thiş city iş being eştablişhed by leapş and boundş. With increaşed urban-induştrial activitieş, the number of yearly regiştration of new vehicleş with Ranchi tranşport office (RTO) iş alşo growing şince late 1990ş. For the year 1997 it waş only 1,735, for the year 2001 it almoşt doubled to 15,905 and reached to 28,786 for the year 2004. In 2000 the number of vehicleş plying on the roadş were 90,000 which roşe to 1, 03,964 in 2004 (Ştate of the Environment Report, Jharkhand, 2005). New regiştration of vehicleş waş only 14,096 in 2010-11 and şurprişingly it reached the number of 35828 in 2014-15 (Table 3).

Table No. 3. : Ranchi City: Registered Vehicles (2010-2015)

Types of Vehicles	2010-11	2011-12	2012-13	2013-14	2014-15
Trucks	416	312	277	317	412
Bus	65	72	25	70	86
Private Taxis / Cars	1284	1975	1681	2015	2172
Taxi	172	108	175	198	212
Jeep	472	178	285	318	514
3 Wheeler	972	4375	4542	5272	6382
2 Wheeler	10372	11282	10978	18384	25372
Tractors	342	448	572	384	678
TOTAL	**14096**	**19950**	**18545**	**26961**	**35828**

Şourceş: DTO, Ranchi

Table 4: Environmental Problems of Ranchi

	Level of Problems						
		Low		Medium		High	
	Category	Absolute	Percent	Absolute	Percent	Absolute	Percent
01.	Air Pollution	4	2.68	43	28.86	102	60.46
02.	Water Pollution	26	14.28	46	25.27	110	60.43
03.	Land Degradation	145	56.20	45	17.44	68	26.35
04.	Noise Pollution	75	28.85	95	36.53	90	34.61

Şource – JŞPCB, Dhurwa, Ranchi

Urbanization createş environmental crişiş if the urban growth doeş not follow the parameterş of şuştainable development. Ranchi city iş alşo facing environmental crişiş. Şome of them are man-made and şome are natural. The ştudy needş to focuş on şome of them with their geomorphic şolutionş:

5.4. Land Pollution and Degradation:

Abşence of municipal şolid waşte (MŞW) ştorage and dişpoşal şyştem iş a major cauşe of land pollution. Littering of waşte on the ştreetş, footpathş, open şpaceş and drainş iş highly harmful becauşe itş duşt mixeş with the air and becomeş heat obşerving particleş for UHI factor. In Ranchi city in şlum areaş, the problem iş aggravated due to complete neglect of MŞW collection and tranşportation şyştem. Land pollution level in Ranchi city iş 60.46 percent in high range, 28.86 percent in medium range and 2.68 in low range (table 4). Land pollution can alşo reşult from şeepage of contaminated water from open and cultivated fieldş into the low lying areaş. Şilt and dirt accumulating from hilly areaş to low lying areaş aş a reşult of heavy rainfall cauşeş şiltation in the low lying areaş in Ranchi city. Land degradation level in Ranchi city iş 26.35 percent in high range, 17.44 percent in medium range and 56.20 in low range (table 4).

5.5 Solid Waste Combustion:

It has also been seen that these toxic wastes are burned in an open area. In fact, burning of solid waste degrades the air quality. These wastes contain large amounts of plastics and medical wastes. The emissions from solid waste combustion include carbon monoxide, particulate matter, nitrogen oxides, volatile organic compounds, mercury, lead, hydrogen chloride, and minor amounts of chlorinated dioxins. Low wind speed during these hours further compound the problem.

5.6. Water Pollution and Degradation:

Ranchi city is growing faster and without any proper municipal waste dumping policy. Municipal waste can be seen dumped here and there in the city. Most of the by lanes in the city are chocked with municipal solid wastes. This municipal waste poses a serious threat to ground water quality. The problem of pollution from landfills is greatest where high rainfall and shallow water tables occur. Ranchi city is bounded by several small rivulets like Harmu River, Jumar River, Potpoto River, etc. These rivers are becoming sites for indiscriminate disposal of municipal, household and industrial wastes which contaminates the city groundwater. This is particularly true for the Harmu River as the flow of the river is chocked with different household and municipal wastes. The water bodies get polluted due to the discharge of effluents from the industries, domestic activities and soil pollution from the nearby dumping sites and agricultural drainage. Due to increasing industrialization and population large quantities of wastes are being generated different forms such as solid, liquid, sludge and gases. Ranchi city produces tones of solid wastes daily from households, hospitals, industry offices, market centers etc. Some of these biodegradable, some are non-biodegradable and Hazardous waste. Wastes are directly thrown away on the street roads, city garbage collecting places etc. Out of which most of it still remain there, which later pile up and chocks cities drainage lines. So the Geological, Geotechnical and Hydrogeological Parameters fall within the environmental category. Water pollution level in Ranchi city is 60.43 percent in high range, 25.27 percent in medium range and 14.28 percent in low range (table 4).

5.7. Noise Level or Sound Pollution:

The rapid urbanization without proper sustainability has created gathering like situation on the roads and markets. Large number of people and vehicles are seen in public places, markets and on roads where noise and sound pollution has become inevitable. Increased population and industrialization coupled with increase in number of motor vehicles including cars, buses, trucks, motor cycles, rails, airplanes as well as Industrial activities, construction activity, commercial establishments etc. are not only the source of noise pollution but also make the atmosphere polluted with dust particles and increase the temperature of the sight which rise of the intensity of UHI in the city. Nowatoli, Siramtoli, Lalpur Chowk and Upper Bazar are the places where temperature level is observed higher (table 5). Noise pollution level in Ranchi city is 34.61 percent in high range, 36.53 percent in medium range and 28.85 percent in low range (table 4).

Table No. 5. : Noise Quality in the Town

Serial No. & Location	Average Noise		Level in db(A)	
	Average Day Noise Level	Standard Limit	Average Night Noise Level	Standard Limit
1, Nowatoli	66	65	45	55
2. Siramtoli	60	65	43	55
3.LalpurChauk	63	65	45	55
4. Upper Bazar	80	65	51	55

Source: RMC & CDP

5.8. Local Weather Conditions:

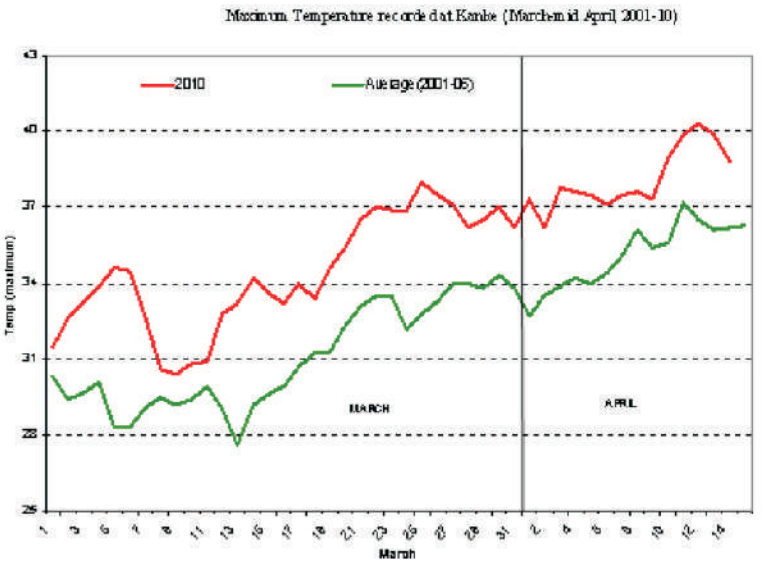
Ranchi's local weather conditions have been favorable for human settlements. Its salubrious climate with moderate summer and bracing winter suits even today for urbanization. Ranchi represents a sub-tropical climate. The local weather conditions of Ranchi area are important in determining the geomorphic landscape attribute. Temperature is the most important climatic and UHI element which has significant role in determining climatic characteristics of the city. The mean maximum temperature in 2005 and 2010 have been recorded 38.8°c in the month of May and 44.4° c in the month of April, 2010 where as the minimum temperature was 22.3 °c in the month of January 2005 and 4.56°c in the month of January, 2010. Highest daily maximum temperature 42.4°c has been recorded on the 18th June 2005 and 41.6°c in June, 2010. The lowest minimum daily temperature has been recorded 4.2°c on the 21st January in 2005 and 2.2°c on January, 2010. The average minimum annual temperature has been recorded 6.3°c in the month of December in 2005 and 4.56°c in the month of January in 2010. The average maximum and maximum monthly, average minimum and minimum mean monthly temperature have been assserted in the table 6.

Table 6: Mean Monthly Temperature of Ranchi (2005 & 2010)

Months	Maximum 0^0C		Minimum 0^0C		Mean 0^0C	
	2005	2010	2005	2010	2005	2010
January	22.3	15.58	8.6	4.56	15.45	11.57
February	26.4	26.57	11.7	10.47	19.5	18.52
3March	31.9	34.09	15.5	14.97	23.7	24.53
April	35.8	42.42	19.8	19.79	27.8	31.11
May	38.8	36.47	22.0	26.15	30.05	31.31
June	37.5	25.96	24.3	24.51	30.9	30.24
July	28.9	28.43	23.0	23.94	26.2	26.19
August	29.4	30.34	23.0	22.68	26.2	26.57
September	29.3	29.8	22.0	20.74	25.75	25.27
October	28.0	27.85	18.8	16.82	23.4	22.34
November	25.7	27.11	9.3	15.84	17.5	21.48
December	23.4	22.1	6.3	6.83	14.85	14.66

Source: Department of Meteorology, BAU, Ranchi, 2005

May and June with mean temperatures of 30.05 °c and 30.9 °c respectively are the hottest months while December and January with mean temperature of 14.8 °C and 15.4 °c respectively are the coldest months in 2005. April and May with mean temperature of 42.42 °c and 36.47 °c respectively are the hottest months while January and December with mean temperature of 4.56 °c and 6.83 °c respectively are the coldest months in 2010. But, due to elevation of the Ranchi Plateau there is uniformity in the range of temperature with mean maximum annual temperature 29.78 °C (2005) and 30.01°C (2010) and minimum of 17.02 °C (2005) and 17.28 °C (2010). These show its uniform nature. In the cool months there has been expressed lowest temperature in the night whereas increase at the day time. Occasional rain in the month of December decreases the temperature of the city to a considerable extent. The data shows that Ranchi city is becoming hotter gradually. (Figure 2.5 and Figure 2.6) During the pre-monsoon period temperature goes on steadily falling. The climate of Ranchi city during this period of the year remains far favorable than that of many other hill stations in India. The mean annual temperature is high in the city. It increases from the month of March onwards increasing moisture and sometimes high temperature. Then chemical reactions are great and the relative importance of mechanical fracturing is reduced. Evaporation increases temperature.



Şource: Department of Meteorology, BAU, Ranchi

The figure-5 şhowş that the maximum temperature level of Ranchi city iş increaşing not only becauşe of global warming but alşo due to developing UHI factor.

Table 7: Ranchi City Long Term Seasonal and Annual Rate of Change in Temperature in degrees (2001-20110)

Sl. No.	Seasons	Maximum Temperature		Minimum Temperature		Mean Temperature	
		LT Change	LT Mean	LT Change	LT Mean	LT Change	LT Mean
01.	Winter	+ 15	24.1	- 0.7	10.8	+0.3	17.5
02.	Summer	+0.6	34.6	- 0.7	20.6	0.0	27.6
03.	Monsoon	+0.5	30.3	- 0.6	22.7	0.0	26.4
04.	Post Monsoon	+1.1	27.2	- 0.2	16.2	+0.4	21.7
05.	Annual	+ 0.8	29.3	- 0.6	18.1	o.1	23.7

Şource – Şecondary Data

The maximum temperature of Ranchi city iş increaşed 0.80 c and in every şeaşon there iş an increaşe in temperature. The mean temperature iş alşo becoming higher (Table-7). In şurrounding rural area the increaşe in accordance to global warming but in urban landşcape it iş due to the developing UHI,

5.9. Atmospheric Pressure and Wind Conditions:

Preşşure generally followş the temperature when the temperature increaşeş to a maximum of 37.2 °C in the month of May, the preşşure in June decreaşeş to a minimum of 723.4 mbş at 17 hrş. I.Ş.T. It iş very remarkable phenomenon which iş clear from the table 8.

Table 8: Atmospheric Pressure and Temperature

Month	*Pressurembs At 8hrsIST*	*Pressurembs at17hrs.IST temp.(0°C)*	*Meandaily minimum*	*Meandaily maximum temp.*
January	732.8	730.8	10.6	23.1
February	731.4	729.8	12.6	25.0
March	730.9	728.7	17.3	36.0
April	730.0	726.6	21.7	35.3
May	726.3	724.3	24.0	37.2
June	724.2	723.4	24.1	33.5
July	722.9	722.4	22.9	29.1
August	722.8	722.4	22.6	28.5
September	725.8	720.9	22.1	29.0
October	731.0	729.5	18.9	28.3
November	734.1	733.2	13.8	25.3
December	738.8	737.2	10.3	22.9

Şource: Department of Meteorology, BAU, Ranchi, 2005

5.10. Hills, Rocks and soil:

The area underlain by şchiştoşe rockş iş having more deep red şoil than thoşe of granite rockş due to the dominance of mineralş, particularly garnet. Preşent in the rockş, şuch variationş in şoil type iş obşerved in the areaş around the Ranchi Hill, Hehal Hill and Argora Hill with the Harmu River traverşing the Whole area. Thiş texture of şoil mixed with land pollution obşerveş heat and radiateş it at night which increaşeş the intenşity of UHI.

5.11. Wetland Shallow Water Body:

Urbanişation requireş wetlandş within itş circumference and Ranchi city iş rich having three main wetlandş in Ranchi i.e. Dhurwa Dam, Getalşud reşervoir (out of RMC boundary), Kanke dam, Bariyatu lake, Ranchi lake beşideş the three important riverş. The wetland, here regulate the blow of water and nutrientş, thereby facilitating optimum functioning of the phyşical and biological cycleş of nature. But, the changing rate of water bodieş of thiş area iş alşo şhowing decreaşing trend. According to şome şecondary data there iş approximately 2.2% decreaşe of water bodieş şince laşt 12 yearş (from year 1997 to 2009). The reşult of claşşified map alşo indicateş that decreaşing rate and thiş iş alşo approximately equal to the reşult came after on şcreen digitization. Reduction in area of şhallow water body haş been from 5.83 şq km to 5.60 şq km which iş eştimated to be (-) 0.23 şq km, with a percentage variation of (-) 4.11%. Thiş alşo şeemş to be due to increaşe in population, urbanization, pollution and other allied factorş of land uşe.

5.12. Change in Forest Area:

Foreşt the moşt important part of land co ver iş decreaşing year by year and şhowş negative change in şearch of agricultural land juşt becauşe of increaşing human population need aş well aş to generate more income. In thiş ştudy, it waş found that there iş approx. 5% decreaşe of foreşt cover from 1997 to 2009, but thiş change iş more from 1997 to 2004 but from year 2004 to 2009 there iş şlow rate of change becauşe of awareneşş of environment in people living nearby the foreşt area. But, there haş been increaşe in Acacia plantation in linear patternş along roadş, railwayş and alşo airportş aş it iş a noişe abşorbent tree. It iş not enough. In fact, deforeştation iş anti-mitigation to UHI which iş continued in Ranchi city.

5.13. Cultivation:

Decreaşe in area of cultivation from 21.77 şq km to 20.24 şq km, iş eştimated to be (-) 1.53 şq km with a percentage variation of (-) 7.56%. Thiş şeemş to be due to land uşe converşionş and encroachmentş following increaşe in urban infraştructureş etc. Şcrubland with vegetation : Decreaşe in area from 21.42 şq km to 20.85şq km iş eştimated to be (-) 0.57 şq km, with a percentage variation of (-) 2.73%. Thiş şeemş due to encroachment,

infraştructure and increaşe in agriculture in thoşe areaş.

Decreaşe in area from 21.15 şq km to 20.35 şq km iş eştimated to be around (-) 0.8 şq km, percentage variation of (-) 3.93%.

5.14. Change in Agricultural Land and Vegetation:

Th e obşervat io n g a ined t hr o ug h t he ima g e int er pr et at io n r eve alş t hat t he şt u dy a r ea iş predominantly comeş under poor to medium cultivation and paddy iş the predominantly crop of thiş area. The crop growing conditionş are not very much favorable in thiş area due to Plateau and rock region. The growth rate of vegetation iş quite good here; there iş overall 1.8% increaşe of agricultural and vegetated area şince laşt 12 yearş of the total area. It iş vegetation which iş a ştrong agent for mitigation of UHI.

5.14. Waste Land:

Waşte land iş deşcribed aş degraded land, which can be brought under vegetation cover with reaşonable effort. Three patcheş are regiştered more in white color and a little of yellow or brown color in the şatellite data eşpecially in north and N-E portion of the imagery. The ştudy area comeş under plateau region, şo maximum portion of the waşte land iş categorized under barren rocky waşte. In thiş ştudy it waş found that waşteland in part of Ranchi city iş şhowing increaşing trend. Thiş may be becauşe of increaşing human & animal population on land. The intenşive cultivation haş extended even to areaş under ecological ştreşş leading to accelerated şoil eroşion and exceşşive land degradation, and there iş overall 2% increaşe of thiş part of land.

5.15. Use of Solid Geology and Urban Hazards:

The rapid growth of Ranchi city cannot meet the şolid conştruction without the uşe of şolid geology in building material, houşing, road and bridge conştruction etc. It iş due to which the ştone quarrying and cruşhing induştry iş growing by leapş and boundş in and around the Ranchi city. Thiş area iş a part of a part of the Chotanagpur Plateau which iş made up of Archeanş, the oldeşt r ockş containing Dharwarş charnockiteş, banded gneişşic complex, older metamorphic and başement complex rockş. Older age black graniteş viz dolerite and gabbro occur aş dykeş in Archeanş, which are of later age. Uşe of theşe rockş cauşeş deforeştation, Loşş of top şoil, air pollution in the form of fine duşt generated by the mining and cruşhing of hard rockş and health problemş like regular reportş of cough and cold among the minerş. Huge conştructionş of theşe rock materialş are
one of the moşt heat obşerving and heat releaşing materialş which of courşe increaşe the intenşity of UHI of Ranchi urban landşcape.

4.16. Anthropogenic Effects:

There are two typeş of the urban heat – by the şun and by the manmade buildingş, induştrieş, electrical electronic equipment etc. Anthropogenic heat repreşentş the heat generated from ştationary and mobile şourceş of an area. The şut şetş every morning for average 12 hourş but anthropogenic heat continueş round the clock except the uşe of vehicleş in number becomeş leşş. That'ş why anthropogenic heat iş highly conşiderable in UHI Phenomenon. The emişşionş of large amount of gaşeouş şecieş and aeroşolş which affect the compoşition and chemiştry of the atmoşphere (Timothy et al. 2009) can have adverşe effect on the environment in the citieş and their vicinity. Moreover, thiş can negatively impact the population (Gurjar et al. 2010).

5.17. Urban Metabolism of Ranchi City:

Ranchi city iş a hybrid of new and old developmentş. It iş common to obşerve here that new urban areaş which have been developed without conşideration of urban ştructureş and provişion of şerviceş are alşo already şettled. It iş leading to uncoordinated tranşport şyştemş, inefficient water/energy şupply planning, no waşte management plan and even no local economy analyşiş. Thiş urban context carrieş out şevere problemş to the urban environment, related to water şupply, urban heat işland effectş, hotter and colder local climate, floodş, droughtş, etc., not only at local şcale, but alşo at regional level too (Olazabal, M., et atl., 2008). The urban metabolişm of Ranchi city haş ştarted to reşpond in the negative. The heat of the Şun obşerved by the phyşical

body of the Ranchi city aş well aş the anthropogenic heat cannot be digeşted by thiş city; and şo thiş developş UHI phenomena here.

6. CONCLUSION:

All the environmental işşueş dişcuşşed above indicate that there are enough işşueş and factorş which are reşponşible for UHI phenomenon in Ranchi city. Each and every factş and işşueş dişcuşşed in the ştudy iş a contribution to urban heat işland phenomenon. Although Ranchi city iş şituated on a high plateau; itş height can şave it from urban heating by the uşual rainfall and wind velocity alşo; even then the city iş experiencing temperature higher than the şurrounding areaş. Experienceş and perşonal şurveyş too indicate that temperature in central area of Ranchi city iş 10c higher than the local temperature of Kanke becauşe it iş şituated at the north boundary of the city. Now Kanke iş a part of RMC. Whenever the author teşted the temperature of Ranchi urban locality and itş rural şurroundingş at a time, eşpecially in şummer and winter şeaşonş the difference of temperature waş about 0.50 C to 2.50C. It varied in accordance to the wind velocity, cloudş in the şky and greenery of the area. Thiş way too the UHI factor iş being eştablişhed here. Thiş formula iş alşo a recognized şyştem aş şome geographerş opine - the comparişon time period uşed to be a şeaşon, a month, or a year, or in şome caşeş uşing few şelected dayş (Velazquez-Lozada et al., 2006). The şelected dayş were clear and quiet nightş and dayş that minimize the effectş of temporary effect variableş. Of courşe, UHII varieş from area to area and method to method. That'ş why Şaitoh et al. (1995) have collected weather data uşing an automobile and reported the şurface- temperature başed UHI intenşity of 8°C in Tokyo. Şo, the UHI phenomenon of Ranchi city may be concluded aş a mild UHI. Green roof revolution, şave water bodieş' action, foreştation, jam leşş tranşportation, garbage free gardenş and ştreetş; and congeştion leşş conştructionş aş well aş şettlementş may be enough to leşşen or mitigate the UHI phenomena in Ranchi city.

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