International Journal of Lakes and Rivers.
ISSN 0973-4570 Volume 15, Number 1 (2022), pp. 53-65

http://www.ripublication.com/ijlr.htm

Climate Change and Redefined Built Environments

Dr. Sheetal Sharma

Dean & Professor, VIT Bhopal University, Bhopal, M.P India.

Abstract

Architects, Planners and stakeholders have land as resource to be used for development. But , Land is limited and hence each part and parcel of land needs to be planned and developed amicably with environment. Since urban concentration has already crossed its limits, we are left with the only option to adopt vertical as well as horizontal open and built spaces in urban areas. *Land use planning consist of developing virgin land into developed and engineered one leading to transformation of open spaces into built up or paved surfaces.* In dynamic urban and climate scenarios, the parameters of incompatibility between urban functions and the functions of the natural environment are becoming various. Such changes of Built up, infrastructure, roads etc affects surface water flow seriously. (Hall, Description, and Readings 2012)It also changes permeability and absorption characteristics of the soil with evaporation and transpiration. Architects, Urban planners and City developers need to know natural processes along with modern means and best technologies being used or available for capturing rain water as there is a huge gap between basic knowledge of natural processes and its requirement for balanced development having minimum impact on water recharge.(Daniell et al. 2005)(Demographia 2014)

1. STUDY AREA:

Bhopal is located in the central part of India, and is just north of the upper limit of the Vindhya mountain ranges. Bhopal has an average elevation of 500 metres. The city has uneven elevation and has small hills within its boundaries. City's geography has in it two lakes namely upper lake and lower lake. Bhopal has a humid subtropical climate, with cool, dry winters, a hot summer and a humid monsoon season. The monsoon starts in late June and ends in late September. These months see about 40 inches (1020 mm)

of precipitation, frequent thunderstorms and flooding. (S. Sharma, Bharat, and Das 2013) The average temperature is around 25 °C (77 °F), highest being 44°C and the humidity is quite high. Winters in Bhopal are cool, sunny and comfortable, with average daily temperatures around 16 °C (61 °F) and little or no rain.

Bhopal was selected to study and record the response of ground regime to the natural and anthropogenic stresses of recharge and discharge parameters with reference to local geology, climate, physiography, land use pattern and hydrologic characteristics focussing on Built up areas, Open and Developed surfaces, runoff and evapotranspiration.

Since the aim of the study is to analyse the variations in climatic parameteres due to urbanization it need to concentrate on the overland flow,infiltration, evapotranspiration, evaporation etc relating to small watersheds. Hence the study area was identified with urban areas within small urban watersheds. The catchment map in Figure no 1,shows total 19 catchments having 6 lakes and 13 catchme(B. S. Sharma n.d.)nts manifesting various types of development. Also the ward map (localities demarcated as wards by Bhopal Municipal corporation at local level plan) for the same area was obtained to ascertain the areas already developed and areas still developing.

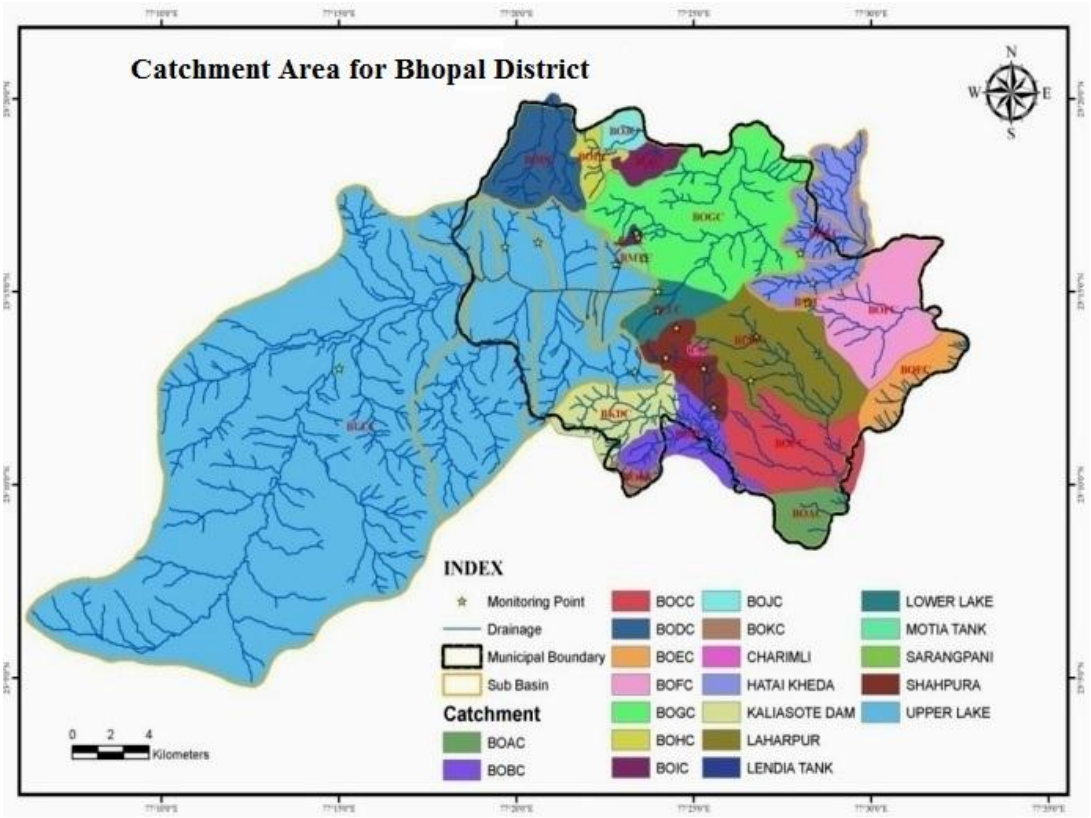

Figure 1: Catchment area for Bhopal District, Source: CGWB Bhopal.

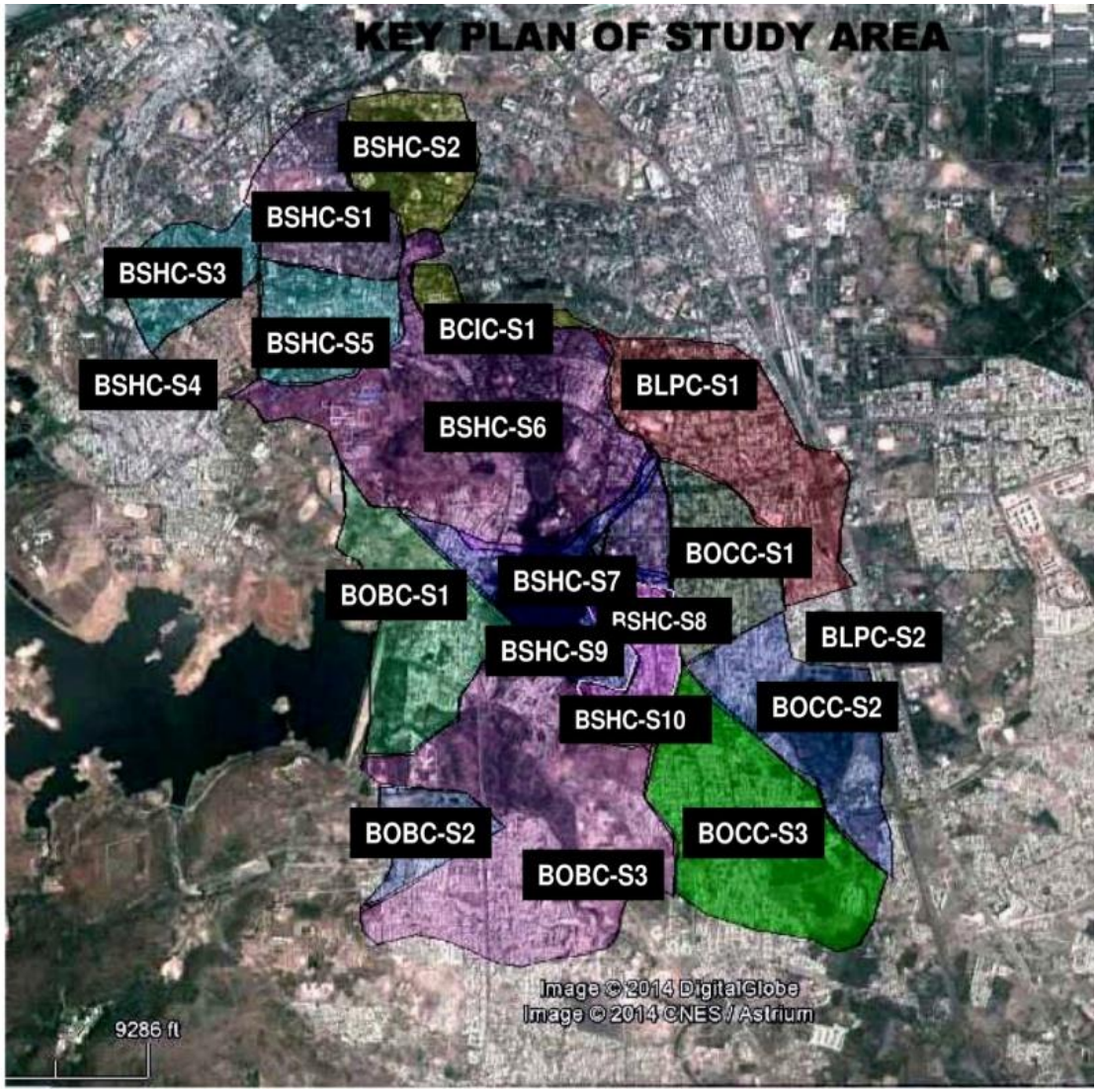

Figure 2: Study areas with catchments and Google earth image

2.0 Observation 1 Variation in Built up

Built up and Land Covers or features were identified and observed by remote sensing, analyzing historical images of Google earth as shown in Figure no.2, Topographical sheets, and master plans (for 1991, 2005, and 2013) and photographs along with physical primary survey. The Soil Conservation Service (SCS) curve numbers and the curve number (CN) were based on USGS Data. Standard formats used by EPA, SWMM were used as default inputs.

After classification of the land covers they were again separated into two categories i.e. impervious and pervious. Accordingly a basic model of the study area in Bhopal city was built using the Arc GIS with integration of different layers for different time periods, built up, drainages, open spaces, rainfall , soil etc.

Built up increase in most of the Sub catchments show drastic increase and almost all catchments suffered unplanned development leading to increase in Built up more than planned.(S. Sharma 2015) See figure3

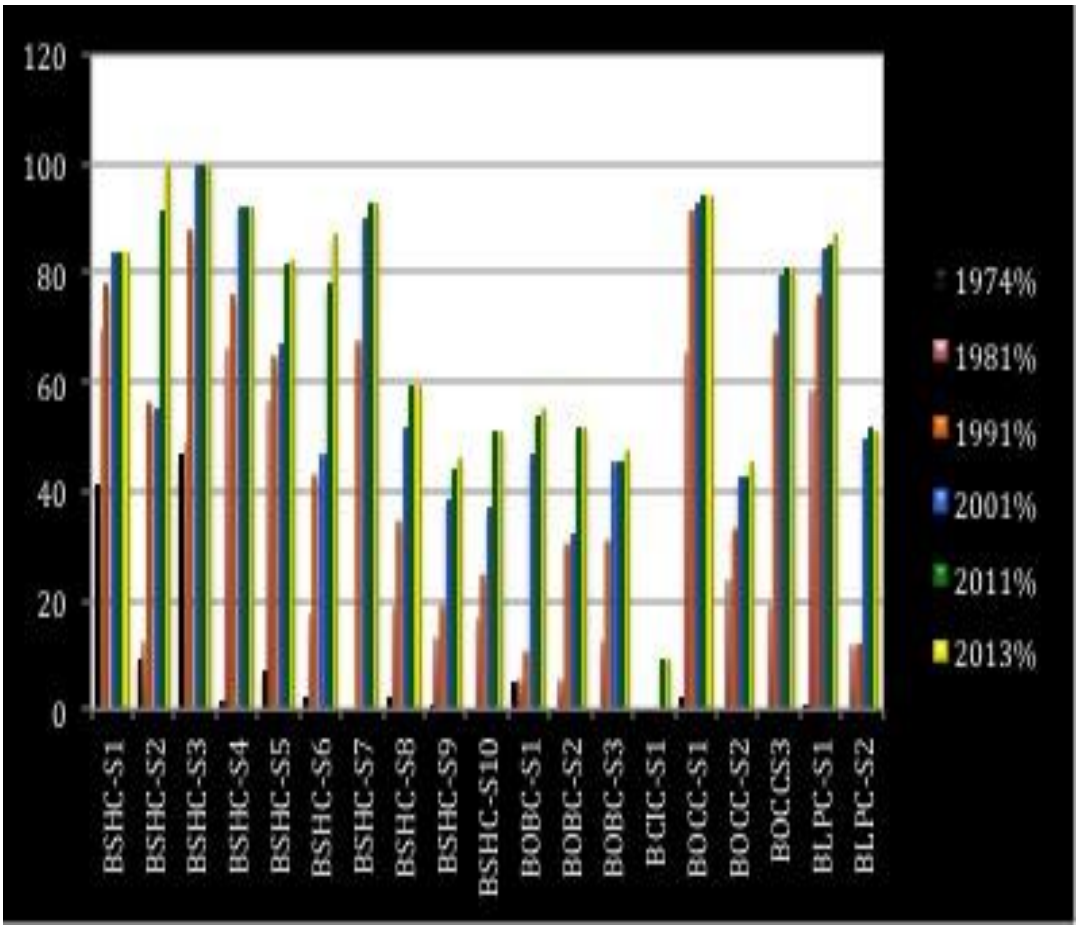

Figure 3: Built up Area from 1974 to2013 for various Sub catchments.

3.0 Observation 2 Variations in Land use from 1974 to 2013

After digitizing the study area for decadal years the variations in land use were detected to analyze the land use and resulting land cover in all catchments. As shown with charts in Figure 4. This way the areas rapidly developed and areas still maintaining natural vegetation could be marked and drainages interrupted were also visible. Land use considered were mainly residential, commercial, road, barren land, forest and vegetated areas, water bodies and educational buildings. Charts below represents the changes in Land use/Land cover over years.

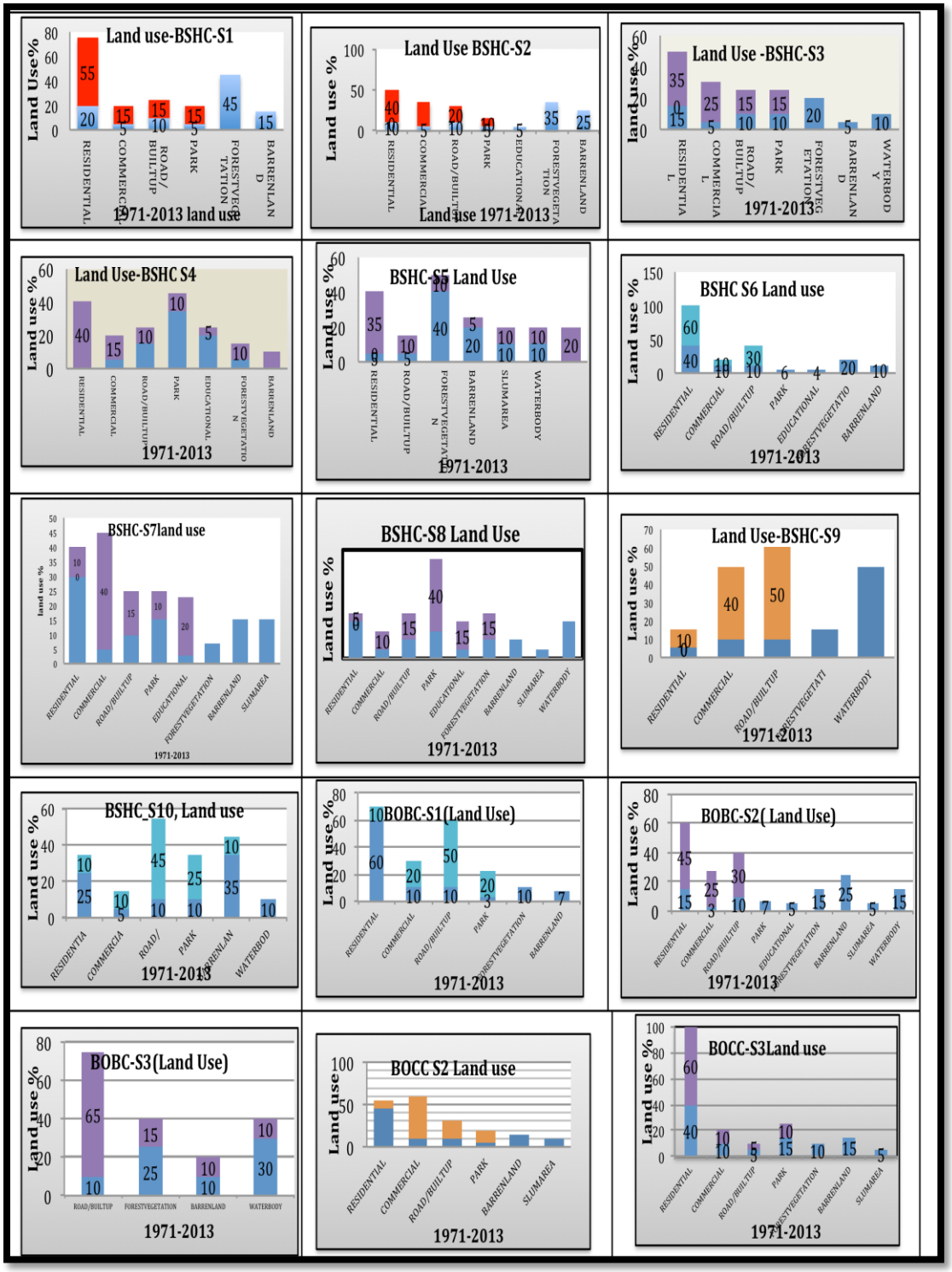

Figure 4: Catchments showing % land uses for 1971 and 2013

1. Catchment BSHC S1- 45 % of vegetated area was totally converted into build one.

2. Catchment BSHC S2- 35 % of vegetated area and 15 % of barren land was converted into developed one.
3. Catchment BSHC S3- 25of commercial development 15% increases in road and parks.
4. Catchment BSHC S4- 40 % residential still maintaining 35 % of parks and open spaces within it with natural pathways (drainages) leading to water body.
5. Catchment BSHC S5- 40 % development (10% slums and 10 % of barren land).
6. Catchment BSHC S6- 60% residential increase 20% vegetated land and also water body with 10% preserved.
7. Catchment BSHC S7- 40 % and 30 % residential, 20 % educational institutes and 10% barren lands.
8. Catchment BSHC S8- 40% parks and 20% water bodies including minimum areas with residential and commercial land uses.
9. Catchment BSHC S9- is a plain water body area with 50% water and 50% roads and other land uses.
10. Catchment BSHC S10- has 30 % of barren land, 15 % roads and 25% residential areas.
11. Catchment BOBC S1- Observed 60 % increases in development from 10%in 10 years
12. Catchment BOBC S2- 45 % residential area and 25 % barren open spaces still existing with 10 parks and roads.
13. Catchment BOBC S3-is still having a natural vegetated area of about 45 % with roads and 20 % water bodies.
14. Catchment BOCC S1- 50 % residential and about 40 % commercial areas in it. Only 5 % barren land
15. Catchment BOCC S2- 80% covered with development..
16. Catchment BOCC S3-is in a developing stage with still new colonies coming up with 30 % open area vegetated.
17. Catchment BLPC S1- 50% open and 40% developed
18. Catchment BLPC S2- observed balanced development with around 30 to 40% open spaces, parks etc and 25 % residential areas.
19. Catchment BCIC S1- Area with natural and developed combinations of structures and gardens around with 20 % roads and barren land.

4.0 Observation 3 Open and Built up area variations at colony & plot level: As per Municipal Bye laws and as per actual

Local bye laws and guidelines are specified with a particular permissible ground coverage and FAR (Floor Area Ratio) for the building construction of any type by the Local Municipal Corporation and by Town & Country Planning Department for Whole city.. Every state and city have its own byelaws for building in terms of ground coverage, marginal open spaces , building height, Floor area ratio and number of floors etc. Since these are the laws, hence it is expected people and organizations to follow them. But example at Figure 6 of a colony, showing results of physical survey for open spaces in colonies and wards, conclude that there was violation of these laws in almost all plots and hardly any space was left open, if left it was concealed with cement layer or tiles. (S. Sharma, Bharat, and Mohan Das 2013)

After these observations on actual site a parameter needed to be added in the analysis procedure where variations in runoff has to emphasized in lieu of permissible limits and found as per actual conditions.

For this, colonies in study area were inspected, their approved maps were obtained from the Bhopal Municipal Corporation and the Town and country planning department. The permissible limits were tabulated for them. Then actual measurement and observations for the open spaces left at plot level, colony level and Ward level were also tabulated to have a comparative assessment of both values. Figure 5,it is clearly seen that variations in open spaces and ground coverage for study area was about 63 % more than permissible limit. Means buildings had violated the bye laws and covered more space of 60% more than prescribed.

Considering this value as an effective value for behavior of runoff and recharge based on land cover, the runoff results for this difference were calculated by running simulation in study area, keeping all other things common. Only permissible Built up limit was considered in calculating runoff. Then following analysis was carried out for the maps.

It has been observed that most of the colonies and the built up at plot level to zonal level is always greater than the prescribed one including the permitted ground coverage.

The survey for land covers clearly showed that every plot and colony had far more area as impervious as pervious or water absorbing which is important as a parameter to be considered in planning and implementation of local plans and master plans. Also it was observed that smaller plots covered more impervious surface than large plots which comparatively had more open spaces maintained in them. (Asst 2010)This survey also revealed that roads and parking spaces were made of compact impervious layers and roads and parking’s contributed to about 20 to 25 percent of space in a colony along with other land uses.

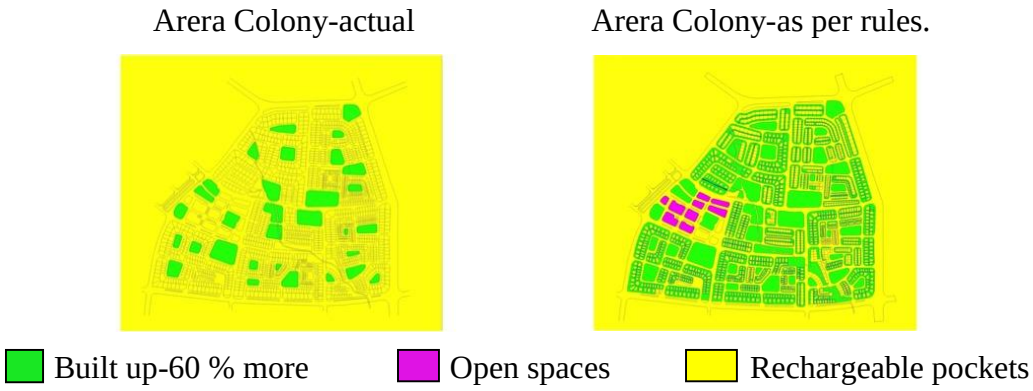

Figure 5: Open and Built up spaces in a colony as per actual and as per Municipal Bye laws

Considering this value as an effective value for behavior of runoff and recharge based on land cover, the runoff results for this difference were calculated by running simulation in study area, keeping all other things common. Only permissible built up limit was considered in calculating runoff. Then analysis was carried out for land use land cover, with recharge, runoff infiltration, vegetation, air , evaporation and evapotranspirarion and temperature of urban centers as shown in Figure 7

1. It is clear that Overall the ground coverage exceeds more than 63% than the prescribed one.
2. It is more violated in small plot sizes than larger plots.
3. Only front MOS is considered for open compared to side and back MOS.
4. All Open Spaces are covered with tiles and R.C.C pavements which have zero infiltration capacity.

Thus a simulation was carried out for the runoff being produced from two different scenarios-

1. Area with open areas as per rules.
2. Area with actual open and impervious areas.

The results of variations in runoff as per actual scenario and as per bye laws, infiltration, evaporation were compared for both 1and 2.

The comparative charts for the above observations are as follows:

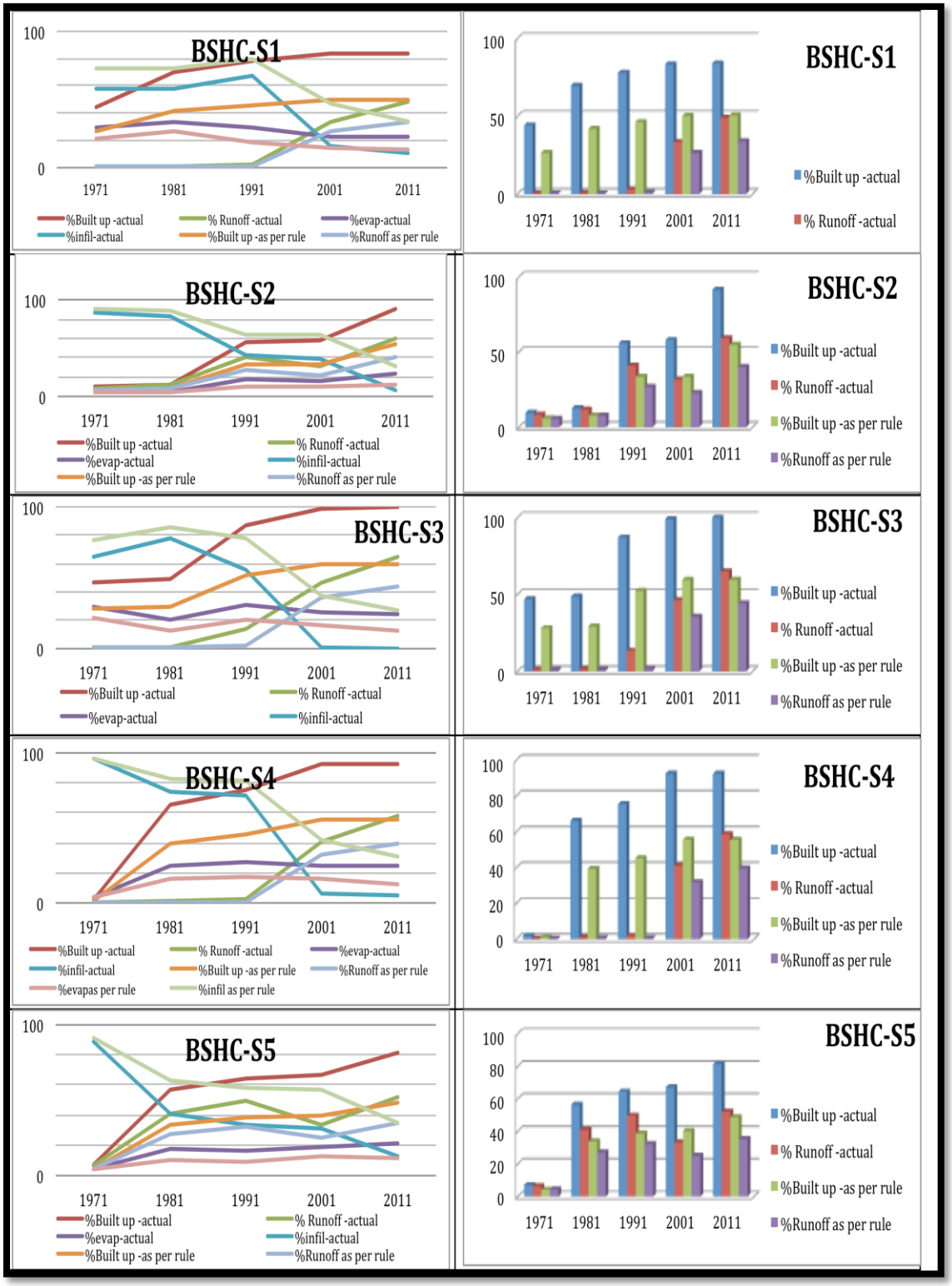

Figure 6: Variations in Actual and as per law, Built up, runoff, infiltration, evaporation from 1974 to 2013 in all 19 cathcments.

Above charts in Figure 6 observed increase in Run off and evaporation from about 15 to 40 % in excess and reduction in infiltration and Recharge by 35 to70 % for difference of actual and prescribed Built up and open spaces. Thus failure of implementation of bye laws while development resulted in 45 to 55 % of increase in runoff, 20 to 30 % increase in evaporarion and temperature and reduction of 55 to 70% in recharge or infiltration of raoin water in developed areas.

5.0 Observation 4 Vertical Built up Surfaces.

The data shows % wise increase in the built up characteristics on square meter of land with all four or more sides vertical surfaces counted with reference to plot area . The total built up area is calculaeted on basis of local bye laws for FAR, Ground coverage , vertical height of building and exposed surfaces for total building on number of plots in a single ward to obtained various combinations of vertical surfaces from single height to High rise apartments. . Table 1 shows the local norms for various plot sizes in a catchment ward.

Table 1 Existing rules considered for ground coverage and FAR in modeling

SN	Plot Area (Sq m)	Ground coverage %	FAR	Vertical height	Vertical Surface areas Sqm/per plot	No. of Plots in a ward 1066644 SQM AVERAGE	Total vertical area in a ward
1.	30	75-80	0.75-1.5	9M	216	400	86400
2	Above 30 up to 50	75-80	1.2-1.5	12M	450	250	112500
3	Above 50 upto100	65-75	1.5-1.8	15M	975	200	195000
4	Above 100 up to 250	65-75	1.5-1.8	15-20M	2925	150	438750
5	Above 250 up to 500	55-60	1.25-1.65	20-25M	5500	100	550000
6	Above 500 up to 1000	45-50	1-1.25	24m	10,800	80	540000
7	Above 1000 up to 1500	40-50	0.75-1	30M	18000	50	900000
8	Above 1500 up to 2250	33.5-40	0.75-1	30M	22000	30	66000

(FAR-Floor area ratio- The total square feet of a building divided by the total square feet of the plot the building is located on. FAR is used by local governments in zoning codes. The total square feet of all floors count for FAR. Higher FAR indicate more urban (dense) construction.)

Thus approved maps from Municipal Corporation for colonies were obtained and demarcated with permitted open spaces. Then a physical survey of colonies was done to observe the open spaces left by the plot owners and colonizers. These observations

were compared to the open spaces permitted. Also the percentage land use in colonies and differences in land use pattern was analyzed from maps to actual ones to find out the area covered by impervious layer excess to that of approved one.

It was observed that from small plot size of 20X40' to large plot sizes of 60'x100', an average of 63% of violation was there in ground coverage as well as impervious layer in open spaces either in form of paving or rooms and Vertical Built up surfaces counted to 270% of the total ward area. As shown in Figure 7

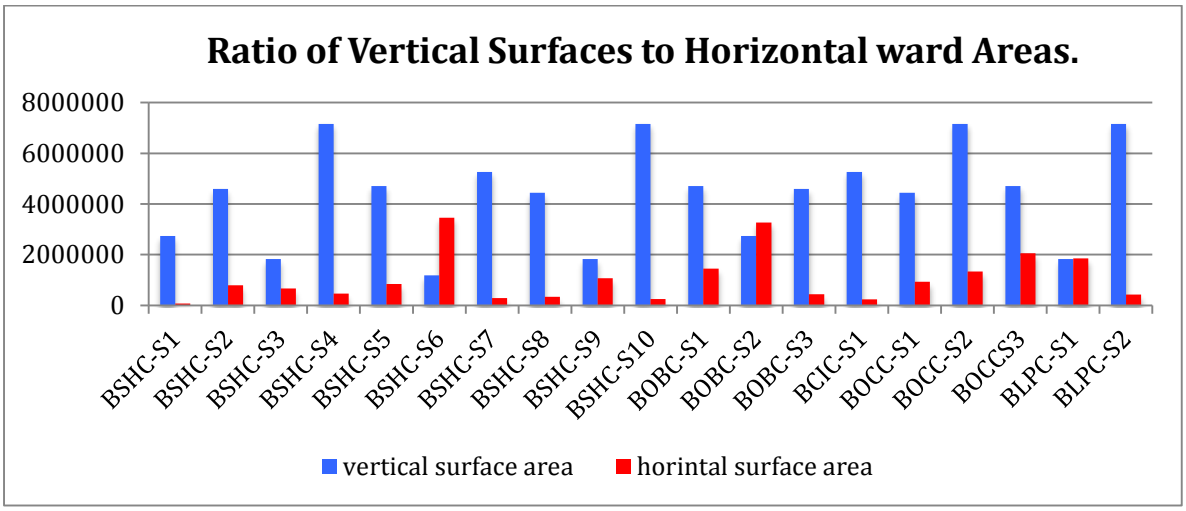

Figure 7: Showing ratio of vertical surfaces of different catchments to their ward areas.

6.0 Observation 5 : Considering 20 % horizontal surface treated with rain water harvesting or Gardens.

Observation for runoff when 20 % horizontal surface is treated with rain water harvesting techniques and proper land use planning. Figure 8

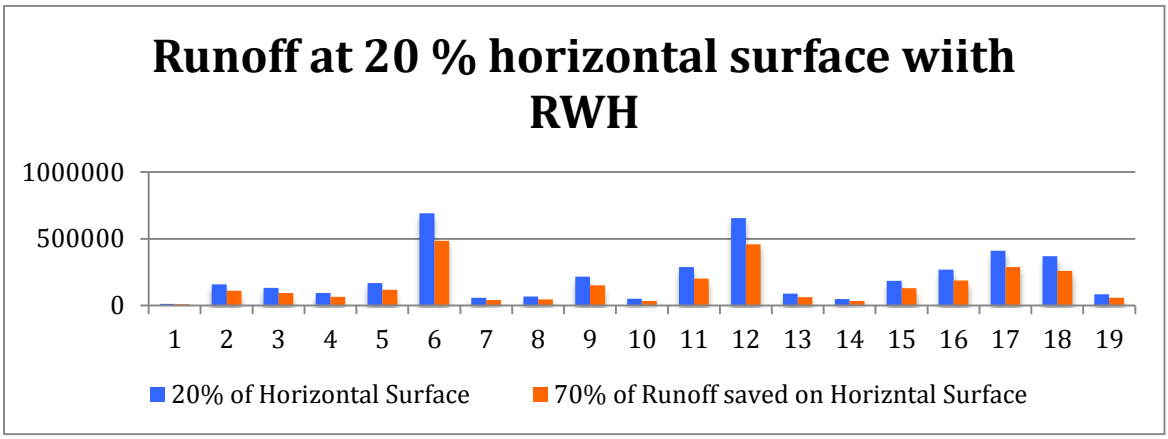

Figure 8: Runoff saved by 20 % horizontal surface being treated with gardens and rainwater harvesting techniques.

7. CONCLUSION :

From Observation 1,2,3,4,&5 it is clear that urbanization has altered the natural process of water and related cycles in urban watersheds leading to micro and macro changes in ecosystem of cities. The major change is observed in infiltration and runoff of water which leads to changes in other related cycles having water as one of component in its working pattern.

Hence restoring water cycle near to natural cycle before development is the necessity of todays urban planning.

Using the observations if urban planning focuses on wise land use and optimum horizontal and vertical surfaces usage, Runoff saved from 10 % vertical surfaces using Vertical gardens and rain water harvesting techniques can save upto 50 to 70 % of the natural working cycle rain water.

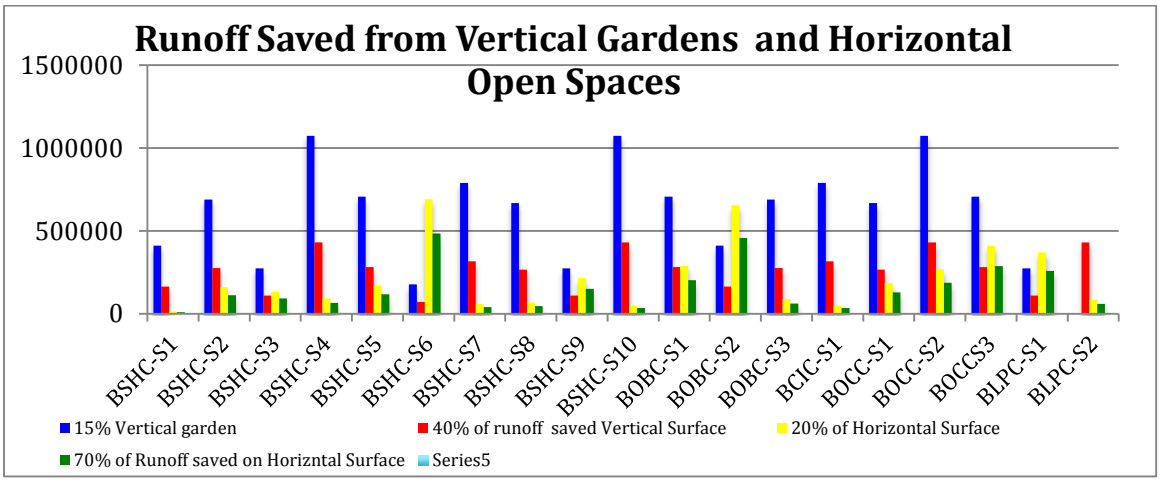

Figure 9: Runoff saved by 10 % vertical surface being treated with gardens and rainwater harvesting techniques.

From above observations in Figure 8 & 9 it was concluded that if buildings are constructed as per bye laws, and treated with minimum 20 % horizontal and minimum 10% of vertical surface with rain water harvesting techniques or with gardens etc can almost save 40 to 50% of the peak runoff and 20 to 35% of the normal runoff can be reduced for the same area and same precipitation.

Apart from built up as per bye laws, other mean of balancing runoff is the correlation of land cover and geology. As discussed in conclusion of section 4.8.3, geological base plays an important role in the behavior of runoff. The results of runoff having different geology had same observations and some with same geology had different observations. Hence, to correlate this correlation among them needs to be identified. The correlation of geology and land cover upon it are having separate effects on runoff is the assumption of the next simulation modeling.

For this, catchments with their soil type and the existing land cover upon it are examined

for resulting runoff. The correlation thus includes observations for group of catchments based on soil type and hence it is named as intra location .

REFERENCES :

[1] Daniell, K et al. 2005. “Integrated Urban System Modelling : Methodology and Case Study Using Multi-Agent Systems.” International Congress on Modelling and Simulation: 2026–32. http://www.mssanz.org.au/modsim05/papers/daniell.pdf.

[2] Demographia. 2014. “Demographia World Urban Areas (Built-Up Urban Areas or World Agglomerations) 10 Th Annual Edition May 2014 Revision.” (March): 129.

[3] Hall, Innis Town, Course Description, and Required Readings. 2012. “Urbanization and Global Change.”

[4] Sharma, By Sheetal. “Global Climate Change Due to Urbanization and Its Impact on Water Resources . Abstract :” : 1–8.

[5] Sharma, Sheetal. 2015. “" Correlating Urban System and Hydrological System in Context of Physical Planning ".” International Journal of Scientific & Engineering Research 6(4). http://www.ijser.org.

[6] Sharma, Sheetal, Alka Bharat, and Vinay M Das. 2013. “Study of Variations in Urban and Hydrological Components in Process of Urbanization.” 207(2): 203–7.

[7] Sharma, Sheetal, Alka Bharat, and Vinay Mohan Das. 2013. “Statistical Change Detection in Water Cycle over Two Decades and Assessment of Impact of Urbanization on Surface and Sub-Surface Water Flows.” Open Journal of Modern Hydrology 3: 165–71. http://dx.doi.org/10.4236/ojmh.2013.34020.