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Urbanization and Its Impact on Water Resources (A Case Study of Aizawl City, Mizoram, India)

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Abstract: In order to understand the urban water problem it is necessary to analyse the pattern of population growth and development of the City. Water demands are a function of the size of the population on the one hand and its lifestyle and activities on the other. Over the years, the amount of fresh water available per capita has been decreasing due to increasing population. High population density and rapid urbanization have severe consequences for the natural environment. The anthropogenic activity of the population far exceeds the infrastructure capacity of the City, leading to the deterioration of the urban environment. The reason for water problem in the study area is the tremendously increasing rate of population. While it may be one of the reasons, water scarcity in the study area is also the culmination of myopic planning, muddled policies and misguided perceptions.

Keywords: Development, Urbanization, Water Problem.

INTRODUCTION

From a small-fortified post established by Mr. Dally of Assam Police in 1890, Aizawl has become the largest urban centre as well capital of Mizoram. The ever-continuing increase of population has already been posing serious challenges in respect of the provision of service lands, shelter, water supply, power supply, storm drain system, garbage disposal, and many other things. It has reached a stage where in population is likely to continue to grow and in the absence of proper economic growth, infrastructure planning and management of spatial arrangement and restructuring, it is bound to have a very serious impact on the life, health and working environment.

Study Area

Aizawl, the capital of Mizoram state, is situated in on the hillcrests, steep slopes and small valleys. It is located on a north-south elongated ridge, which acts as the main hill from which many small ridges and valleys are extending towards the east and west directions. The topography is highly undulating and rugged. The altitude varies from 120 m to 1400 m above mean sea level. It falls between 23º 40’ N to 23º 50’ N latitudes and 92º 40’ E to 92º 49’ E longitudes. It covers an area of about 128.98 sq km, and as per 2011 Census, the population is 293,416 persons. There are a number of streams in and around Aizawl, but none of them is dependable for providing adequate water. The only dependable source is the River *Tlawng* located more than 1,000 m below the City.

Literature Survey

Literature survey/review is necessary in research to have clear theoretical background about the research problem and to know the empirical works done on it. Therefore, in the following lines relevant literature survey has been made.

Functions of the city are linked to its land use. Each function has consequences on the surface and sub-surface water, regardless of the source of the water that is used (Zaadnoordijk *et al*, 2004). The flow of ground water in the sub-surface is determined by the permeability of geologic layers in the underground and the interaction with the water on the surface. Urbanization may result in a net change in overall ground water recharge with anything from a major reduction to a modest increase being possible (Foster *et al.*, 1998).

The increase in impermeable area in an urban area changes the surface and ground water hydrology (Lerner *et al.*, 1990; Ku *et al.*, 1992; Foster and Morris, 1994; Carmon *et al.*, 1997). Surface impermeable include construction of buildings, roads, parking lots, etc. The proportion of land covered is a key factor in the degree of impermeable surface. Some types of urban pavement, such as tiles, bricks and porous asphalt are quite permeable (Foster *et al.*, 1998). After rains, surface runoff is increase, although this water may become localised recharge from soak ways and storm drains (Lerner, 1997; Yang *et al.*, 2000). Recharge is also increased by leakage from piped water and sewers, septic tanks and pit latrines (Lerner *et al.*, 1990; Morris *et al.*, 1994). According to Foster *et al.* (1998), un-sewered sanitation greatly increases the rate of city’s ground water recharge.

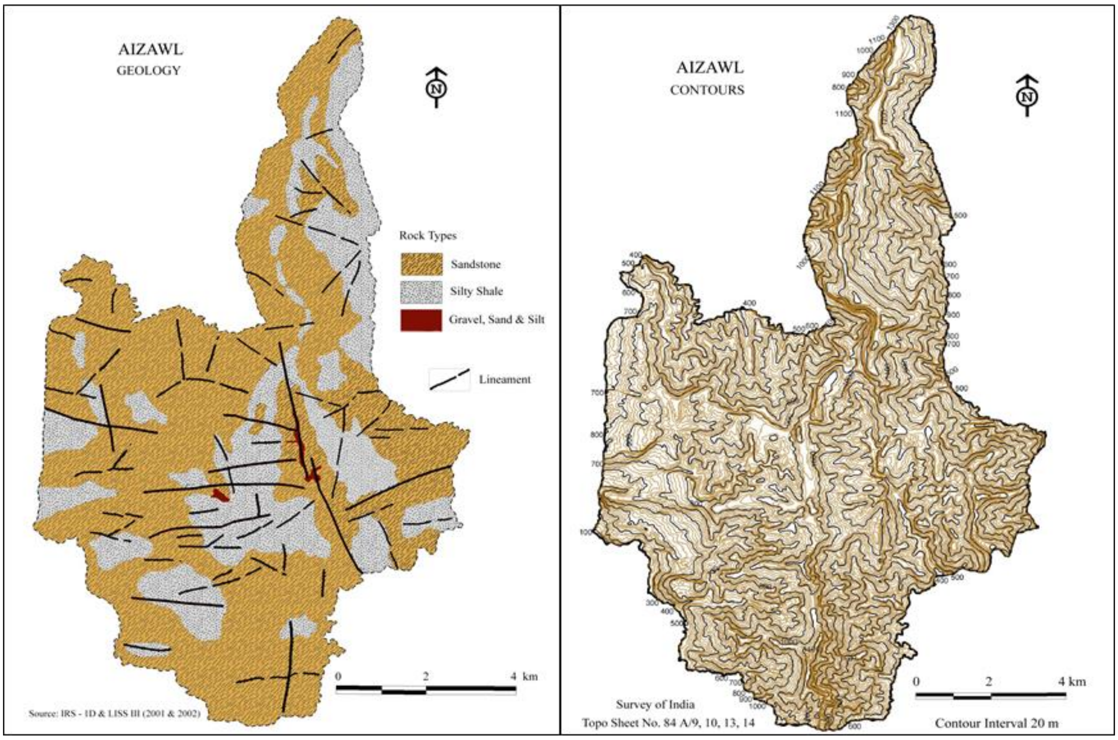
The quantity and quality of water available from fresh water systems are greatly influenced by land use within the watershed from which the water is drawn (Brunner *et al.,* 2000). Foster *et al.* (1998) highlight the provision of water supply, sanitation and drainage as a key requirement of the urbanization process, with the sub-surface playing an important role in all these three elements, and in the disposal of industrial and domestic effluents and solid waste. Sewage contamination is a global issue. The sources and pathways will differ depending upon whether waterborne sewerage or on-site sanitation is employed (Barrett, 2004).

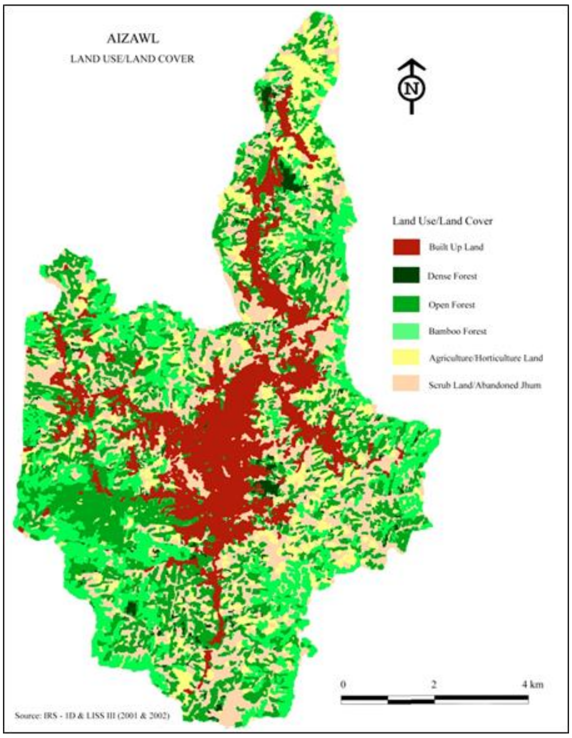
Urbanization not only affects ground water quantity through modification of recharge pathways, but it also affects ground water quality (Nazari *et al.,* 1993; Eiswirth and Hotzl, 1994; Lawrence *et al.,* 1996; Lerner, 1996). Sewage contamination of ground water results not only from direct infiltration from on-side sanitation and leaking sewerage systems to the sub-surface, but also from surface runoff entering poorly designed or maintained springs and boreholes (Foster *et al.*, 1998; Barrett *et al.,* 2000). Sewage can be a significant factor in the pollution of water (Craun, 1984). Bodhankar and Chatterjee (1994) reported the occurrence of various waterborne diseases because of contaminated drinking water in Raipur. Storm water runoff may also enter the sub-surface. This water may also contain contaminants such as heavy metals and organic compounds washed from building and road surfaces (Foster *et al.,* 1998; Yang *et al.,* 1999).

Interplay of geomorphic and geologic factors governs the movement of water from the time it reaches the land surface and the time leaving it. The nature, distribution and structure of geologic formations control the occurrence, movement, quality and availability of ground water (Melton, 1957; Singhal, 1973; Walton, 1970). The surface and sub-surface runoffs are governed in part by the geology on which depend the development of landforms, infiltration characteristics of zones of aeration, and transmissive characteristics of aquifers (CGWB, 1975). Surface runoff is strongly influenced by the sub-surface hydrogeologic configuration, the saturated permeability and specific yield of the component formations and the unsaturated soil characteristic of soil types (Freeze, 1972).

Data Base and Methodology

The present study is based on the information obtained from primary source. Survey of India toposheets No. 84 A/9, 84 A/10, 84 A/13, 84 A/14 (scale 1:50,000), and Satellite imageries of IRS – ID LISS III (2001) of false colour composite (FCC) (scale 1:12,5000) are used to develop base map of the study area, geological map, contours, and land use/land cover.





DISCUSSION

Urbanization and man's development of water as a resource distort many aspects of the land-water ecosystem, a subject that falls within the realms of the geomorphologist (Coates, 1974). There are four interrelated but separable effects of land-use changes on the hydrology of an area: (i) changes in peak flow characteristics, (ii) changes in total runoff, (iii) changes in quality of water and, (iv) changes in the hydrologic amenities. The hydrologic amenities are what might be called the appearance or the impression which the rivers, its channel and its valleys, leaves with the observer. Of all land use changes affecting the hydrology of an area, urbanization is by far the most forceful. The two principal factors governing flow regimen are the percentage of area made impervious and the rate at which water is transmitted across the land to stream channels. The former is governed by the type of land use, the latter is governed by the density, size, and characteristics of tributary channels and thus by the provision of storm sewerage (Leopold, 1968).

The study area is characterized by hilly topography with a large number of primary order streams. The peak flow characteristics of the streams are changing due to channelization of its numerous streams and creation of impervious layers along the banks. Land reclaimed from these streams areas for urban use is causing high frequency floods during heavy rain. Thus, increased imperviousness due to rapid urban growth leads to increasing the floods during heavy rainfall and decreasing the flow of streams and springs causing water scarcity during winter season.

The rapid population growth and other developmental works are responsible for land-use changes in the study area. The forest and agriculture areas are increasingly being transformed into concrete structures, paved roads and metalled pathways. These impervious structures influence the hydrological cycle by increasing the runoff as percolation of water reduces considerably. The volume of runoff is governed primarily by infiltration characteristics and is related to land slope and soil type as well as to the type of surface cover. It is, thus, directly related to the percentage of the area covered by roofs, streets, pavements, and other impervious surfaces at times of hydrograph rise during storms. The natural drainage channels are often blocked by the debris that has the potential of triggering heavy landslides and heavy storm during heavy rainfall. Huge losses were reported by mud flowing and landslides. This aspect of changing runoff pattern can be considered a major problem related to urban hydrology of the hill city like Aizawl.

The land use/land cover pattern revealed that scrub land covers the largest area, constituting 41.98 per cent of the study area. The built up area also covers a large area of about 15.56 sq km or 12.07 per cent of the total area (Table 1). The built up area was scattered following the main ridge lines running in north–south direction, on the central part it spread out to both east and west direction covering a large area. The drainage density is low in the central part and one could assume that it will have a ground water potential, however, due to expansion of residential area on the central part infiltration rates have been reduced considerably. An increase in total runoff from a given series of storms as a result of imperviousness results in decreased ground water recharge and decreased low flows (Leopold, 1968).

Table 1: Land Use/Land Cover in Aizawl

Land Use Category	Area	
	Sq km	Percentage
Built-Up-Land	15.56	12.07
Agricultural Land	13.16	10.21
Primary Forest	8.2	6.33
Secondary Forest	22.52	17.46
Bamboo Forest	15.4	11.95
Scrub Land	54.14	41.98
Total	128.98	100

Source: IRS -1D & LISS III, 2016 & 2017.

The porous and varied terrain of natural landscapes like forests traps rainwater and allow it to slowly filter into the ground. Runoff tends to reach receiving waters gradually. In contrast, non-porous landscapes like roads, bridges, parking lots, and buildings don't let runoff slowly percolate into the ground. The cumulative result of such changes throughout in the study area is an increase in the volume of runoff directly to the streams and rivers. The increased volumes of runoff also travel more quickly to surface waters, which in turn produce higher peak flows and velocities. Therefore, development of urban centre does result in a reduction in direct infiltration of rainfall. Surface impermeabilisation processes include construction of buildings, roads, parking lots, pavements, etc. The proportion of land cover is a key factor in the degree of impermeabilisation. Direct recharge from precipitation is clearly reduced by impermeabilisation. Thus, reduction of recharge in Aizawl has result in lesser discharge of *tuikhur*, wells and hand pumps and increased demand of water due to improving standard of living which has been creating scarcity of water in the study area, especially during the lean season. Land use changes are considered to have contributed largely to the reduced recharge and consequently reduced discharge of the natural water sources.

Today the study area is facing water scarcity because reserves of water are depleting, while the demand for water is increasing due to rapid population growth and improved standard of living. Each day, the residents are finding that water is more scarce. Much of the rain that falls on the catchment area either evaporates, or becomes runoff as surface water, with a small percentage that replenishing scarce ground water. The clearing of vegetation decreases capacity to capture moisture, increasing the amount runoff. Natural surfaces that absorb water and recharge ground water supplies are covered with hard impervious surfaces (streets, sidewalks, rooftops, driveways, parking lots, etc). Conversion from predominantly vegetated land use to urban uses results in tremendous reductions in water absorption capacity.

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