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An Appraisal of Geoenvironment in Aizawl City, Mizoram, India

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Abstract:
The knowledge of geoenvironment is of great significance in deciding the extent of urban growth in geomorphologically fragile zones such as unstable hillslopes with weal lithology and frequent slope failures, alluvial riverine zones affected by frequent floods, areas of probable subsidence, tectonically and seismically active areas etc. The application of geomorphic knowledge in urban development comes under the domain of urban geomorphology. Urban geomorphology, a recent but more useful branch of applied geomorphology, is the study of landforms, and their related process, materials and hazards, ways that are beneficial to planning, development, and management of urbanized areas or areas where urban growth is expected. Regional variations of water availability mainly arise due to differences in climatic and geomorphic conditions.

Keywords: Geology, Physiography, Climate, Soil, Drainage.

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 2001 Census, the population is 22,828 persons. Aizawl is linked with rest of India through the National Highway 54 (NH 54). The nearest air linkage is at Lengpui, 32 km due west from the City. The City is located in Seismic Zone V (Sankar and Nandy, 1986). The climate is moderate with an average annual rainfall of around 2240 mm. The City has a rugged and steep topography with slopes varying from about 15° to 36°. The soil formation in general, is of loose sedimentary type. The physical development pattern of the City is dictated by the fragile topography, extremely limited buildable land, lack of accessibility, and steep slopes coupled with frequent landslides. The present physical structure is almost linear along the NH 54, the transportation spine of the City.

Data Base and Methods: The present study is based on the information obtained from primary and secondary sources. 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, streams network, contours, geomorphic units, and land use/land cover. Procedure of digitisation has been adopted to convert different maps into digital form by using MapInfo. In order to interpret geomorphic units the satellite imageries of IRS – ID (2001) and LISS III (2002) of false colour composite (FCC) in the scale of 1: 125,000 were visually interpreted. The satellite imagery was enlarged to 1: 50,000 scale using Procom-instrument. Based on the colour, tone, texture, pattern, association, etc., geological formations, lineaments are delineated and verified during the field visits. The thematic details thus finalised are transferred to the base map prepared from topographic sheets.

Discussion: The mountain and hill environment offers a variety of resources with some of its limitations and specificities, such as the inaccessibility (much greater variation in relief, slope and topography), the fragility (rock structure, soil erosion and natural hazards), the diversity in flora and fauna and the ecological niches that exit as unique resources and specific environment and adaptation (Singh, 2002). These specificities obviously are seen in the form of diverse landscapes with variations in their natural resources, which are operated by physical processes relating to geomorphic, climatic and social realms.

1. Geology: The rocks of Mizoram are sedimentary comprising of sandstones, shale and siltstones. Their intercalation constitutes the hilly terrain in and around Aizawl. These soft rocks ultimately converted into soil, giving rise to possibility of growing crops and vegetables (Kumar et al., 1997). The study area comprises a monotonous sequence of sedimentary rocks, such as sandstone, shale, siltstone, clay and intermixture of these rocks, which has been regarded as part of the Surma Group of rocks. The distinction between various units is difficult because of absence of marker horizon or some index fossil and because of the gradational nature of the lithological contact. Hence, the classification has been done based on proportions of argillaceous and arenaceous content and topography. The area is formed by anticlinal ridge, which is doubly plunging with approximately north-south trend. Rocks belonging to Middle Bhuban formation occupy the core of the anticline and the overlying upper Bhuban formation flanks the anticline on both sides (Geology and Mining, 2005).

(i) Middle Bhuban Formation

This formation is represented by argillaceous predominance. It consists of alterations of thinly bedded siltstone with subordinate bands of shale and sandstone. Rocks of the Middle Bhuban formation are mainly thinly bedded sequence of sandstone and siltstone with mudstone. Sandstones are fine to very fine grained, ash to bluish grey in colour and light brown, compact and hard and generally thinly bedded. Nevertheless, occasionally few thick beds of sandstone are also seen. Band of argillaceous materials are present within the sandstones near the upper slopes. The thick bedded sandstones are of light grey or light brown colour and at the base embedded rounded to sub-rounded shale and mud pebbles are invariably observed. The siltstone is generally gray in colour and massive in appearance (Tiwari and Kumar, 1996).

(ii) Upper Bhuban Formation

The Middle Bhuban formation is overlain by younger arenaceous rocks of Upper Bhuban formation consisting of medium grained, moderately hard, sandstone with subordinate shale/siltstone. They are well bedded, grey and yellow in colour with well-laminated khaki and grey shale, silty shale and siltstone (Tiwari and Kumar, 1996). This formation is exposed along the Zokhawsang ridge in the eastern part; on the western side, this formation is represented from Luangmual towards Tanhril; and on the northern part, it is exposed from Durtlang Vengthar towards Sihphir ridge.

The tectonic and structural condition of Aizawl is represented by repetitive cyclic succession of Neogene aranaceous and argillaceous sedimentary rocks of about 20 to 40 million years old, which were later thrown up, folded and faulted into series of N-S or NNW-SSE (approximately) plunging or trending anticlines and synclines. Aizawl and its surrounding areas seriously suffered from tectonic activities during late Cretaceous to Tertiary. The sediments show prominent primary bedding. Ripple marks are preserved at some places, which are of interference type, small scale cross bedding are noticed in both middle and upper Bhuban formations. These structures indicate shallow marine to deltaic environment of deposition. The rocks of both the formation are thrown into N-S trending doubly plunging anticline, which runs almost along the main ridgeline of the study area (Kumar et al., 1997). The axial trace of the fold seem to be affected by the cross faults which thus formed subsequent to the formation of the folds. Siltstones are hard and compact in nature exhibiting well-defined bedding planes. The shale is thinly bedded showing laminated and splintery patterns. The joints are generally tight and widely space except in shale bands. As the study area is part of a linear belt of folds which comprise not only Mizoram but also its adjoining areas, the area bears tectonic marks of folding and faulting.

The common rocks found are sandstone, shale, siltstone and slates. Sandstone covers the largest area covering about 70.60 per cent (91.05 sq km), Silt and shale covers 29.16 per cent (37.61 sq km), and gravel, sand and silt covers 0.24 per cent (0.32 sq km) of the total study area (Fig. 1). The rock system is weak and unstable, prone to frequent seismic influence. The geomorphological features consist of steep hill slopes and deep valleys oriented on the topographic surface in a linear fashion. The present valleys and ravines are the result of the underlying faults and structural patterns giving origin to different types of drainage patterns. Faulting has resulted in creation of steep curves, highly dissected ranges with deep ravines, spurs etc. vulnerable to comprehensive erosion.

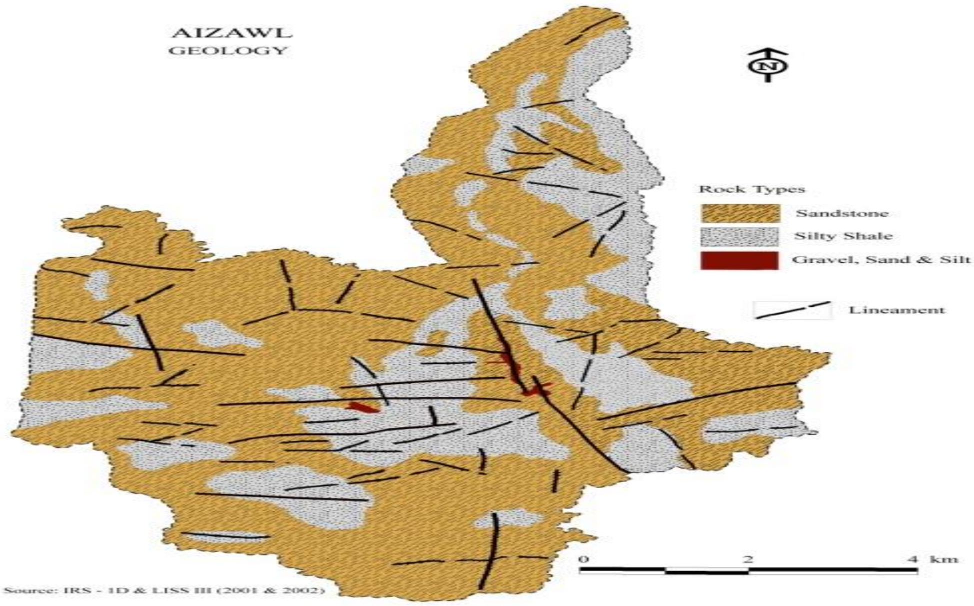
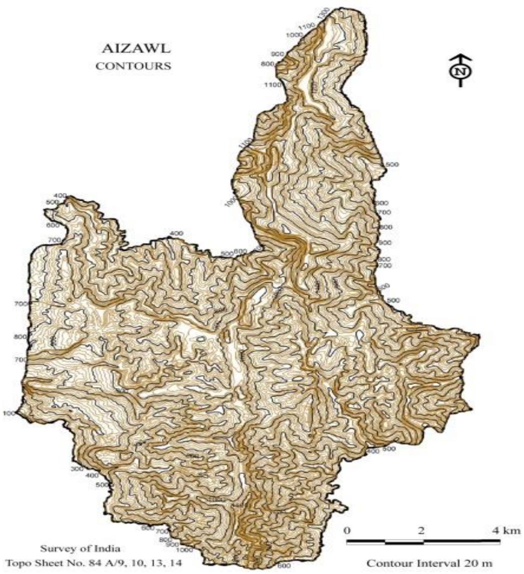


Fig. 1: Geology of Aizawl

1. Physiography: The study area is located on a prominent north-south extending ridge amidst subdued spurs on either flank, situated between 120 m to nearly 1400 m above the mean sea level (Fig. 2). The entire length of the main ridgeline is about 19 km, which runs almost through the entire study area. The River Tlawng bounds it in the west and River Tuirial in the east. The physical development pattern of the City is dictated by the fragile topography, extremely limited buildable land, lack of accessibility, and steep slopes coupled with frequent landslides. The present physical structure is almost linear along the NH 54, the transportation spine of the City.

The altitude of the area is more or less gradually decreases from north to south. Along the main ridge, the predominant elevations are Neihbawi (1441 m), Durtlang (1383 m), Laipuitlang (1188 m), Babutlang (1140 m), Tuikhuahtlang (1132 m), Tlangnuam (1156 m) and Hlimen (1191 m). Thus, the two highest elevations are located in the northern most part of the area. The other prominent hills other than the main ridge are Haidai-Tlang (1005 m), Tanhril (970 m), and Seventh Day Tlang (960 m), all of them are lying in the western part of the area. The lowest point is located at River Tlawng valley, which at 120 above mean sea level. The other lower places are at River Ser valley (180 m to 200 m) and River Chite valley (460 m to 500 m).

The area is highly dissected with sharp crests, steep hill slopes and scarps. The west facing scarps are noticed in Laipuitlang, Chaltlang, Bawngkawn and Durtlang and the east-facing scarp are seen at Ngaizel in the southern part of the study area. The spurs are mainly running in east-west directions. Majority of spurs are found in the western part of the City. The main geomorphological unit is classified as structural hill, which is further divided into three classes, viz., high structural hills (above 1200 m), medium structural hills (800 m to 1200 m), and low structural hills (below 800 m). The high structural hills cover an area 3.67 per cent (4.73 sq km), medium structural hills cover 47.91 per cent (61.80 sq km), and low structural hills cover 48.32 per cent (62.32 sq km) of the study area. The valley fills covers an area of about 0.10 per cent of the study area (Fig. 3).



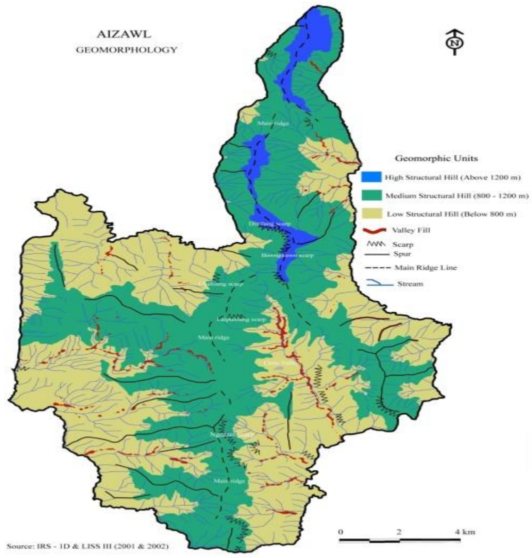


Fig. 2: Contours of Aizawl **Fig. 3: Geomorphology of Aizawl**

Physiographically the study area is undulating and conspicuous by the presence of N – S or NNE – SSW trending linear ridges with steep slopes representing a very rugged topography. The slope angle varies from 15º to 36º forming concave shape in the middle. The hill slopes are dissected by a number of streams forming wide and deep gullies due to destructive works of the streams. The slopes are steeper near the streams. The slopes found in Chaltlang, Durtlang, Sihphir, Tlangnuam, and Laipuitlang are very steep and are unsuitable for human habitation. The study area is highly susceptible to erosion and rain induced landslides leading to severe damage to property and lives every year. In general, the eastern side slope is less vulnerable than the western side slope because of higher dip amount of the bedding plane with respect to the topographical slope.

2. Drainage System: Being a hilly terrain with steep slopes, most of the rainwater flows down as surface runoff. Two rivers surround the City from two sides, namely River Tuirial on the eastern side and River Tlawng on the western side. The storm water and the wastewater from the City are ultimately drained into these two river systems. The River Tlawng and Tuirial directly influence the drainage system of the eastern part and western part of the City, respectively. The drainage pattern as a whole is dendritic, which is a characteristic feature in horizontal sedimentary rocks. The drainage system can broadly be divided into: i) the eastern drainage system, and ii) the western drainage system flowing into the River Tlawng (Fig. 4).

Fig. 4: Drainage Network of Aizawl

(i) <u>Eastern Drainage System</u>

The eastern part of the City is drained mainly by river Chite and Muthi flowing eastwards to join river Tuirial. The River Chite is the most important single stream as nearly more than two-third of the eastern part is drained by it. River Chite has many tributaries of which the most important are Chanmari Lui rising from the central part (Chanmari saddle), Ramthar Lui, Mirawng Lui rising from Bawngkawn saddle, Bethlehem Veng Lui, Tlak Lui, Taite Lui, Lawibual Lui, Hmawngkawn Lui, Zemabawk Tuikhur Lui, Zuangtui Lui, Kawmthlang Lui, etc. The other important streams draining the eastern side of the study area are Sihphir Lui, Sele Lui, Lubuka Lui and Chhuahlam Lui.

(ii) <u>Western Drainage System</u>

Several numbers of streamlets drain the western part of the City. Ramri Lui, Vai Lui and Zawngkawt Lui join River Ser flowing on the southwestern part of the City, before it joins the River Tlawng. Tuikual Lui and Chakai Lui rising from the heart of the City join Tuithum Lui, after flowing in southwest direction Tuithum Lui meets River Tlawng. Other important streams in the northwestern side are Leitan Lui and Melnga Lui. Parallel to sub-parallel drainage pattern is observed in the southwestern part of the study area.

As far as the streams and storm water work on the eastern part is concerned the streams coupled with storm water namely Chite, Chanmari Lui, Bethlehem Lui, Tuikhurhlu Lui, and Mirawng Lui are turbulent with high velocities of current during the monsoon and they are very destructive to human life and property within their respective catchment areas. In the same way, on the western part, Vai Lui, Tuikual Lui, Vaivakawn Lui and its tributaries also form destructive phenomena.

3. **Soils:** The soils of different places in the study area are of homogenous nature as far as the genetical aspect of the soil formation is concerned. The soil is mainly derived from sandstone and shale. The soil type generally found in the area varies from sandy to loam and clay to loam mixed with broken angular shape of varying size. The colour of the soil varies from red to yellowish with varying depth. Red soil is mainly found at the up-hill slopes. The soil is acidic in nature due to heavy rainfall and the pH values ranges from 4.5 to 6. Soil contains a high amount of organic carbon and is high in available nitrogen, low in phosphorus and potassium content. The pH and organic content decrease and the clay content increases with depth.

The study area experiences warm humid sub-tropical climate under the influence of monsoon. Based on rainfall and humidity, the soil moisture regime of the study area is classified as Udic. The soil moisture regime refers to the presence or absence of water in the soil by periods of the years. A soil may be continuously moist in some or all horizons throughout the year or some part of the year. The soil may be saturated or the amount of water is enough to cause leaching and non-leaching regimes. The Udic moisture regime is common to the soils of humid climates that have well distributed rainfall or that has enough rainfall in summer that the amount of stored moisture plus rainfall is approximately equal to or exceed the amount of evapotranspiration. The soil of the study area also qualify Hyperthemic soil temperature class to be used as family modifiers since the mean annual temperature is 22°C or higher and the difference between mean summer and mean winter soil temperature is more than 5°C (SSSO, 2001).

Classification of soils of the study area has been done according to soil taxonomy (USDA, 1974) based on their physio-chemical and morphological properties. The soils found at order level are Entisols, Inceptisols and Utisols. The types of soils found at sub-order level are Orthents, Ochrepts and Udults. Soil formation of Aizawl in general being of loose sedimentary type has high porosity and therefore is highly permeable and highly susceptible to erosion.

Though there is fair percentage of clay soil on either side of the streams but its water or moisture holding capacity is very low due to deforestation, porosity in nature combined with predominantly argillaceous and compact nature, which causes very dry top soil during the dry season. Generally, natural moisture content varies from 14 per cent to 23 per cent where field dry density varies from 1.58 to 1.65 g/cc. The saturated density varies from 1.92 to 2.25 g/cc, liquid limit varies from 25 per cent to 38 per cent, plastic index varies from 15 per cent to 26 per cent and permeability varies from 2.1 x 10-5 cm/sec to 4.2 x 10-5 cm/sec. The effective cohesion varies from zero to 1.0 kg /cm², effective angle of sheering resistance varies from 252 to 402, and the clay content varies from 15 per cent to 35 per cent, whereas silt content varies from 20 per cent to 35 per cent (SSSO, 2001).

4. Climate: The climate of Aizawl is tropical monsoon type climate. The climate is neither very hot nor very cold, but moderate throughout the year. It falls under the direct influence of south-west monsoon and receives an adequate amount of rainfall. Aizawl receives an adequate amount of rainfall during the monsoon. The mean annual rainfall is calculated to about 2240 mm per annum (Directorate of Agriculture and Minor Irrigation, Mizoram). During summer monsoon, it receives about 1863 mm, while during winter season it is around 379 mm. The general character of the periodical distribution of the rainfall tends to be more or less similar each year though there are some variations in their occurrences from year to year. However, the same general characteristics ordinarily prevail for any given month. The maximum and minimum rainfalls occur at distinct periods. The character of the mean monthly rainfall distribution varies widely ranging between 8.36 mm in January to 356.53 mm in May. Generally, the rainfall starts from the month of late April and ends in the mid of October. In other words, precipitation is heavy in summer normally from the month of May to September, and lasts until mid-October. At least 75 per cent of the total annual rainfall occurs from May to October. The rainfall that takes place during December to April contributes only 20 per cent of the total annual rainfall. January receives the least amount of rainfall with an average of 8.36 mm or 0.4 per cent of the annual rainfall.

Temperature affects disposal of precipitation through evaporation and transpiration, accumulation of snow and frozen ground. The rate of emission of molecules from water is a function of its temperature, higher the temperature greater is the rate of emission because the molecules have greater energy to escape. Evaporation increases with the temperature of the water surface due to the increase in vapour pressure with temperature (Monteith, 1981).

General information about the temperature conditions of the study area is made through the analysis of the temperature data of 20 years. The temperature record reveals that the average annual temperature of Aizawl is about 22.50°C. The temperature of the study area does not fluctuate much throughout the year. The highest temperature observed during May to July and it starts decreasing with the onset of monsoon. This fall of temperature continues with the span of monsoon and becomes more evident with the retreating monsoon. Minimum temperature is found in January. The mean monthly temperature during January is 17.41°C. In other words, the mean daily maximum temperature in the month of January is 26.06°C and the mean daily minimum temperature is 8.33°C. Moreover, the monthly temperature begins to rise from the month of March. The highest mean monthly temperature is observed during the month of June and July, which is about 24.94°C and 24.87°C, respectively. Meanwhile, April and May are the warmest months with mean daily maximum at about 33°C and the mean daily minimum at 13.73°C. Therefore, during the last two decades a substantial increase in average temperature has been observed, which may be due to global-warming.

Humidity is the general term to indicate moisture in the atmosphere. It is closely related to the temperature of air, the higher the temperature, the more amount of vapour the air can hold. A space, which contains the maximum amount of water vapour for a given temperature is said to be saturated. The degree of saturation is often expressed by the term relative humidity (Harrison, 1963). The air is highly humid nearly throughout the year. Relative humidity is high during the period of south-west monsoon. The average monthly relative humidity ranges from 60.58 per cent in January to 86.54 per cent in August (Directorate of Agriculture and Minor Irrigation, Mizoram, Aizawl). The mean monthly relative humidity in the month of June, July, August and September is more than 80 per cent. Thus, the average relative humidity has been calculated to 74.75 per cent. It is known that the higher the humidity value, slower is the rate of evaporation. Hence, because of high relative humidity in the City, the rate of evaporation is somewhat slow and the vegetation gets the benefit.

Conclusion: An appraisal of geoenvironmet in Aizawl city with respect to the geomorphic units and climate proved the following conclusion:

The temporal distribution of the rainfall influences the water availability in the study area on one hand. Though the rainfall is heavy, most of it is highly seasonal and confined to five or six months. The general lithology consists of alternations of siltstone, shale and sandstone has significantly reduced the water yielding capacity of rocks, since the porosity are very limited in these rocks. However, the presence of numerous sets of joints, fractures, bedding planes and faults act as good conductor for ground water. In the areas of higher values of lineaments density there is a development of secondary porosities like joints and fractures. These are the main factors controlling the occurrence of natural water sources. The entire City is situated on a hilly terrain such type of terrain is not favourable for ground water recharge and storage. Storm water cannot longer infiltrate into the ground but drains through natural drains. Infiltration rates are generally maximised when slopes are gentle with permeable soils and when rainfall intensity is low. The unplanned growth of the City, without proper collection and treatment of sewage has created real threat of pollution of rivers, streams, and ground waters. Even in the higher altitude, inherent structural weakness of the rocks (fractures, cracks and joints) cause short circuiting and untreated waste water often enters the ground water body to pollute it.

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