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Evaluation of physical characteristics using geomatics: a case study

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Abstract
The main objective of the study is to evaluate the physical characteristics and the natural resources in the study area and to develop methods for its efficient utilization and sustainable management using tools such as remote sensing and GIS. The thematic layers are derived from IRS-ID PAN + LISS-III merged satellite imagery and survey of India (SOI) topo maps using visual interpretation technique. These maps are converted to digital format using AutoCAD software and further integrated using Arc/Info and Arc view GIS software for the generation of final outputs. Physical characterization helps for quality of environment and natural resources development, which are optimally suitable to the terrain and to the development of water resources. The physical characterization of an area is also useful to plan the basic minimum needs of farmers, thereby improving their socio-economic conditions and helps in evolving a broad national policy which can be applied by decision makers for sustainable development of any given study area. This case study would help in developing municipalities with details at micro level for further planning.

Keywords: Remote sensing; geographical information system; sustainable development.

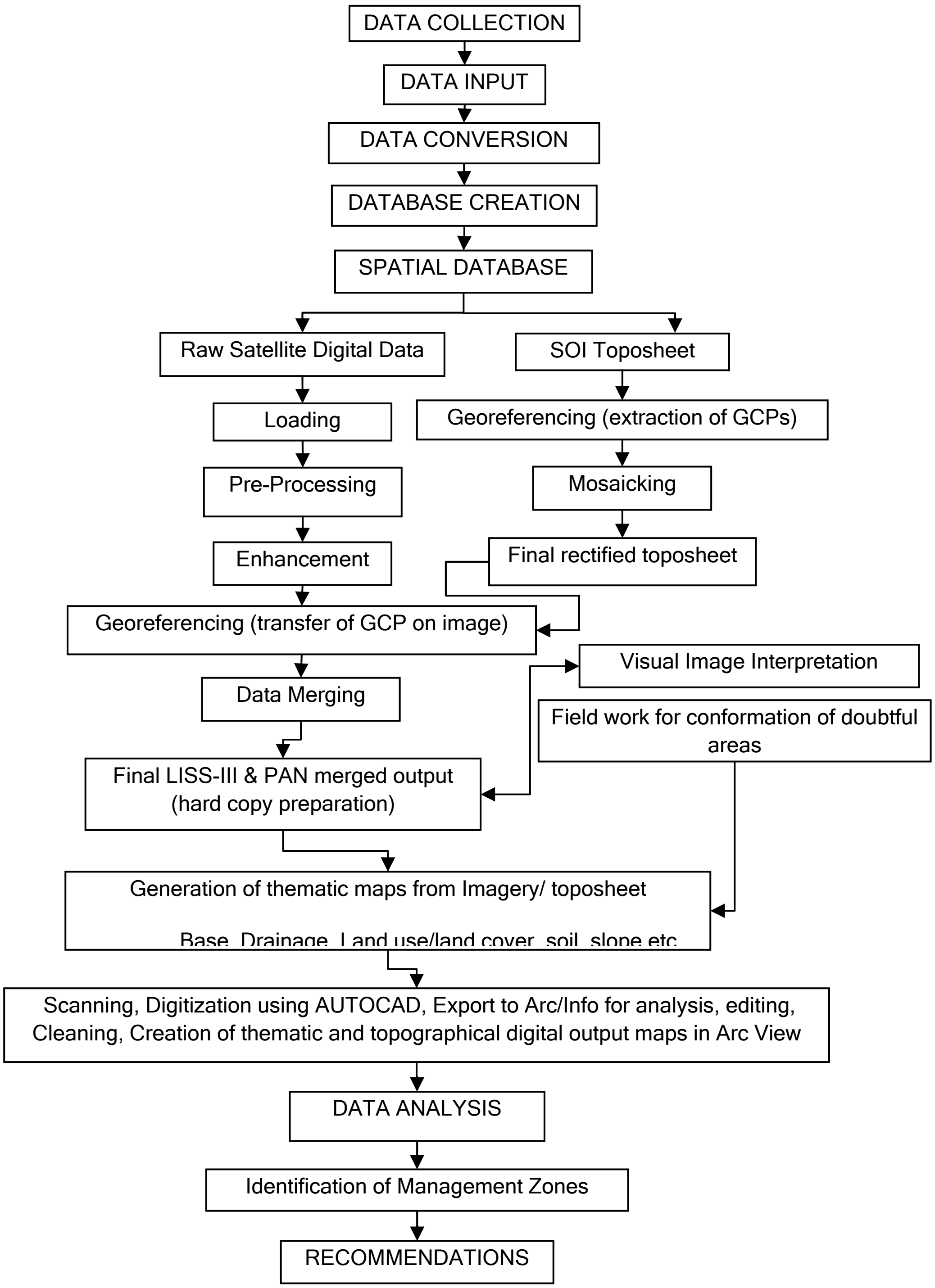
Introduction
Land and water are valuable natural resources that are often viewed solely in terms of their value for supporting agriculture, forestry, mining and human settlement. However, land and water also have social, ecological and cultural uses and values. As with most environmental concepts, land cannot be considered in isolation from other components of the environment. The consideration of land within the context of watershed is one way of ensuring that this interconnectedness is not overlooked. Comprehensive information about the status of the natural resources and their utilization is essential for any watershed area treatment and management (Govardhan, 1993; Lenin *et al.*, 2008; Gurugnanam *et al.*, 2009). Among others, status of water resources, land evaluation for irrigation, cropping pattern and land use are the important factors that influence soil and water use efficiency, not only for optimizing agricultural production but also for control of the twin problems of soil and water which are usually associated with overuse and mismanagement in a watershed area (Isobel & Heathcote, 1998). Periodic mapping and monitoring of land and water resources and their utilization status is therefore important for formulation of appropriate strategies for planning and implementation of ameliorative and development measures. This can be achieved by conventional ground surveys or by application of modern technology of remote sensing with limited ground studies.

The conflicting demand of human activities and the pressure of increasing population have made it essential to plan the use of land in an optimal manner, so as to reap maximum benefits for the millions of human beings (Arakeri & Donahue, 1984). The constant pressure of growing population, increased demand for food, fodder and fuel wood combined with intensive industrial activity have led to large-scale environment degradation and ecological imbalance. Hence in order to use land optimally, it is necessary to have first hand information about the existing land and then assess the location in the study area. Remote sensing, because of its advantage like synoptic view, repetitive coverage and multi spectral and multi sensor data availability, have been universally accepted as a powerful technology for resources survey mapping and regular monitoring (Nag, 1992). Remote sensing data with rapid in-time availability, high resolution and low cost product is an important tool for planning activities and can be used to study the physical characteristics of terrain depicting various land and water resources. These maps as a reliable input can be put to a Geographic Information System (GIS) to describe natural resources both renewable and non-renewable as well as cultural and human resource (Anji Reddy, 2003).

The objectives of the study area are: To extract and understand the physical characteristics of the study area for effective management and future development. To create spatial digital database consisting of land use/land cover, drainage, physiography, soil and slope maps using IRS-ID PAN & LISS-III merged satellite data, SOI toposheets and ground data on ARC/INFO GIS platform. To generate attribute data base consisting of statistical details of each of the above thematic layers.

Methodology (Flow chart 1)

Flow chart 1. Steps of method adopted for the present study



Study area

The study area is Municipal Corporation of Hyderabad, India. Hyderabad is situated in the Krishna basin and the river Musi, which is a tributary of river Krishna, is passing through the city of Hyderabad, and bifurcates the city into Northern and Southern Hyderabad. The study region covers an area of 179 sq km. The study area is situated between 17^0 18' 26" and 17^0 27' 40" North latitudes and 78^0 22' 26" and 78^0 33' 26" East longitudes and is at an altitude of 536 m above Mean Sea Level (MSL). The population growth rate of Andhra Pradesh during 1991-2001 is 13.86% and that of Ranga Reddy district is 21.66%, which is higher than Hyderabad district (17.18%) (Hand book of Statistics, 2001). This clearly indicates the urbanization towards rural areas of Ranga Reddy from Hyderabad city, which in turn might have adverse effect on quality of Osmansagar water in terms of domestic discharges.

The climate in the study area is characterized by hot summers and is generally dry except during the Southwest monsoon season. The watershed receives an average annual rainfall of 788.64 mm. May is the hottest month with mean daily maximum temperature around 31.6°C and December is the coldest month with mean daily minimum temperature around 13°C. Agriculture is the main land use in this area. National Park, which is a part of study area, is southern tropical dry deciduous forest of degraded nature. The park is endowed with the last vestiges of the endemic flora of Hyderabad and is an urban refuge for small mammals. The topography is undulating having rocky exposures of the deccan trap formation. Red soils predominate in the area followed by black cotton soils.

Data collection

Different data products required for the study include SOI toposheets bearing the numbers 56K/7 and 56K/11 on 1:50,000 scale, fused data of IRS-1D PAN and LISS-III merged satellite imagery obtained from National Remote Sensing Agency (NRSA) and collateral data collected from related Government organizations and demographic data.

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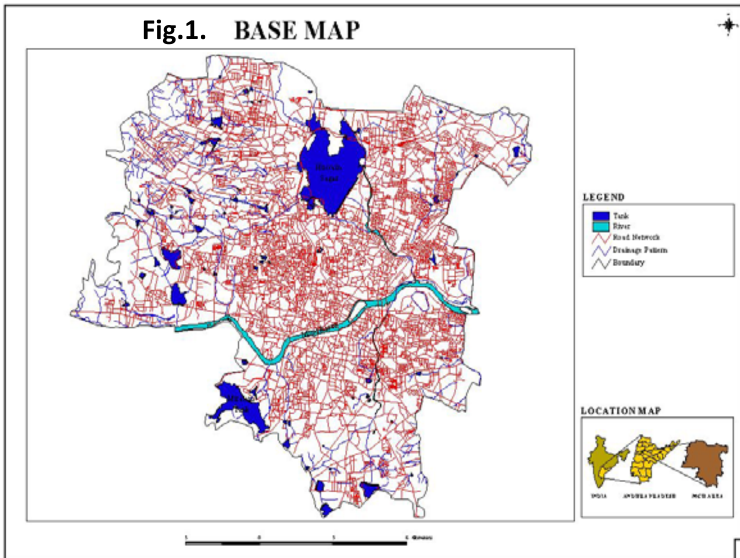

Fig.1. BASE MAP

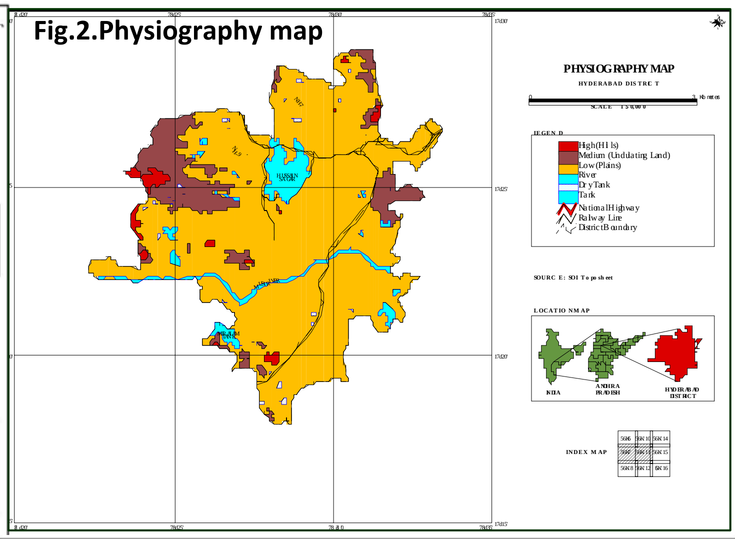

Fig.2.Physiography map

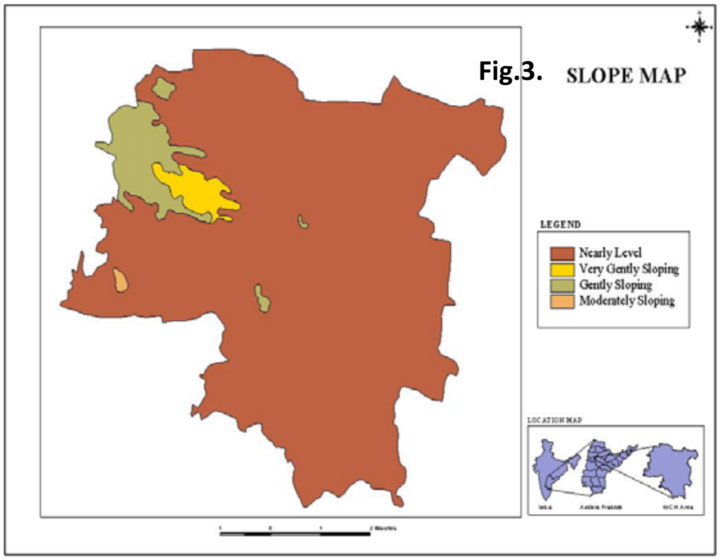

Fig.3. SLOPE MAP

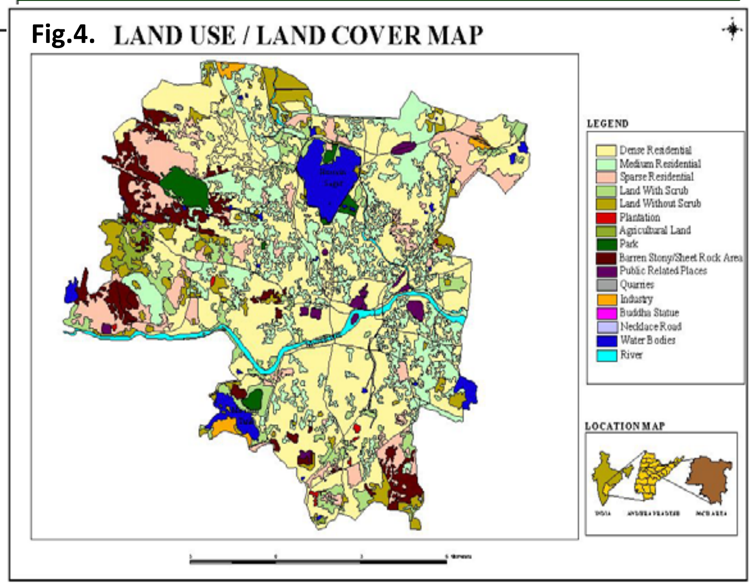

Fig.4. LAND USE / LAND COVER MAP

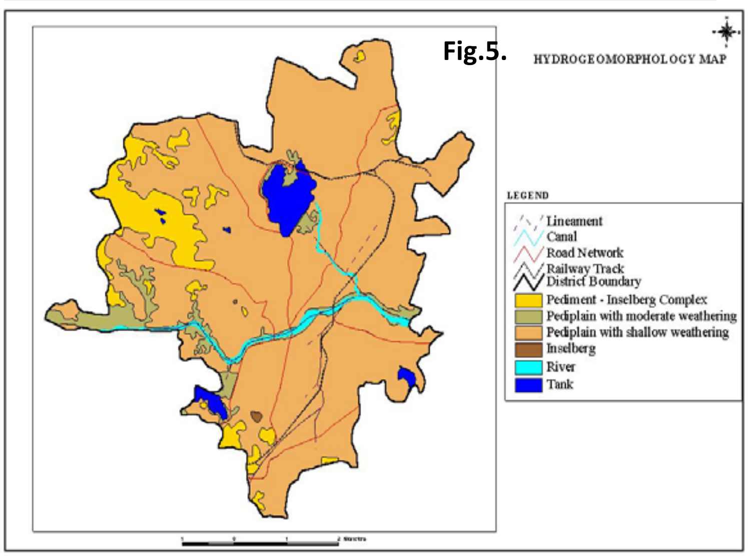

Fig.5. HYDROGEOMORPHOLOGY MAP

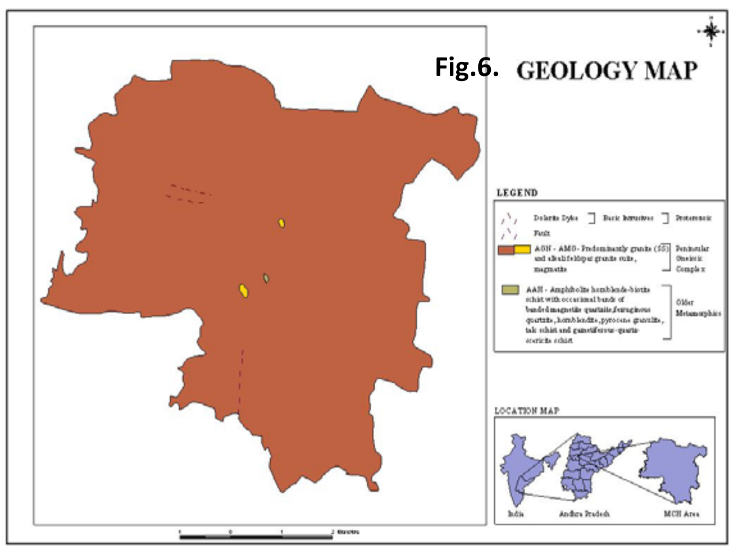

Fig.6. GEOLOGY MAP

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Data input and conversion

IRS-ID LISS-III and PAN satellite imageries collected from NRSA are geo-referenced using the ground control points with SOI toposheets as a reference and further merged to obtain a fused, high resolution (5.8m of PAN) and colored (RGB bands of LISS-III) output in ERDAS Image processing software. The study area is then delineated and subsetted from the fused data based on the latitude and longitude values and a final hard copy output is prepared for further interpretation.

Database creation and analysis

Creating a GIS spatial database is a complex operation, which involves data capture, verification and structuring processes. Raw geographical data are available in many different analogue and digital forms such as toposheets, aerial photographs, satellite imageries and tables. Out of all these sources, the source of toposheet is of much concern to natural resource scientist and an environmentalist (Jensen, 2003). In the present study, different thematic layers viz., Base map, Land use / Land cover map. Hydrogeomorphology, Slope, Physiography, Soil, Geology, Drainage network maps are generated from toposheet and satellite data using visual interpretation technique. The paper-based maps are converted to digital mode using scanning and automated digitization process. These maps are prepared to a certain scale and show the attributes of entities by different symbols or coloring. The location of entities on the earth's surface is then specified by means of an agreed co-ordinate system. It is mandatory that all spatial data in a GIS are located with respect to a frame of reference. For most GIS, the common frame of reference co-ordinate system is that of plane, orthogonal cartesian co-ordinates oriented conventionally north-south and east-west (Cracknell & Hayes, 1996). This entire process is called geo-referencing. The same procedure is also applied on remote sensing data before it is used to prepare thematic maps from satellite data. This digitized data is then exported to ARC/INFO and further processed in ArcView GIS software to create digital database for subsequent data analysis.

Results and discussion

Base Map

A map which depicts the outline structure of the district is called as base map. The base map is prepared using survey of India (SOI) toposheets (56k/7 and 56k/11) on 1:50000 scale and updated with the help of satellite imagery. The information content of this map is used as a baseline data to finalize all the other physical features of maps. The features included in the base map in general are district boundary, Taluk/ Block/Mandal boundary, rivers/water bodies, District/mandal headquarters, major settlements, major roads, railways and others. The major settlements in the present study area are Mehdipatnam, Koti, Himayathnagar, Malakpet, Langer house, Tolichowki, Shaikpet, Golconda etc. and the major water bodies represented in the base map include Musi river, Miralam Tank and Saroornagar and Hussain Sagar lakes. The South central railway line passes through the city along with the NH-7 and NH-9 which connect different places (Fig.1).

Drainage pattern

In the present study a drainage network map is prepared from the toposheets which is further scanned, digitized using AutoCAD software and then edited in ARC/INFO GIS platform to produce a digital output. The major water bodies represented in the drainage map include Musi river which flows from west to east in the central part of the study area, Miralam tank and Hussain Sagar lake. There are small water bodies located in different parts of the study area such as Langer house, Yousufguda, Banjara Hills, Saroornagar, akbarpura etc.

Physiography

The plains occupy the major part of the project area, which indicates nearly level, gently sloping and very gently sloping terrain. The next major unit is the undulating terrain indicating moderately and strongly sloping terrain, which indicates the pediments and inselbergs of the geomorphic units. The third class is hills which indicate the steep and very steep slopes along with the residual hills. These landforms indicate the granitic rocks. The maximum elevation of the study area, 610 m above mean sea level is observed at Jubilee Hills, Banjara Hills and Golconda which are located at the northwest part of the study area (Fig. 2).

Slope

Survey of India topomaps on 1:50,000 scale are used for deriving the information. Contour lines on topographic maps are particularly useful for preparation of slope map. Closed space contours on the map reflect steepness when compared to widely spaced contours. The different classes of slopes have been categorized as per the guidelines suggested by All India Soil and Land Use Survey (ALS & LUS). The study area has been categorized into four slope classes in this about thirty two percent of the total study area is indicating its near level nature, whereas the distance between the successive contours is short and numerous contours are present in about twenty three percent of the total study area indicating steeply sloping nature. In the remaining portion the distance between successive contours is moderate. In general, the elongated shape of the contours suggests the elongated morphology of the hills (Fig. 3).

Land use/Land cover (LU/LC)

The LU/LC map of the study area is prepared from satellite imagery using visual interpretation technique (Fig.4). This technique consists of a set of image elements, which help in the recognition or interpretation of various land use/land cover features systematically on the enhanced satellite imagery during the classification of features (Lillesand & Kiefer 1994). The land use/land cover and soil classification system used in this study is the system, which is pioneered by United States Geological Survey (USGS) and is modified by National

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Remote Sensing Agency (NRSA) according to Indian conditions. A preliminary image classification key is prepared for the fused pictorial data and is used during interpretation process. The base map is overlaid on the satellite imagery. Then the features of LU/LC and soil are extracted and transferred from the satellite pictorial data. The doubtful areas (due to similar spectral response and spectral signature) identified during the preliminary image classification are listed out before ground verification. The doubtful areas are physically verified by field observation, based on which, corrections and modifications of misclassified soil and land use/land cover details are carried out for preparation of final maps so as to extract the entropy or information content in accordance with the above thematic maps. In the land use/ Land cover map these classes are identified residential land in the study area is classified into dense residential (77.79 sq. km), medium residential (37.108 sq. km), sparse residential (17.0887 sq.km) (10%), public related places(2.5538 sq. km), agricultural land (1.5335 sq. km), plantation (1.5353 sq. km), parks (2.5629 sq. km), land with scrub (10.5492 sq. km), land without scrub (8.6786 sq. km), industrial (1.268 sq. km), BSA (9.0703 sq. km), Quarries (0.223 sq. km), rivers/canals (1.4607 sq. km), tanks (7.6379 sq. km).

Hydrogeomorphology

In the present study, IRS ID, LISS III data and the survey of India (SOI) topographic maps are the main input data for preparation of hydro-geomorphological map. The geomorphic units are delineated based on the image characteristics like tone, texture, shape, colour and associations. Overlapping the base map over the geo-coded FCC image, the geomorphic units and forms, the structural information and structural trend lines are incorporated. The available geological maps, published literature and other information are used in enriching the geological and geo-morphological details. The doubtful units encountered are noted and confirmed with ground checks. The legend is classified and incorporated on the map based on the origin and chronology. The study area has been categorized into 4 classes i.e., pediplain with shallow weathering (163.884 sq. km), moderate weathering (12.584 sq.km); Inselberg (0.185 sq.km); pediment-Inselberg complex (16.953 sq.km) (Fig. 5).

Soil map

It depicts different soil classes identified from the satellite imagery. Their area extents are obtained through GIS analysis. The total study area is covered with red sandy soils.

Geology map

Geologic mapping involves the identification of landforms, rock types, and rock structures (folds, faults & fractures) and the portrayal of geologic units and structures on a map. The study area constitutes mainly a granitic terrain (pink-grey) exposing a variety of Archaean granitoides of peninsular gneissic complex (PGC) and schistoic (older metamorphic) rocks. They are intruded by basic dykes (proterozoic) and covered locally by the deccan traps (upper cretaceous to lower eocene). The granitoides (PGC) of the area are classified into three main suites based on the field relation and petro-chemical characteristics (Fig.6). They are: 1) Tonalite-trondhjemite-quartz chlorite (TT), 2) Adanellite-granodiorite-quartzdiorite (AG) and 3) Granitealkali feldspar granite. These types of rocks are formed by the cooling and hardening of magma, a complex molten material that originates within the earth.

Conclusions and suggestions

Most municipal corporations in India are yet to be connected with physical characteristics information or additional information network to serve the people. Case study would help in developing municipalities with details at micro level for further planning. In this junction GIS (geographical information system), a rapid developing field, will be the platform for better analyze of resources very efficiently. This model study helps to get the digital data of the total study area physical characteristics information, according to their importance. If we analyze any resources and economic information we can get the total detailed information. We can get the information of the each physical characteristic, and to plan to meet future demands. We can obtain the full details of the municipal corporations as it is decision support information of micro-level planning. This study is very useful for government officials and public can easily get the data and to take decisions to manage the any disaster and natural resources management.

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