Application of Satellite Images and GIS in the Preparation of Development Plans:

Case Study
Master Plan for TUDA Region and
Zonal Development Plan for Tirupati Town

Authors:
Shirley Ballaney, Architect – Urban Planner
Project Coordinator at EPC, Ahmedabad
shirley@wilnetonline.net
Bindu Nair, Geographer – Urban Planner
Project Manager at EPC, Ahmedabad

Contact Address:
Environmental Planning Collaborative
701, Paritosh, Usmanpura, Ahmedabad – 380013
Gujarat, India
Ph (O): (079) 7550102, 7550875, Fax: (079) 7550649

Presenting and Contact Author:
Shirley Ballaney
shirley@wilnetonline.net

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Application of Satellite Images and GIS in the Preparation of Development Plans: Case Study: Master Plan for TUDA Region and Zonal Development Plan for Tirupati Town

Authors:
Shirley Ballaney, Architect – Urban Planner[1]
Project Coordinator at EPC, Ahmedabad
Bindu Nair, Geographer – Urban Planner[2]
Project Manager at EPC, Ahmedabad

The paper is based on the experiences and learnings from a project that is being currently done at Environmental Planning Collaborative (EPC), Ahmedabad - Preparation of Master Plan for TUDA Region and Zonal Development Plan for Tirupati for Tirupati Urban Development Authority (TUDA).

Abstract
Our urban areas are growing rapidly and therefore need to be planned and adequately serviced to avoid problems associated with unplanned and adhoc growth. Planning so far has been a time consuming activity and by the time a plan is prepared and implemented development continues unabated often defeating the very purpose. A part of the delay can be attributed to the current status of data (outdated maps, lack of information) data collection & analysis and techniques employed to prepare plans. Another aspect with the current methods is that it is not easy to make rational and informed planning decisions. Hence there is need for tools/techniques that enable rapid planning and enable taking rational and informed planning decisions that ultimately lead to plans that are better and implementable. Satellite Images and use of Geographical Information Systems (GIS) are examples of such tools that facilitate preparation of rapid, comprehensive, rational and implementable plans as this paper attempts to highlight through the Case Study of Preparation of Master Plan for TUDA Region and Zonal Development Plan for Tirupati in Andhra Pradesh.

Introduction
A Mater /Development Plan lays down the basic framework for guiding and regulating future growth. This is done through 3 basic instruments:
1) Land use Zoning Plan that determines the use of each land parcel in the development area
2) Structural Road Network Plan that guides laying of the trunk infrastructure in the development area
3) Development Control Regulations that determines the built form in the development area

It is a statutory document and must be prepared by every city/development area. It is reviewed and updated every 10 years. It therefore must be based on recent and accurate information about the city/urban area.

The plan preparation process is severely constrained by lack of availability of basic information starting with accurate maps, data pertaining to the land uses, road networks, structures, open spaces, water bodies etc. The city maps have been prepared long ago and have not been updated since then and thus redundant for preparing a city plan. Further most of the secondary information is spread across diverse departments/sources, not updated and the process of procuring it is time consuming. Moreover there is no systematic way of collecting, maintaining and analyzing data/information that may be relevant for planning purposes.

The most crucial information for preparing a Plan is an accurate and updated Base Map of the planning area, road networks, spatial extent of development and the information on the use of each parcel of land. It is the basis for making rational planning decisions. Use of Satellite Images and GIS can fill this gap as is illustrated through the preparation of Master Plan for TUDA Region and Zonal Development Plan.
This paper is divided in three sections –
A Use Satellite Images for Preparation of Base Map for TUDA Region and Tirupati Town
B Use of Satellite Images for Land Use Mapping for TUDA Region and Tirupati Town
C Use of Satellite Images and GIS to support Planning Decisions

The first section illustrates the status and need for accurate maps, available methods to prepare accurate and updated maps and the Base Map preparation process in detail for TUDA Region and Tirupati Town. The section explains how the task of land use mapping is considerably eased up through interpretation of satellite images. The third section demonstrates the usefulness of satellite images and GIS to enable and support rational planning decisions and framing implementable proposals.

A Use Satellite Images for Preparation of Base Map

A1 Need for Accurate Base Map for a Development Plan

A Development Plan lays down the framework for future growth, determines the infrastructure development proposals & investments and prescribes the use and development rights for each parcel of land. It is therefore absolutely essential to have a reasonably accurate and updated map to lay the road map for future growth. City Maps are prepared on the basis of maps showing plot details that are obtained from the cadastral maps /Land records available with the District Inspector of Land Records and Revenue Department. These were made during the British times and haven't been systematically updated since then. There are piecemeal changes made by individual plot owners owing to sub division of land or when land is acquired for roads/public projects etc. The information regarding these changes vests with different departments and has not been systematically collated to prepare updated maps. Further new growth and development are not reflected on the maps. Also as these maps are rarely computerized and have been manually traced/replicated over the years, they are even inaccurate geographically. Consequently, they don't serve contemporary requirements as they are mostly outdated, their generation and maintenance is cumbersome, and they are incompatible with the planning and development requirements of the present times.

However it is not only important to have accurate and up to date Base Maps, but also city maps must be computerized so that layers of information can be attached and spatially represented to support and aid planning decisions. Further, computerization ensures accuracy, makes constant updation easier and makes it possible to view and analyze data at various scales. The first major task in any planning exercise is to prepare an accurate, up to date and computerized Base Map.

A2 Available Methods to Prepare a Base Map for an Urban Area

A geographically accurate Base Map can be generated either by undertaking a detailed topographical survey or by using satellite images along with other sources of information. The salient features and pros and cons of both the methods are briefly described.

A2.1 Topographical Survey

A comprehensive physical survey of the planning area can be carried out using total station survey equipment. Several details can be surveyed ranging from all built features, roads, natural elements, levels etc. This process ensures considerable accuracy however stringent controls have to be ensured while setting the traverse and taking measurements. Such a survey can not only serve the planning objective adequately but also can be later used for detailed planing of infrastructure. Detailed surveys are required while planning and implementing infrastructure works such as roads, drainage, water supply works etc., which need not be repeated. Subsequently the survey information can be used to generate other applications such as assessment of property taxes, mapping of other infrastructure networks for the purpose of maintenance, management, planning etc.

However this requires considerable amount of resources/investments upfront and in most cases wherein the planning agencies don't have adequate resources a topographical survey is rarely undertaken. Also considerable amount of time is required to carry out a detailed topographical survey especially when there are densely built up areas which is the case with most Indian cities. But this is highly recommended as the investment is justified given the usefulness of such a survey by building centralized databases for all planning agencies, utility agencies etc.

A2.2 Use of Satellite Images

Given the resource constraints, availability of satellite images has made the task of correcting and updating the existing city maps much easier and faster. A reasonably accurate Base Map can be prepared using the satellite images (PAN and IKONOS) as a base and integrating information from various sources such as aerial photographs, revenue maps, SOI sheets, maps from various departments etc. Appropriate corrections are required to ensure geographical accuracy such as geo-referencing and registration of satellite images with topographical sheets. Accuracy can be ensured depending on the resolution of the satellite images used. Certainly the use of such maps is limited as compared to the ones based on topographical surveys.

This methodology has been used for correction and updation of the region and town map of Tirupati Urban Development Authority. The next section describes the process in detail.

A3 Case Study – Preparation of Base Map for TUDA Region and Tirupati Town

Tirupati Urban Development Authority (TUDA), Andhra Pradesh commissioned Environmental Planning Collaborative (EPC) to prepare the Master Plan for TUDA Region and Zonal Development Plan for Tirupati Town in August 2001. The first task was to prepare a Base Map for the entire planning area.

The entire planning area under the jurisdiction of TUDA has an area of 847.95 sq. km., half of which is covered by Reserved Forest. The TUDA area spans across the four mandals of Tirupati Urban, Tirupati Rural, Chandragiri and Renigunta. It includes well developed towns of Tirupati, Tirumala, Renigunta, Tiruchanur, Avilala and Chandragiri - and 85 rural settlements. There is no computerized Base Map for Tirupati Urban Development Authority area or the Tirupati Town area. The existing Base Maps have not been updated since a long time.

Because of the complexities of the issues involved and the availability of data, the Base Map preparation exercise for the entire planning area was divided into two parts.

1) TUDA Region, comprising of 87 settlements and
2) Tirupati Town, comprising of Tirupati Municipal Limits and Tirupati Non Municipal Area.

TUDA Region

TUDA Region comprises of 85 villages and 2 urbanized settlements and the Reserved Forest. Individual maps exist for villages. Each village map includes survey plot boundaries, survey numbers, roads and water bodies and drainage channels (major and minor). TUDA has manually traced and combined to form a seamless Base Map for TUDA Region by TUDA. However in the process a lot of detail was lost in terms of plot boundaries and survey numbers. Further the TUDA Region map was digitized and placed on the satellite images. It was found that the map was not geographically accurate. This is evident from the fact that when this map was digitized and the areas was calculated, it did not conform to published revenue area and various features such as roads, railways, water bodies, plot boundaries etc., did not match with those on the satellite image.

Further the map is outdated and does not reflect the recent developments that have occurred. Individual layouts for major developments are available with TUDA (as they have to be submitted for approval). Some of these layouts have been manually incorporated in the Base Maps for TUDA Region and hence the geographical/locational accuracy is questionable.

Tirupati Town

Tirupati Town comprises of Tirupati Municipal Limit and Tirupati Non Municipal Area (NMA). Tirupati Municipal Limit further comprises of 53 blocks and the Tirupati Village Revenue Area. Individual maps are available for 53 blocks. The block maps show revenue survey numbers, road plots and water body plots. The area within the blocks has Town Survey numbers and area within Tirupati Revenue Village and NMA has revenue survey numbers. There is no other source for the Tirupati Village Revenue area and NMA apart from the existing Town maps.

A seamless map for Tirupati Town has been prepared by combining Tirupati Municipal Corporation and M.R. Palle (NMA). There are two maps available for the Tirupati Town (at different scales) and both do not contain the same degree of information – in terms of roads, survey plots and survey numbers. Hence features from both maps were brought in. The two town maps were digitized and placed on the satellite images. It was found that both maps are not geographically accurate. This is evident from the fact that when these maps were digitized, and the areas were calculated from these maps they do not conform to published revenue areas and various features such as roads, railways, water bodies, plot boundaries etc. do not match with the satellite image.

Further both the maps are quite outdated and do not reflect the recent developments that have occurred. Individual layouts for major developments are available with TUDA (as they have to be submitted for approval). Some of these layouts have been manually incorporated in the Base Maps for Tirupati Town, but again geographical/locational accuracy is questionable.

Features for the Base Map

Before commencing the exercise the features required and their sources were determined and they are as follows:

Features	Source
Administrative boundaries of all spatial Units: TUDA, Municipality, Non Municipal Area, Wards, Town Survey Plots, Revenue Survey Plots	Drawings from TUDA, TMC – Village Maps, Town Maps, Block Sheets Census SOI Sheets
Survey plot numbers	Drawings from TUDA, TMC – village maps, town

	maps, block sheets
Water bodies: rivers, streams, channels, ponds and tanks	Satellite Images SOI Sheets Aerial Photographs Village Maps
Contours, Drainage	SOI Sheets
Reserved Forests	SOI Sheets
Roads	Satellite Images SOI Sheets Aerial Photographs Village Maps Maps from R and B
Railways	SOI Sheets
Layouts	Drawings from TUDA
Settlements	Satellite Images SOI Sheets Aerial Photographs Village Maps

Key Features of the Process Adopted to Prepare the Base Map

On the basis of the availability of maps for TUDA Region, Tirupati Town, features for the Base map and the availability of other sources of information, a well structured process was adopted for the preparation of the Base Maps. Key features are:

1 Use of Multiple Sources of Information

These include:

- Satellite images, PAN and IKONOS dated 2000
- Aerial photographs, taken in the 1980s, available with TUDA
- Survey of India Toposheets (at 1:50,00 and 1:25,000 scale) for TUDA Region
- Survey of India Toposheets for Chittoor District.

2 Use of Satellite Images

Satellite images were largely made use of for the preparation of the Base Map for TUDA Region and IKONOS images for the Base Map for Tirupati Town. National Remote Sensing Agency (NRSA) has only recently started providing IKONOS images. And it must be emphasized that TUDA was one of the first few agencies to procure the IKONOS images. In fact, TUDA is the only planning agency to use these images for preparing its Base Map.

3 Computer Hardware and Software Used

High end computer systems were employed to handle large volumes of data. the computer software used include AutoCAD Map R2 to prepare the base Map, image processing software to register the satellite images and Survey of India topo sheets to ensure geographic accuracy.

4 Separate Base Maps for TUDA Region and Tirupati Town and their Integration

Base Maps were prepared separately for TUDA Region and Tirupati Town. For both maps, a step-by-step process was adopted which is described in subsequent Sections. In the end, the two maps were merged/integrated to prepare one complete seamless map.

A3.2 Base Map for TUDA Regions

The flow chart illustrates the process of preparation of Base Map for TUDA Region and the various stages are described in detail (Fig No 1a).

i) Preparation of Village Maps

The maps for 87 (85+2 – Tiruchanur and Avilala) villages in TUDA region were procured from TUDA. All the village maps were scanned and digitized to prepare drawings including features such as village boundaries, survey plot boundaries, survey numbers, roads, railways and water bodies

ii) Procurement and Registration of Survey of India Toposheets

A parallel exercise was to register the Survey of India (SOI) Topo sheets and pick selected features for the Base Map. The features taken were roads, water bodies, contours, settlement locations, railway lines etc. This was done to ensure geographic accuracy of the Base Map as SOI Toposheets are based on actual ground surveys. The scale of the base map was determined from these features. The entire region is covered in six sheets in the scale 1:25000 (57/0 6 NW, 57/0 6 NE, 57/0 6 SW, 57/0 6 SE, 57/0 10 NW, 57/0 10 SW) and five sheets in the scale 1:50,000 (57/0 1, 57/0 2, 57/0 3, 57/0 5, 57/0 9)

iii) Procurement and Registration of Satellite Images

PAN image (IRS 1 D) was procured for the entire TUDA Region. The PAN image was then registered with the Toposheets to ensure compatibility and generate a geographically accurate map. PAN image forms the base for the preparation of the Base map for TUDA Region. It was used to update the base drawing prepared from Toposheets and mosaic the individual village maps accurately. Subsequently the IKONOS Image for procured for 151 sq km of area around Tirupati Town. Both the PAN and IKONOS Images were combined to form the Base for correcting the village maps and block maps in case of Tirupati Town.

iv) Preparation of Preliminary Base Map from SOI sheets

Select features were picked from the Topo sheets namely, roads, railways, water bodies and their names, contours, reserved forest, settlement locations and their names and drainage lines. This formed the **Preliminary Base Map** of the TUDA Region on which other information was gradually added to generate the Draft Base Map (Fig No 2).

v) Correction of Preliminary Base Map from PAN Image

The Preliminary Base Map from the SOI sheets was then placed on the registered PAN image. As both the SOI sheets and PAN image had been registered, the Preliminary Base Map from the SOI sheets fitted almost perfectly on the PAN image with the exception of a slight mismatch in case of a few roads and a part of the railway line and some water bodies. This is because it is not possible to remove all errors from the Topo sheets while registration and in case of water bodies, because they change course over time. The Preliminary Base Map was then corrected from the registered PAN image.

vi) Mosaicing of Village Maps

All individual village drawings were mosaiced to form one seamless map for TUDA Region. Features included were - TUDA boundary, Mandal boundary, village boundary, plot survey boundary, roads, railways, water bodies and survey numbers. This seamless map was then placed on the Pan Image but it did not match and hence it was decided to fit each village individually on the image and then join the villages (Fig No 3).

vii) Placing of each village drawing on the Preliminary Base Map and PAN image

Each village drawing was then superimposed on the registered PAN image (Fig No 4). Each village was then individually scaled and rotated to get the best fit by matching plots. It was not possible to match all the plots, however care was taken to matching the maximum number of plots and features such as water bodies, roads and railway lines. In some cases, correct alignment of roads from satellite image as shown in the Preliminary Base Map were replaced on village maps.

In other cases, there were drastic corrections as in the case of Karkambadi and Durgasamudram villages. As can be seen from Fig No 5, there was drastic error in the map of Karkambadi village and it was impossible to fit the village on the satellite image. The village drawing was then cut in six groups of plots along main features - roads and water bodies. Each group of plots was then rubber sheeted and stretched to match with the satellite image. The major roads and railway line was rotated almost by 45° to the left. In case of Durgasamudram, the village had to be cut in two pieces and then adjusted on the satellite image. The village was cut along the major road passing through the village and the plots were then adjusted. This process was done for all the 87 (85+2) villages.

viii) Mosaicing of all corrected villages

All the village maps were individually corrected and placed on the Preliminary Base Map. There were still minor gaps/overlapping between village boundaries. These were then adjusted on the basis of PAN image (Fig No 6). The map was cleaned in terms of continuation of roads, railway lines and water channels. Water bodies and drainage lines were corrected from SOI topo sheets, PAN image and aerial photographs. This was the **Draft Base Map** for the Region.

ix) Updating the Draft Base Map - Incorporation of Layouts

The village maps do not reflect the latest status as on ground. As development occurs, layout drawings for Survey Plots are prepared by individual developers and submitted to TUDA for approval. Such 135 layouts were procured from TUDA, scanned and digitized. Individual drawings were prepared for each of the layouts in AUTOCAD14. Each layout was then located on village maps and fitted into the village. To fit each layout, techniques employed included scaling, rubber-sheeting and rotating (Fig No 4).

x) Updating Draft Base Map - Incorporation of Village Settlements

Part of the process of preparing the Base Map for TUDA Region also required details for village settlements as no maps exist for rural settlements. Sources for these include plane table surveys, aerial photographs and IKONOS image (Fig No 7).

Plane Table Surveys (PTS) were available for 19 villages, however these surveys were done in the 80"s and hence do not give a true idea of the development that has occurred, especially in the recent years. The Plane Table Survey drawings were scanned, digitized and drawings were prepared in AUTOCAD 14. Further growths were taken from aerial photographs and satellite images. Settlements for which PTS are not available were digitized from aerial photographs and IKONOS satellite image and incorporated in the Draft Base Map for TUDA Region.

xi) Updating the Draft Base Map - Incorporation of road network

Roads were incorporated from satellite images, aerial photographs and SOI sheets and hierarchies assigned.

xii) Final Base Map

The Draft Base Map was checked and finalized in collaboration with TUDA and ready for beginning the work on the Development Plan (Fig No 8).

A3.2 Base Map for TUDA Regions

The flow chart illustrates the process of preparation of Base Map for TUDA Region and the various stages are described in detail (Fig No 1b).

i) Procurement of IKONOS Images

IKONOS images were procured from National Remote Sensing Agency for the Tirupati Town. These images have a resolution of 1m X 1m and gave a very accurate picture of the plot boundaries, layouts, structures and road networks. The IKONOS images cover an area of approximately 151 sq. km spanning across Alipiri junction in the North to Vedantapuram in the South and from Mallavaram in the West to Renigunta in the East.

ii) Digitization of Block Maps

As mentioned earlier, Tirupati Municipal Limit comprises of 53 blocks and the Tirupati Village Revenue Area. The area within the blocks has Town Survey numbers. The 53 Block Maps procured from TUDA were scanned and digitized. Individual drawings were prepared for each of the Blocks in AUTOCAD14.

iii) Digitization of Town Maps

Two maps of the town, were procured from TUDA. The maps were scanned and digitized to prepare drawings. While digitizing the features included were - survey plot boundaries, survey numbers, roads, railways, water bodies and drains. The two maps did not match. The large map is old and has better clarity in terms of survey plots but does not show latest situation in terms of roads and layouts. The smaller map is relatively recent and reflects recent developments (layouts have been schematically inserted) and roads have been drawn but clarity on survey plots is less.

iv) Mosaicing of Block Maps

The process of preparing the Preliminary Base Map for the Town was initiated by first placing each block map on the IKONOS image. Each block was 'best fitted' by scaling, rotating and correcting some plot boundaries from the image. When all the blocks were best fitted, there were some minor gaps, which were then resolved by matching the plot boundaries of the edge plots (Fig No 9).

v) Incorporation of plots from Tirupati Revenue village area

As mentioned earlier, the Block Maps were not available for the entire municipal area and NMA area. Here, the plots digitized from the two town maps were compared and brought on to the IKONOS image. This gave the Preliminary Town Map (Fig No 10).

vi) Road network from the IKONOS Image

All the major and minor roads were traced from the IKONOS image. Roads from the surrounding area was also later incorporated on the Regional map to get the latest road network. The Preliminary Town Map was updated by incorporating the Road network (Fig No. 11).

vii) Digitization of layouts

The layouts were digitized and fitted on to the Preliminary Base Map. To fit each layout, techniques employed included scaling, rubber-sheeting and rotating. 71 layouts were thus incorporated in the Base Map. In addition to this, layouts were traced out from the IKONOS image (Fig No 12).

viii) Incorporation of layouts on to the Preliminary Base Map

The digitized layouts were now placed on the Preliminary Base Map. This gave the Draft Base Map.

ix) Final Base Map

The layouts and plot survey numbers were checked in the Draft Base Map. The continuation of roads and boundaries were checked with the TUDA Region Base Map. Hierarchy of roads was incorporated. The names of roads, junctions and areas were also added. This gave the Final Base Map (Fig No 13).

B Use of Satellite Images for Land Use Mapping

The next major task in the exercise of preparing a Development Plan is the land use mapping. Usually an extensive physical survey for this task is a must and this process is quite time consuming. Hence for the TUDA Region a preliminary land use map with over 70% of the land use marked was prepared by visual interpretation of the satellite images. Interpretation was based on shape, patterns, textures, location and shades. This was then taken for ground truthing and updated. This considerable saved the time and resulted in a fairly accurate land use map. In case of Tirupati Town a far more detailed break up of land uses was required. The Base Map was superimposed on the IKONOS Image and uses such as open spaces, channels, agricultural areas and water bodies were easily marked. Further using the knowledge of the local officials certain institutional uses and important areas were marked. Then a detailed land use survey was carried out. This process considerably shortened the survey period.

C Use of Satellite Images and GIS to support Planning Decisions

After preparing the Base Map and undertaking the land use survey, a database was developed in GIS environment. This section illustrates the use of the satellite images and GIS to support planning decisions and frame rational proposals.

C1 Developing Land Use Database on GIS

For the built up area in the Town a very detailed and systematic land use survey was carried out. There were various layers of information to be represented such as major land use, land use by floor, intensity of development for each plot and building typologies. A GIS environment was required to reflect and represent such a wide range of information, which was not possible through the Auto CAD software (Fig No 14). Further by attaching a database of varied information to the map, it was possible to carry out several types of spatial analysis, to support land use planning decisions. Moreover in Arc View it is possible to generate areas of major categories and sub category of uses which cannot be done in AUTOCAD (where it is a manual process of calculation and prone to errors).

The various thematic layers that were built were:

- Detailed land use maps with plot wise and floor wise land uses (Fig No 15)
- Buildings heights showing the intensity of development
- Open spaces – with a detailed database, which helped in the estimating the open space deficiency and the appropriateness of spatial location.
- Social infrastructure – schools (public, private), hospitals (public, private), community facilities etc., which aided
- Heritage structures – temples, important monument and buildings

The proposals framed on the basis of the above analysis were-

- Land use zoning
- Density zones
- Delineation of heritage precincts and proposed heritage walks

C2 Identifying Potential areas for Future Development/Urbanizable Zone

The most important application of the satellite images was the mapping of the development sprawl. It gave an indication of the growth directions. It also became evident for the first time that the town of Tirupati had doubled in size and that most of the development was happening outside the municipal limits. The town area is 16 sq km and about 8.5 sq km of development had already occurred outside the municipal limits and another 8 sq km of area is already under layout formation. This has tremendous implications on provision of infrastructure. It is essential to identify an urbanizable zone and plan for infrastructure in this area in the near future to avoid problems of adhoc and unplanned growth.

The various thematic layers that were built were (Fig Nos 16, 17, 18):

- Urban Sprawl, rural settlement and their expansion
- Direction of development/identification of the growth corridors

The proposals framed on the basis of the above analysis were-

- Urbanizable Zone
- Release of land for future growth

C3 Evolving an Implementable Road Network

Road network planning and proposals are a crucial aspect in a Development Plan. In case of Tirupati town all the minor and major networks were mapped from the satellite images and an updated network was prepared. This formed the basis of evolving a rational structure plan for roads to cater to the future growth. Appropriate hierarchies were delineated and proposals were framed. A road network thus evolved is more implementable.

The satellite images were used for updating the road network in terms of (Fig No 19):

- Correcting the existing road alignment
- Updating the old map by picking up the new/missing roads
- Correcting the railway line alignment
- Picking up the alignment of the under construction roads

The proposals framed on the above analysis were (Fig No 20):

- Establishing an efficient road network structure plan along with traffic studies
- Identifying road links for widening based on the built up intensities.
- Proposing alignment of the new road links in a manner that they were taken through open areas and avoiding water bodies and channels.

C4 Integrating Environmental Concerns – Conservation of Water Bodies

Environmental issues generally are not given sufficient importance while planning for urban areas. TUDA Region has a total of 241 tanks interconnected by water channels. This is fantastic system of natural drainage, which ensures ground water recharge and support the needs for agriculture. Unfortunately this system is getting disrupted as quite a few tanks are getting encroached by development particularly near the town. Tirupati Town had 38 tanks and now only 8 are functional and the remaining have been encroached. While preparing the Development Plan for TUDA Region Tirupati a systematic inventory of all the water bodies was done using the satellite images and topo sheets and various proposals have been framed.

The satellite images were used for (Fig Nos 21, 22):

- Inventory of functioning tanks/ponds and feeder channels
- Inventory of dried up or encroached water bodies and nature of encroachment
- Identification of blocked/ vanished feeder channels
- Establishing the connections between water bodies

The proposals framed on the above analysis were (Fig No 23):

- Delineating conservation zones around the water bodies and the feeder channels
- Removal of encroachments and blocks in the water bodies and channels
- Developing groups of water bodies as open spaces with recreational activities
- Upgradation of waste lands/scrub land

About EPC

Environmental Planning Collaborative established in 1996, is a private not for profit, professional planning and development management company incorporated under Section 25 of the Companies Act, 1956. EPC provides professional consultancy services primarily to urban local bodies including Municipal Corporations and Urban Development Authorities. EPC also works with a variety of other agencies involved in urban development such as State Government Departments, International Funding and Lending Agencies, Special Purpose Vehicles for urban development and non-government/autonomous organisations. Most projects are undertaken in a collaborative manner with significant involvement of the client and other related agencies.

Contact Address:
Environmental Planning Collaborative
701, Paritosh, Usmanpura, Ahmedabad – 380013
Gujarat, India
Ph (O): (079) 7550102, 7550875, Fax: (079) 7550649
email: (O) epcamd@wilnetonline.net

[1] Shirley Ballaney is an Architect Urban Planner, currently working at EPC and was the Project Leader for the preparation of the Master Plan for TUDA Region and Zonal Development Plan for Tirupati.

[2] Bindu Nair is Geographer Planner, currently working at EPC and was responsible for and coordinated the Base Map preparation Process for the Master Plan for TUDA Region and Zonal Development Plan for Tirupati.