

## Structure plan for newly merged villages in Pimpri-Chinchwad using Remote Sensing data

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Pimpri-Chinchwad township is the most developed industrial belt in the State of Maharashtra accommodating some of the most reputed industrial companies of the country such as TELCO, SKF, Bajaj Auto, Garware Nylon, Philips, Alfa Laval, Bajaj Tempo, etc. With the advent of rapid growth and expansion in the area, the Department of Urban Development, Government of Maharashtra notified extension of the erstwhile Pimpri-Chinchwad Municipal Corporation (PCMC) limits by merging 18 fringe villages within the corporation limits. The total area of newly merged fringe villages is 84.51 sq. km. A Development plan (DP) was to be prepared for these newly merged villages in order to yield a guided future growth in the region. This was the first initiative of any local authority in Maharashtra to invite private consultancy organisations for the preparation of a development plan. PCMC was the nodal agency for the preparation of DP and the job was awarded to Tata Consultancy Services.

Major objective of the study was to prepare a DP in a duration of one year on a Geographic Information System (GIS) platform ensuring the connectivity and integration of these villages with the rest of the region using spatial information obtained through remote sensing data, village maps and Survey of India (SOI) maps.

Some of major visionary goals in the preparation of DP were to:

- Ensure proper utilisation of land in the interest of the residents of the area
- Provision of an efficient traffic and transportation network
- Make provisions for civic amenities and social facilities to cater to the present and future needs of the residents community
- Reserve sites for public utilities, transport and other services to meet present as well as future requirements of the area
- Preserve buildings and areas of historical, religious and cultural significance
- Improve existing living conditions, physical quality of life, and guide future development.

The Phases involved in the preparation of DP were:

- Survey, analysis and findings
- Preparation of Base Map and Existing Land-use (ELU)
- Structure Plan
- Development Plan

The following surveys were carried out to assess the socio-economic, travel and environmental characteristics of the study area.

- Traffic and Transportation Surveys
- Industrial Survey
- Housing Survey
- Surveys on existing facilities such as health care, education, shopping and recreational etc
- Environmental Surveys

### **Preparation of Base Map and ELU**

#### ***Base Map***

The basic prerequisites for a "Development Plan" is the preparation of a base map indicating the limits of the planning area, along with important physical features such as existing roads, water bodies, hillocks, contours, etc. The base map was prepared with the help of remote sensing satellite imageries, obtained from NRSA Hyderabad. Every built-up land feature having dimensions more than 3m x 3m was recorded and mapped to facilitate proper planning of the area. Accordingly a combined base map of the planning area, to the scale of 1: 5000 was prepared on the basis of the details recorded from the satellite imageries. For the purpose of showing built-up area on the base map both from village Gaothan and outside, a detailed survey based on plane table and total station technique was carried out. The cadastral details about the property boundaries obtained from revenue village maps, showing survey numbers or gat numbers (S. Nos. / Gat. Nos.), were also superimposed on the base map, duly verifying their correctness with the help of suitable ground control points.

Satellite images of IRS 1C and LISS-III were procured from NRSA for the PCMC region. Various features such as rivers / streams, water bodies, forests, agricultural lands, barren lands, limits of settlements etc., were extracted from these images. The extraction process made use of latest classification technique. Required numbers of ground checks were carried to determine the accuracy of classified features. Any modification, if required, was then done. The output of these processes has culminated in the classified land cover map. From the satellite imagery various congested pockets within the village were identified for the purpose of detailed survey. The classified land cover map was integrated with the base map, which is the first step in preparation of the Existing Land Use map.

SOI toposheets of 1:50,000 scale were procured from the maps division of SOI, Pune. These maps were digitised to the GIS-compatible format. The maps were then integrated with each other and area of interest was extracted. This formed the initial base map and helped in registration of satellite images and incorporated the features from the cadastral and village maps.

Maps of the newly merged 18 villages were procured from the District Inspector of Land Record (DILR) Office. The scale of the procured maps was 1:10,000. Maps of the regional plans were also collected from the Town Planning Office of Pune. The Sanctioned regional plans for the Pune District was also collected from the office of the Assistant Director of Town Planning.

***Approach and Methodology***

Based on the input data available and the review of the data, the following approach has been followed for various activities under the scope of preparation of base map / ELU map.

The planning area was studied using Survey of India (SOI) toposheets. The SOI toposheets no. 47 F/10 and 47 F/14 on 1:50,000 were procured from SOI for planning work. Initial field visits were conducted to study the general topography of the area. SOI toposheets no. 47 F/10 and 47 F / 14 were scanned and digitised for the following features:

- Latitude / longitude grids
- Contours
- Road network
- Railways
- Village polygons (for 18 villages)
- Village names
- Rivers and streams
- Ponds / Lakes.

A quality check and modification on the individual toposheet vector data was completed after digitisation of various features and finally all the toposheets have been edge-matched to get one digital map for the project area. Village maps for all the 18 villages under the project area obtained from the DILR Office / PCMC were already in the GIS-compatible format. The details available in these maps were

- Village boundary
- Cadastral plot boundary
- Survey number / cadastral number
- Roads.

Regional Plan maps obtained from PCMC was integrated with the village maps of the newly merged area. This RP map served as a guideline for framing proposals for the DP of newly merged area.

***Creation of Initial Base Map***

Map of SOI toposheets, cadastral maps, and RP maps were all integrated to form a base map of the study area.

***Remote Sensing Data******Browsing and procurement of Satellite Image from NRSA***

IRS satellite PAN digital image has been identified and procured from NRSA, Hyderabad for the minimum cloud period. For land use classification, IRS LISS-III images were procured from NRSA.

***Collection of Ground Control Points (GCPs) and Registration of Satellite Image into Project Database***

Ground control points were collected with the help of Satellite Image and a digital base maps was prepared. Well-distributed GCPs (e.g. road, railway intersection, intersection, of roads, bridges and river confluence's etc.) were selected over the area. GCP was verified and extended by using Global Positioning System (GPS). IRS 1C LISS-III and PAN were registered using a number of GCPs over the SOI toposheets. All the images were merged to get a single one. Various image enhancement techniques were applied to increase the visibility for visual interpretation.

Visual interpretation was carried out to study the digitally enhanced satellite image. This was carried out based on the various image characteristics such as shape, size, texture, pattern, tone, association, etc. Depending on these keys, various land use / cover classes were identified.

Ground truth verification was conducted for verifying the land uses classes and accordingly incorporated into the map. GPS was used for ground truth verification. The output of this work helped in developing an interpretation key.

False colour composite (FCC) was prepared using IRS LISS-III multi-spectral image to identify the land use classes. For better identification of the land use classes, IRS PAN data was merged into the IRS LISS-III data. The minimum level of accuracy was 85 to 90 percent. A database was created to store the satellite image data and the vector data of the base maps. All the vector layers were then imported into the vector segments of the database created and imported into separate layers. The IRS 1C PAN and LISS-III digital images were imported to the plan database.

The Base map of the planning area was updated for the features, obtainable from the satellite image. All the roads and linear features were updated using satellite image in the base map. Prominent buildings identified from the satellite image were transferred to the base map.

With the help of the base map prepared using satellite image, the exact amount of congested pockets of settlement were identified. Gaathan / habitation and new development were marked on the map. Incorporation of missing features such as power line, telephone line, transmission line, main water supply lines, overhead tanks, other prominent public and semi-public buildings, commercial and industrial land, etc., were surveyed and marked on the map. Details obtained from the survey have been integrated and shown on the maps. The entire maps and satellite image were integrated into MapInfo GIS.

The ELU map has been prepared using the information from base map, satellite image classification and information from the detailed survey. The following layers of information were used in preparing the ELU map:

- Agricultural land
- Barren land
- Forest land
- Open spaces
- Plantation
- Play ground / stadium
- Cremation ground
- Residential land
- Commercial land
- Industrial land
- Water body
- Lakes / ponds
- Public / semi-public buildings, post office, police station, town halls, park, dispensary, schools, banks, cultural / religious buildings, educational buildings
- Transportation network details
  - Roads
  - Railways
  - Bus / Railway station
  - Truck terminus
- Miscellaneous features
  - Well, overhead tank, etc.

### ***Creation of 3D Model***

Using SOI contour information, were interpolated for 5-10 m contour interval and a 3D-digital terrain model was created using the contour information. The map information was then overlaid onto the 3D model.

## **TRAFFIC AND TRANSPORTATION INFRASTRUCTURE**

The transportation infrastructure is the lifeline of the urban area. It acts as a catalyst for development and determines the degree of accessibility of various land-uses such as residential areas, work centres and facilities. For a city to function efficiently, the transportation network needs to be well planned, efficient and cost effective. In order to assess the future requirements related to traffic and transportation infrastructure, it is necessary to estimate the future travel demand.

### **Regional Context**

In the present case, the traffic and transportation system for 18 newly merged villages of the Pimpri-Chinchwad municipal area was perceived in a regional context covering entire Pune Metropolitan Area (PMA) at a broader level. This was an important step for effectively integrating the newly merged areas with the existing PCMC area in particular and the entire PMA region in general.

It is a known fact that travel is a derived demand from the landuse distribution pattern. Therefore, travel demand and the travel pattern are guided by the governing factors such as population, employment distribution, accessibility, vehicle ownership etc. In other words it can be said that future travel demand can be derived from the future distribution of population, employment and the characteristics of transportation facilities.

A comprehensive travel demand-forecasting model for projecting trip generation, trip distribution, modal split and trip assignment in the planning area was used. As the planning area including the existing PCMC area is an integral part of the Greater Pune Metropolitan Area, the findings of a recent study on 'Feasibility of High Capacity Mass Transport System (HCMTS) for Pune Metropolitan Area 1998' have been adopted as the basis for developing the travel demand forecasting methodology for the planning area.

### **Road Network Details**

Travel demand is function of the road network characteristics. Once the base map for 18 villages were ready, links and nodes of the existing road network were identified and numbered for network analysis. The physical characteristics of links such as length and width were extracted from the base map details. Traffic characteristics of these links were obtained through traffic surveys. Remaining network in the PMA region, at a very broad level, was extracted from a previous study "Feasibility of High Capacity Mass Transit System (HCMTS) for Pune Metropolitan Area 1998" supported by some traffic surveys such as volume counts at mid block and junctions.

The coding of links and nodes was carried out to suit the requirement of SATURN – a specialised transportation evaluation software tool. A coded network with traffic zoning scheme at regional level was ready by the end of this exercise.

### **Traffic Zone Scheme**

In order to build an Origin-Destination (OD) matrix the area under consideration is divided into smaller geographic units. Accordingly, the planning area (newly merged villages) was divided into 20 traffic zones and remaining area of the PMA was consolidated into 34 zones.

**Future Landuse**

Future Landuses at a very broad level were projected for each zone based on the overall regional plan and following the urban norms and standards. Landuse characteristics of the traffic zones of newly merged 18 villages were projected/defined based on the growth patterns, discussions with planning authorities and group discussions. Landuse characteristics for the traffic zones in rest of the PMA are extracted from HCMTS study.

**Travel Demand Forecast*****Trip Generation (Trip Productions and Attractions) and Passenger Trip matrices***

The equation system that was developed for work, education and other purpose trips in terms of person trips during HCMTS (1998) was applied to estimate the future trip productions and attractions of the traffic zones. A gravity model developed as a part of HCMTS was used to establish the passenger trip matrices in the PMA region. These trips were converted into PCUs using the occupancy factors.

***Estimation of Goods Traffic***

The goods OD matrix in terms of PCUs was developed based on the traffic surveys that were conducted as part of this study in April 1999. From the past studies, it was observed that there is a growth of around 8% per annum in the truck movement. The goods OD matrix in terms of PCUs is updated using this growth rate for the horizon year.

**Combined OD matrix**

The goods and the person trip matrices were added together to generate the combined OD matrix in terms of PCUs in 24 hours. In practice, the major road network is designed to meet the peak hour demand that is generally taken as 10% of the 24 hour traffic.

**Trip Assignment on the present road network**

The horizon year-2021 peak hour origin-destination (OD) matrix derived and then assigned using All-or-Nothing (AON) assignment to the shortest zone to zone paths in order to estimate traffic loading on individual road links in terms of PCU during peak hour per direction for the horizon year. The deficiency of the link capacity was evaluated using the future traffic on the road links. AON is used primarily to ensure higher order level of service to the traffic in future.

**Proposed Traffic and Transportation Infrastructure**

Transport network proposals for the development plan have been formulated on the basis of future traffic projection and assignment, proposed road network of the regional plan, present accessibility of land parcels and site factors.

**Regional Plan Proposals**

According to the sanctioned Regional Plan for the Pune Metropolitan area, the alignment of new roads shown shall be considered as tentative and necessary changes in alignment, if warranted, could be made at local level. This should be done after studying the site conditions and after consultation with the Planning authority. As per section 27 of the MR& TP Act 1966, it is necessary to have due regard to the proposals of the Regional Plan, while framing the proposals of draft development plan. Giving due consideration to both the above requirements, Pune Metropolitan Area regional plan proposals relating to the planning area were carefully studied and incorporated the major proposals in the future network.

**General Planning considerations**

Besides the regional plans proposals certain major arterial were incorporated in the structure plan based on the following criteria.

**Regional Traffic**

The Mumbai -Pune National Highway along with the Pune-Nashik and Pune-Alandi highways passes through the Planning area and carry heavy regional traffic. It is important to control and restrict access to these highways from traffic generated from abutting land uses within the planning area. The proposed road network along the highways has been designed to minimise access and avoid unnecessary delays and congestion. Service roads have been recommended along all stretches of highways passing through the Planning area and have been incorporated in the proposed Right of Way (ROW).

**Connectivity to Village Gaothans**

Gaothans are centres of concentration of the village population and are likely to act as important growth nuclei within the planning area. Providing proper connectivity to village Gaothans has been an important planning criteria in the design of the proposed road network. Collector/distributor roads have been proposed to provide effective connectivity to Village Gaothans in the Planning area. As far as possible, roads are proposed along the village boundaries. Advantage with this type of arrangement is that physical boundaries are clearly defined for any administrative purpose.

**Site constraints and existing Structures**

Existing land use information depicts the location of the structures, water bodies and other site conditions. While proposing new alignments/extra widening of roads and ROW, site constraints such as topography and the presence of existing built-up structures have been given important considerations.

**Accessibility to proposed residential areas and work centres**

The proposed residential areas and work centres would act as generators and attractors of trips within the Planning area. The proposed road network of arterial and sub-arterial roads is designed to provide effective connectivity between these areas. The internal network of roads within the residential areas would however seek to prevent through traffic.

**Ensuring Adequate Capacity**

Based on the above criteria, a road network was proposed for 2021. The new links and nodes were coded to suit to the SATURN software assignment and AON assignment was carried out to assess the adequacy of the proposed road network while supporting the future traffic in the 18 villages merged. Links having Volume to Capacity ratios more than 0.8 were considered as congestion prone road links and parallel links were proposed as a measure to prevent the congestion in future.

**Summary and Conclusions**

The PCMC Development Plan provides a model for local authorities and demonstrates how GIS can be effective for Land Use Planning, Transportation Planning and Environmental issues. The GIS tools permit planners and decision-makers to seek a large number of viable options before selecting the best option for future growth. The GIS databases provide an effective system for data management and its strength lies in providing fast, accurate and reliable data display.

GIS is likely to play an increasing role in transportation planning and management in future i.e., providing safe, efficient and affordable transportation system to the society.