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Title of Paper: A GIS Based Master Plan for Hilly Terrain – Lavasa Case Study

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A GIS Based Master Plan for Hilly Terrain – Lavasa Case Study

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1. Introduction

1.1. Lavasa the New Hill-Station

Western Maharashtra offers magnificent hilly terrain for various nature based tourism activities. Substantially big lakes like Pavana, Mulshi, Warasgaon, Panshet and Koyana add to the beauty of the place. Tourism policy 1999 of Govt. of Maharashtra encourages development of new tourism attractions. Lavasa Corporation Ltd. selected 25,000 acre of land in the backwaters of Warasgaon Lake, for creation of a new Hill-Station. In 1999 Urban Development Department of Govt. of Maharashtra delineated 18 village of Taluka Mulshi and Velhe as Hill-Station and authorized Lavasa Corporation Ltd. to develop it. The city is conceived to be a vibrant place for residents and tourists. The site is blessed with above-average monsoon, 22 km long lake and 55 km of lakefront. The place is approachable by road from two of the important cities, Mumbai and Pune. It is situated approx 200km from Mumbai and 65km from Pune. The valley is full of rare and extraordinary flora and fauna. Throughout the year, temperature remains from 4⁰ C to 36⁰ C.

Once it is complete by 2020 Lavasa will have capacity to have 1,30,000 residents and would generate 50,000 employment opportunities. Housing and workplaces for residents will spread across 7 towns of Lavasa.

1.2. The Master Plan of Lavasa

The master plan of Lavasa is based on the philosophy of new urbanism which stands for creation of socially safe and vibrant residential community. The master plan incorporates sensitively various natural features and environment. The master plan encourages walking community thus reducing stress on transport and resultantly reducing the vehicular pollution. The master plan creates town center as hub of public activity and major workplace for each town. The workplace is surrounded by the condominiums and apartments for employed residents. This reduces the distance of residential areas to work place. The density of housing reduces based on the distance from Town Center. Houses located on slopes and hilltops will have least density as they are far away from Town Center which is generally located in valleys. These villas will cater to the demand of second home. Each town is distributed into various districts based on their distance from Town Center. The district dictates the architectural and urban character of the development within. All these measures are oriented towards creation of very strong and native architectural character and closely knit community.

2. Scope of the Study

The use of GIS in master planning can generally be seen in three stages. GIS can supply very useful information such as terrain analysis like Slope, Aspect and contours in pre-planning stage. Whereas GIS becomes extremely useful in post-planning stage where it generates vital results of traffic and transport study, population profiling and spatial distribution of density of population. This becomes key information for detail engineering design of road and infrastructure. In the stage when planning and design is ongoing GIS is used very powerfully as quick visualization tool.

GIS is not just used for planning but for other core business needs as well, like Sale and Status Monitoring. The scope of the paper remains limited to elaboration of how GIS is useful for addressing the concerns of urbanization in hilly terrain. However the paper concentrates primarily on the pre-planning stage and planning process stage. Only some aspects of post-planning analysis are touched upon towards its end. Moreover it is not intended to be an elaboration of various GIS tools, their algorithms and intricacies. It is a qualitative description of how and how much Master Planning process can be made efficient and reliable due to correct use of GIS technologies.

The case of master plan for Mugaon (one of the village in Lavasa) is studied in the paper as demonstration.

3. The Area of Study

Total area of Mugaon village is 1,185 ha and the village is proposed to have one of the primary connections from Mumbai. Since the village settlement was submerged under Warsgaon Dam in 1980 most of the villages were rehabilitated as part of dam project. Today the total population of village is 224 persons.

(Data source: Primary Census Abstract and Census Village Profile; 2001; Census of India)

Management decided that unlike rest of Lavasa, Mugaon will have very less residential area and more workplaces. Out of 7 proposed towns in Lavasa each town has its own Town Center as work place; one such center for entire City was considered to be required. Due to strategic location, Mugaon became the obvious choice.

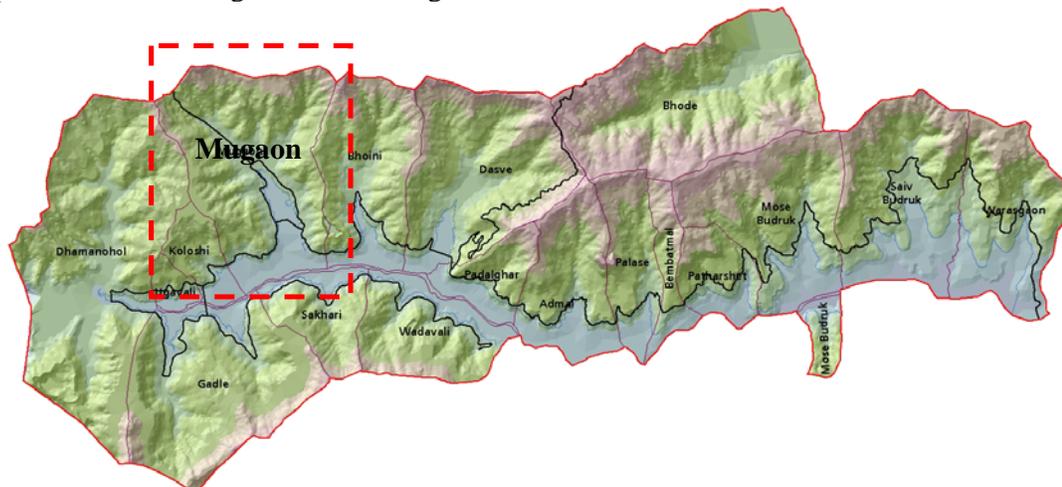


Figure 1: Location Mugaon; the area of study

4. Process of Master Planning

Better development is the development which is planned and done as per the plan. Based on scale and complexities, various methods of planning have evolved. Most of the existing cities adapt the method called Development Plan. Many of the mega cities adapt the method of structure plan. In most cases where the stakeholders are limited in number and ownership is in private realm method of Master Planning is considered to be most effective. Before further elaboration about use of GIS in master planning process, it is useful to understand first the process of master planning in brief.

Master Plan is an instrument to control the development in totality. Unlike many other methods of controlling development, master plan is far diligent and detailed. Due to these

qualities it may also be seen as very stringent control. It determines the use of land, use of buildings, use of open spaces, road network, architectural character of the town and many more aspects. Thus preparation of Master Plan is done by a process which is as follows.

4.1. Base Map and Existing Land use

The base map provides all the information about what exists on ground. The information about terrain, flora-fauna, soil, streams, human habitat and any existing infrastructure facilities is mapped on base map. This becomes the basis of deciding the character and shape of proposed development. The base map along with existing use of land becomes the document on which all the reasons are drawn.

4.2. Vision for the Development and Program Brief

Once the existing situation is known the question comes about the vision for the development. The vision statement in a concise manner tells about the character of the development. Once vision is understood the program brief is required. The brief talks about various numbers e.g. saleable land, total built-up area, projected population, number of roads, kind of buildings and amenities, open spaces, tourism activities and various other things. This brief becomes the base to marry the vision and existing condition.

4.3. Compliance with Regulations

Every master plan is prepared under certain set of regulations. Compliance with regulations is one of the important aspects in master planning. Furthermore, in order to guide development, the master plan has to prescribe building design guidelines for the buildings being built in proposed development.

4.4. Master Plan Document, Land use and Circulation Network

Based on all the information and considerations stated above a final land use and road network is proposed. This is the final product of entire exercise. This controls the use of land and in turn use of buildings. Thus this plan becomes the regulating plan. The master plan document further elaborates the development and its character. Based on the circulation network roads are designed and infrastructure is planned. 3-dimension visualization can be done, to understand the character and density of town, based on this document.

5. Information for Master Plan

The planning project in hilly terrain calls for a very different approach in comparison to the plains. Instead of master plan being a result of only vision or brief, here it has to be understood as an effort to enhance the nature. Thus information about nature becomes primary for master plan.

5.1. Terrain Information

5.1.1. Contour Analysis

The understanding of terrain comes from contours. The conventional way of preparing a contour plan is to conduct a grid survey or random survey of site. This requires traversing entire site. Unlike plain land, in hilly terrain line-of-sight becomes a major roadblock in such survey. Thick vegetation worsens the problem. Manual survey of site also requires lot of site clearing i.e. chopping off bushes and small trees. All these efforts take lot of time and mostly the results are not very reliable. Moreover it defeats the very purpose of doing an environmentally sensitive master plan since the basic survey process degrades the site. Some of the land is not possessed by Lavasa thus doing survey in those lands such as reserve forest or private forest is not possible.

Since these lands also form part of the hydrological system of valley it is very important to have terrain understanding of these lands.

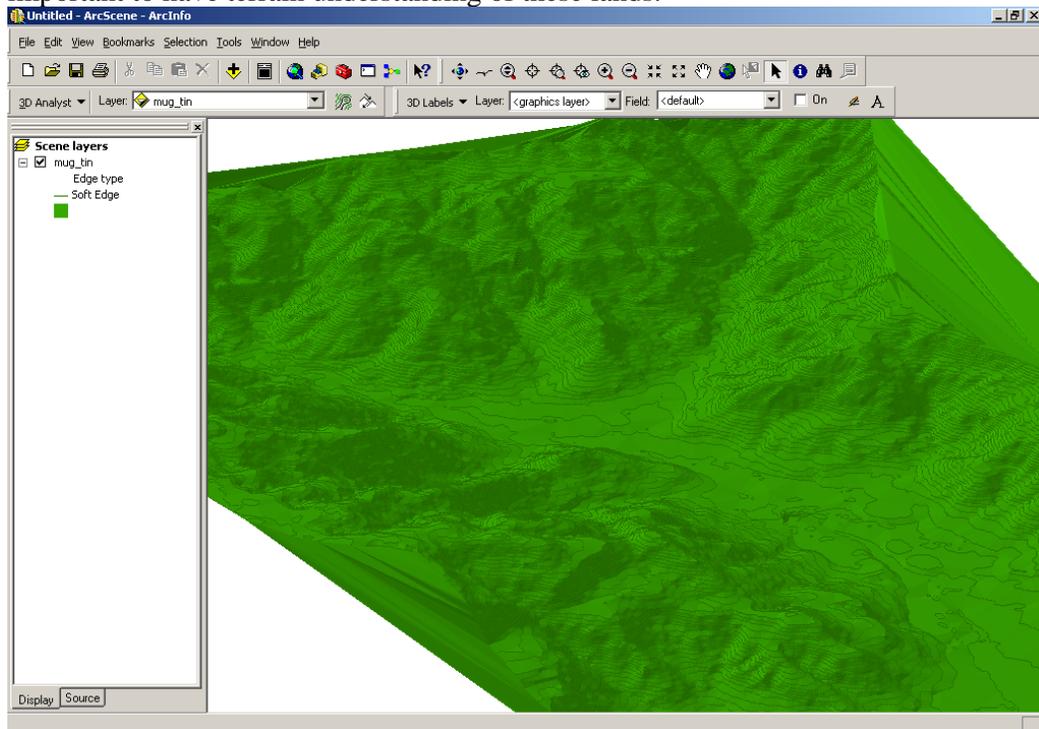


Figure 2: Contour from stereo pair satellite image and TIN

The solution to this problem was to use stereo pair satellite image to generate contours of 1m accuracy. Approximately 200 Ground Control Points (GCP) were fixed across entire site and were visible in image. The DGPS readings of Latitude, Longitude and Altitude were taken to reference the image correctly. With the help of GCP the elevation information of image was corrected and Digital Elevation Model (DEM) was prepared. Contours were generated from this DEM. These contours were segregated for each village and were used for creation of Triangular Irregular Networks (TIN). This TIN was used for various types of terrain analysis.

5.1.2. Slope analysis

As per Special Regulations for Hill-Station Development, construction is not allowed on slopes steeper than 1:3. Therefore it becomes critical to identify parcels of land having slope flatter than 1:3. The development can be concentrated on these developable land parcels and rest remains preserved. The road network may also be designed to connect these developable parcels.

The slope raster was created from the TIN. The map was classified into following 7 categories of slope.

- Flatter than 1:10 - Maximum allowable road gradient is 1:10
- 1:10 to 1:5
- 1:5 to 1:4
- 1:4 to 1:3 - Limit of developable land as per regulations
- 1:3 to 1:2
- 1:2 to 1:1
- Steeper Than 1:1 - Maximum angle of repose for soil (45°)

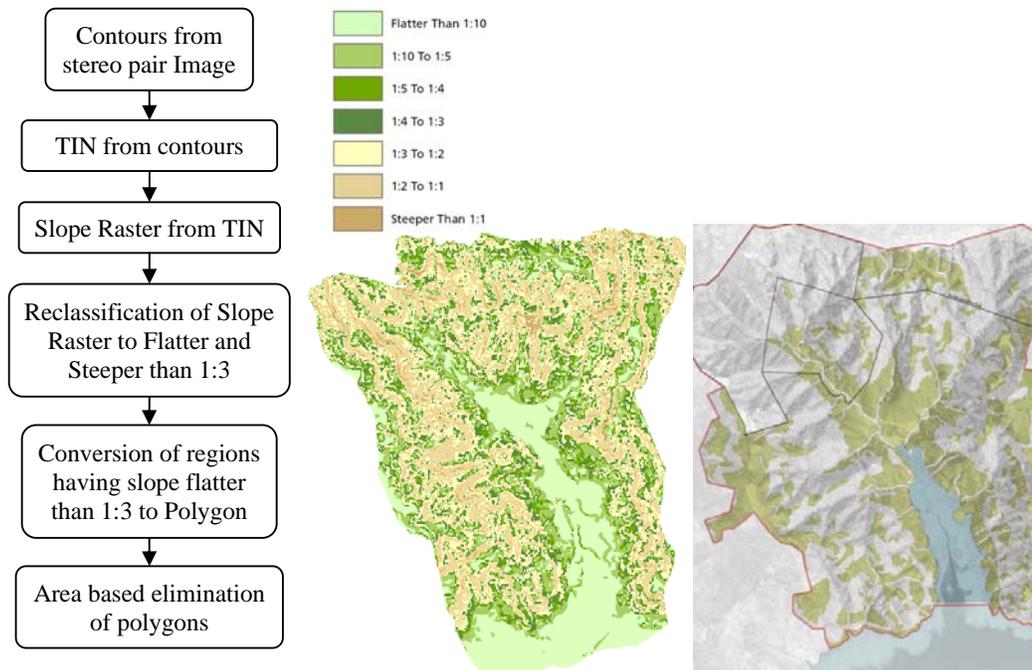


Figure 3: Process flow for slope map (left) and developable land parcel map (right)

The raster was reclassified based on above stated categories and non-developable land parcels were then eliminated. Further all developable parcels having area less than 100sqm were also eliminated. Remaining parcels were converted into polygon shape files and smoothed and rationalized to create final developable land parcels.

5.1.3. Aspect Analysis

Aspect analysis is particularly useful for determining location of activities based on the amount of sunlight it will receive. Locations of activities like sports complex and golf academy are some of the examples.

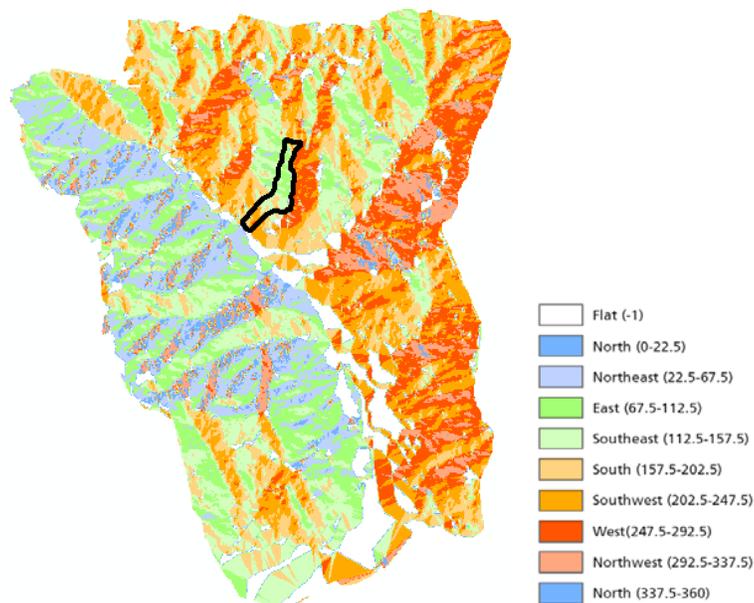


Figure 4: Aspect map of Mugaon with location of golf academy

5.2. Hydrological Systems

5.2.1. Delineation of Ravines

Lavasa receives 5000mm to 8000mm annual rainfall. It creates dendritic ravine pattern all over hills. These ravines or streams create most magnificent waterfalls and cascades. They not only enrich flora and fauna but they have potential to become asset to proposed development as well. Therefore as a planning principle these ravines need to be preserved. It was a challenge to map all the ravines of the valley by manual survey due to earlier stated problems. The problems become worse due to the fact that Ravines are most thickly vegetated.

For mapping the ravines same contours were used for preparation of elevation raster. From elevation raster slope direction raster and water accumulation raster was prepared. Then based on these two rasters stream link raster was prepared to generate ravine pattern. This raster was then converted into vector line feature class. By using STRAHLER method, stream ordering was done to know the preservation importance of the streams. The ravines were ordered into 1st, 2nd, 3rd and 4th order ravine.

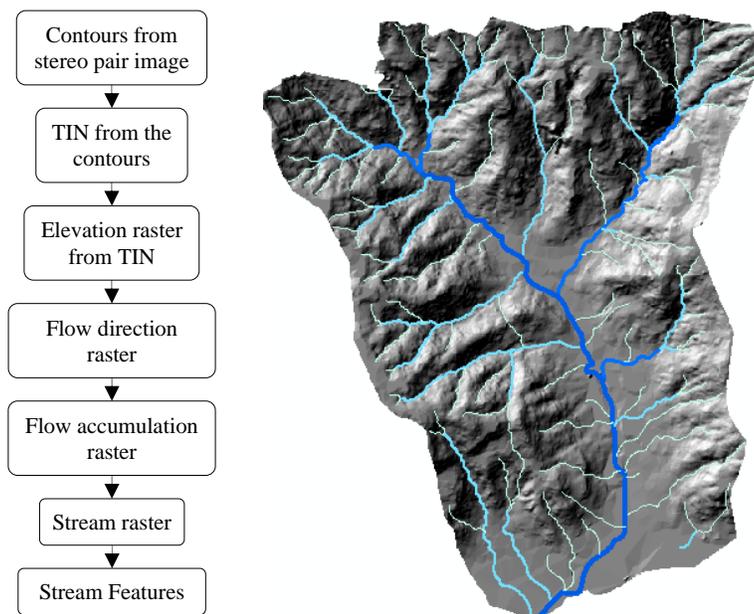


Figure 5: Process flow of stream network and stream ordering map

5.2.2. Delineation of Ravine Preservation Buffer

In order to preserve the ravines it is required to define buffer zone around them. The buffer was defined based on the order of ravines.

Stream Order	Buffer Width
First	10m
Second	20m
Third	30m
Fourth	40m

These buffers were verified from visual inspection of satellite image for density of vegetation. The ravines were the verified by GPS on site with random sampling. This buffer zone became one of the land use control in master plan for each parcel. Further the portions of developable parcels overlapping the ravine buffer were erased.

5.2.3. Location of Reservoirs

Lavasa, in order to bring features like water body in core of development, has decided to have water bodies in upstream region. The locations of reservoirs were very critical since it had to add value to the development but at the same time should not occupy precious developable land. Based on slope map and anticipated proposal of master plan locations of reservoirs were decided.

6. Proposals of Master Plan

On the basis of all of this information Master Planners proposed the development. Master plan is elaborated by Land use plan, road network and built form.

6.1. The Land use Map

Based on various such considerations the final Land use was proposed. The map elaborated various uses and specific activities. The land use proposal became base for various other proposals and estimations. This plan became one of the tools for regulating the development and tracking the changes and deviations in course of development. The land use plan shows parcel boundary and use of the developable parcels which have come from the previous slope analysis. The remaining area apart from buildable slopes became the green preserve area within the land parcel.

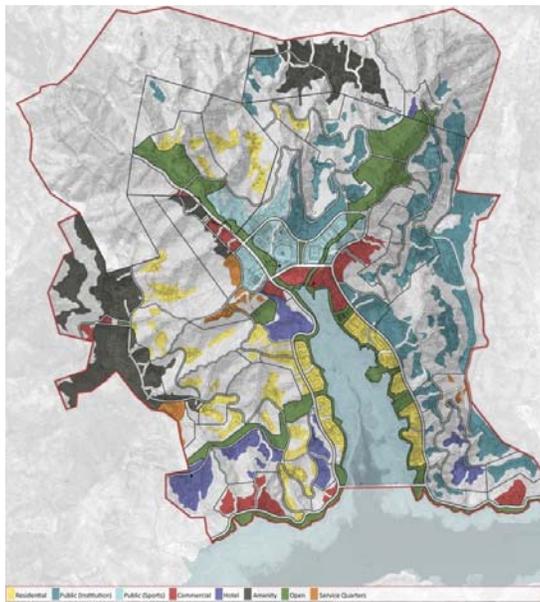


Figure 6: Proposed land use map for Mugaon

6.2. Roads

The roads for the development were proposed based on slope analysis and access to developable parcels. However it was required to check the roads on site for its feasibility. This task required walking along the proposed road alignments. Demarcation of roads by survey methods was time taking. This process did not allow any changes if needed. In order to do it quickly hand held GPS was used. Many such road alignments were examined and changed based on the actual observation on site by GPS tracking. The GPS track log was further refined to meet road geometric design standards.

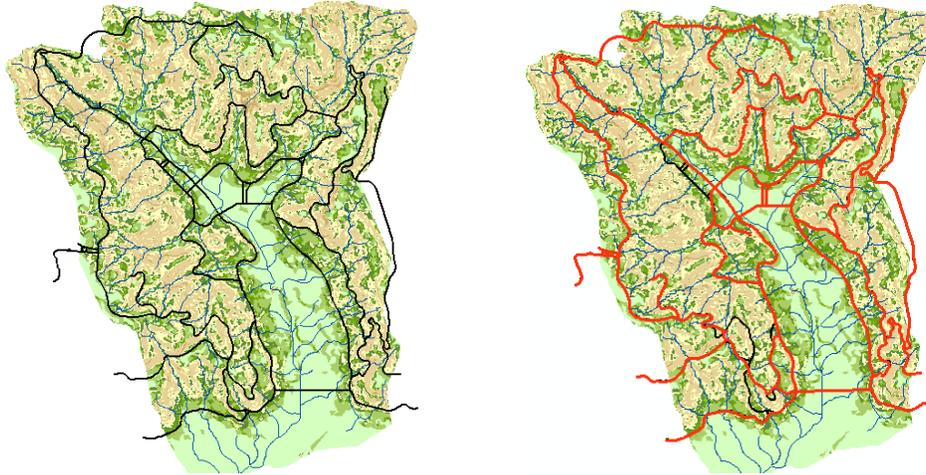


Figure 7: Proposed streets (left) and on-site rectified streets (right)

6.3. The Built Form

Built form configuration defines the urban character of any town. This is one of the essential elements in urban design. It creates understanding of density of built form as well as of various activities. The proposed built form was required to be seen quickly in 3-dimension, enabling designers to visualize the development pattern.

The polygons of proposed building footprints were exported as polygon shape file and heights were assigned for extrusion. The entire extruded shape file was draped over TIN to produce real life simulation. The 3D model was used to take snapshot from different angles. It provided quick and comprehensive understanding of character of town in terms of built form.

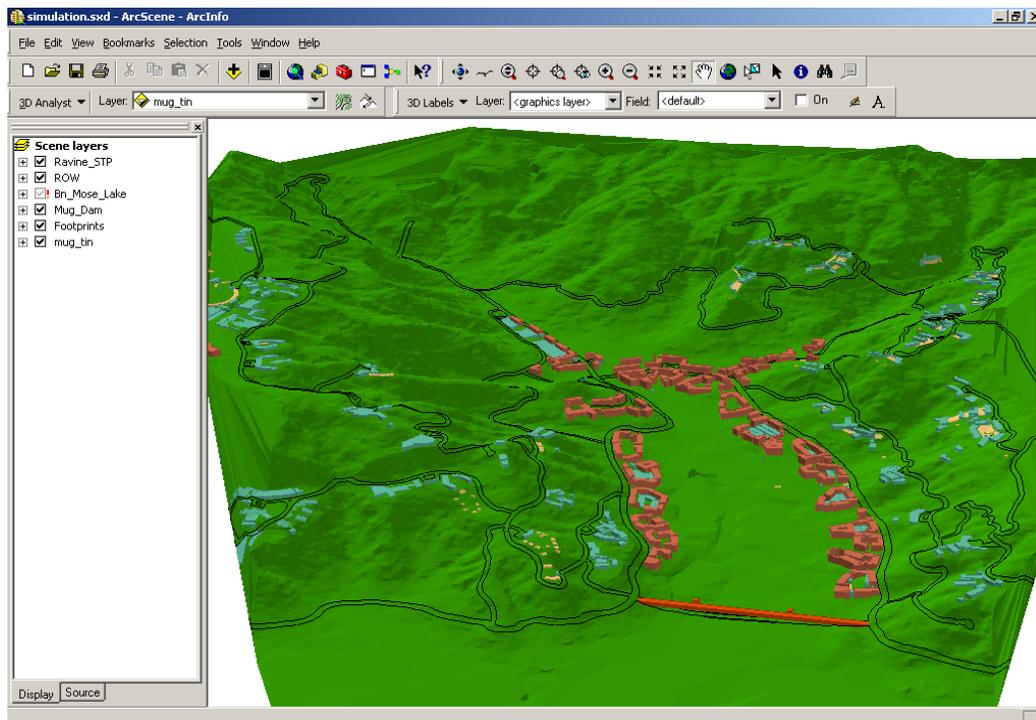


Figure 8: 3-Dimensional simulation of proposed built form

7. Conclusions

Entire study points towards few key findings that are as follows:

7.1. Acquiring Terrain Information

Use of stereo pair satellite image allows quick and initial terrain information. Though the information from this process is not very useful for engineering design, but master planning process can be initiated with this. This enables developer to formulate business plans and kick start the development.

7.2. Preservation of Nature

Terrain information is very important for preservation of nature during urban development. Planners get the information in desired format by use of GIS. This enables them make urbanization more responsive towards natural environment. Use of GIS technology, lead to the path of sustainable urban development.

7.3. Feasibility Check and Rectification

In most of the development process checking the physical feasibility of roads, buildings and infrastructure elements is avoided due to the enormous time required for the same. This causes lot of damage ecologically and financially. Use of GPS reduces the time required drastically and hence making physical feasibility check efficient.

7.4. Post Planning Analysis

Once the master plan is prepared lot of analysis is required to fine tune it. It involves detail road design, infrastructure design, urban design and building design. GIS offers enormous possibility in automation of various computations and estimations like population, employment and traffic volumes. Better concentration on post-planning analysis might bring up various such possibilities.

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