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"Three Dimensional Modelling and Rural Landscape Geo-visualization using Geo-spatial Science and Technology"

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Abstract:

Map is a two dimensional (2D) representation of cartography and the presentation of geographical information of an area or region. Three Dimensional Modelling (3D)-geo-visualization is a quite generic term that is used for a range of 3D visualizations for representing the real world or other data with a spatial reference. Some of the areas that will get benefit from the 3D GIS capabilities like rural landscape mapping, environmental monitoring, mining exploration, geological analysis, etc. Generally, creating a 3D model is difficult as it requires a lot of data, time and particular software which support 3D data. The present study has carried out for landscape geo-visualization of Alsisar village of Rajasthan and to get a real 3D view of the site. In this paper, the different types of 3D models have been developed using modelling software like Google sketch-up and ArcGIS.

Keywords: 2D, 3D Modelling, Landscape Geo-visualization, Sketch Up, ArcGIS.

Introduction:

Nowadays, 3D representation has the rapid advances in computer technology enhancing the interpretability of the rural landscape model. As a definition, 3D modelling is the process of developing a mathematical representation of any three-dimensional surface of object (either inanimate or living) via specialized software. Further, it is usually displayed as a two-dimensional image through a process called 3D rendering or used in a computer stimulation of physical phenomena. The development of new technologies there occur the need for applying 3D model instead of 2D model. The 3D model gives us the opportunity for a better and more comprehensive data evaluation. 3D spatial modelling is an abstract representation of reality using mathematically proven relationships defined as points, lines, polygons and solids to represent man-made and natural features above, on and below the surface of the Earth (Duncan and Rahman, 2013). The wider implementation of spatial technologies, such as geographical information systems (GIS), planning support systems (PSS), more readily available spatial data layers and a continued improvement in computer performance have in recent times that leads to a greatly enhanced ability to generate in 3D, existing and future spatial scenarios (Lovett, 2005). In recent times there have been a number of applications of 3D geographical visualization to assist in collaborative planning processes, both in rural and urban contexts (Bishop et al. 2005; Pettit et al. 2004). This growing body of literature and the related 3D geographical visualizations of future planning scenarios are referred to by Lovett (2005) as 'futures capes'. The rural landscape, although strongly influenced by human action, is generally regarded as the natural environment for excellence, and nowhere the rise of rural tourism and the recovery of traditional agricultural areas such as playgrounds and leisure are getting increasingly importance (García, et al.1999).

2D, 2.5D and 3D GIS:

For instance, In 2D one might require all objects form a planar partition, thus banning empty spaces between objects. The availability of topological relationships can also improve query performance during analysis. As 2.5D modelling is far less complex than 3D modelling, this has lead to the concept of combined 2.5D/3D modelling. The basic assumption is that the earth's surface can be modelled in 2.5D and that some more complex situations like buildings, viaducts or tunnels can be placed on top or below this surface. Apart from the intention to extend topographic models from 2D into 3D, another important characteristic of the new modelling approach is to introduce the use of a foundation data structure. Within a data structure redundant data storage (geometry) can be avoided and the relationships between objects enable validation. 3D modelling would be necessary, whereas in the majority of cases modelling in 2.5D would be sufficient. In a 2D GIS, a feature or phenomenon is represented as an area of grid cells or as an area within a polygon boundary. The transition to 3D means an even greater diversity of object types and spatial relationships as well as very large data volumes.

Integrity of 3D GIS and Visualization:

Generally, 3D GIS deals with the volume. Consider a cube. Instead of looking just at its faces, there must be information about what lies inside the cube too. To work, 3D GIS require this information to be complete and continuous. Clearly, the data management task has increased by another power. More problematic, however, is the initial task of acquiring 3D data. The combination of Geographic Information Systems (GIS) with 3D visualization technology is an emerging tool for landscape design and planning of an area. The needs for 3D models are growing and expanding rapidly in a variety of fields. In a steady shift from traditional 2D-GIS towards 3D-GIS, a great amount of accurate 3D models have become necessary to be produced in a short period of time and provided widely on the market. Hence, it is expected that 3D GIS should be able to perform the same tasks as 2D GIS. 2D Geographic Information Systems (GIS) are designed to handle information relating to spatial

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

locations. It is a collection of computer hardware, software, geographic data, people, and organizations, for collecting, storing, analyzing and disseminating all types of geographically referenced information (Dueker, 1989). The most common understanding of a GIS emphasizes it as a tool for storing, retrieving, transforming and displaying spatial data (Burrough, 1986). Three-dimensional (3D) GIS are comparable to that of 2D GIS, and the basic variation between them is the fact that the data in the former is related to three-dimensional spatial phenomena (Abdul-Rahman, Zlatanova and Pilouk, 2001). Therefore, it is anticipated that 3D GIS have the ability to execute the same tasks as 2D GIS. Since the entire world all around us is (3D), it is only normal that presentations of GIS information need to move in this direction also. Similarly, the growing need for 3D information along with the remarkable developments recorded in 3D data collection methods have aided the progress of 3D GIS (Stoter and Zlatanova, 2003). 3D geo-visualization is a quite generic term that is used for a range of 3D visualizations representing the real world, parts of the real world or other data with a spatial reference. Especially with the advent of virtual globes or geo browsers like Google Earth or already earlier since the vision about digital earth (Gore, 1998) they are increasingly popular and many people know about 3D geo-visualizations even though they may not call them so. Bartoschek and Schonig (2008) did a study on the streets of Munster, Westfalen where they found out that 65% of the participants are familiar with virtual globes such as Google Earth. Many of the 3D geo-visualizations focus on representing the landscape of the real world and often also real world objects such as buildings. Typical examples are digital elevation models draped with ortho or satellite imagery and more or less detailed 3D city models. Typical 3D geo-visualizations include 3D village or city models with photo-realistic or abstract renderings or virtual globes.

3D visualization is most often used in conjunction with computer graphics which is concerned with the processes such as rendering algorithms for displaying all kinds of 3D objects and virtual environments from real to fantasy on the screen. Geo-visualization is defined more methodically than technically. It integrates different approaches from fields such as cartography, exploratory data analysis and information visualization “to provide theory, methods, and tools for visual exploration, analysis, synthesis, and presentation of geo-spatial data” (MacEachren and Kraak, 2001).

GIS is increasingly being relied upon by a wide range of professionals from various fields for

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

the purpose of accessing, viewing, relating and analyzing maps and data. When combined with other applications, GIS has the unprecedented capability to manage, aggregate, quality-control, preserve and secure data. Since early '90s, GIS has become a sophisticated system for maintaining and analyzing spatial and thematic information on spatial objects and the need for 3D information is rapidly increasing especially due to the limitations of 2D GIS in analyzing situations such as water flood models, geological models, Air pollution models (Van wees, 2002). The two most common sources of 3D models are those originated on the computer by an artist or engineer using some kind of 3D modelling tool and those scanned into a computer from real-world objects. Models can also be produced procedurally or via physical simulation. 3D models represent a 3D object using a collection of points in 3D space, connected by various geometric entities such as triangles, lines, curved surfaces, etc. Being a collection of data (points and other information), 3D models can be created by hand, algorithmically (procedural modelling) or scanned. 3D models are widely used anywhere in 3D graphics. Actually, their use predates the widespread use of 3D graphics on personal computers. The need for 3D information is rapidly increasing. Currently, many human activities make steps towards the third dimension, i.e. urban planning, cadastre, environmental monitoring, telecommunications, public rescue operations, landscape planning, transportation monitoring, real-estate market, hydrographical activities, utility management, military applications. 3D is adding third dimension i.e. height (z co-ordinate) to two dimensional (x & y co-ordinates) plane or feature creates a 3D (three dimensional) and 3D GIS inherits strongly from 2D GIS yet it has its own unique characteristics. Geographic information system's applications are moving towards 3D; as it has the capacity to give a better representation of the real world. The emerging of geo-browsers such as Google Earth, Google sketch-up and ArcGIS made the demands for these kinds of applications increase tremendously. 3D GIS include terrain visualization, rural or cityscape modeling or virtual reality and analysis of complex spatial data. The main components of 3D GIS are: 3D data capture, 3D visualization and 3D modelling and management. 3D GIS unremarkably combine abstraction with realism. It can be used in location based services systems, pedestrian and car-routing systems, rural or urban planning, police/army training simulators and others. The definition of 3D GIS is similar to that of 2D GIS and the fundamental difference between them is the fact that the information in the former is associated with three-dimensional spatial phenomena (Abdul-Rahman,

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

Zlatanova and Pilouk, 2001). Once the developments in 3D GIS provide a well-suited functionality and performance, the spatial information services will evolve into the third dimension. The research in 3D GIS is intensive and covers all aspects of acquisition, storage and analysis of real world phenomena. Among all, 3D analysis and other related issues (topological models, frameworks for representing spatial relationships, 3D visualization) are mostly in the focus of investigations. Ervin and Hasbrouck (1999) present a concise history of visualization techniques for landscape planning. Over the past 15 years there has been an increase in research projects seeking to develop or apply technological tools for 3D landscape modelling (Auclair, Barczi, Borne and E´ tienne, 2001; Bishop, Wherrett and Miller, 2001; Danahy, 1989; Danahy and Hoinkes, 1995; Herwig and Paar, 2002; Lange, 1994; Lange, Schroth, Wissen and Schmid, 2003; Lovett et al.2001; Orland, 1994; Orland et al.2001; Snyder, 2003).

Visualization is at the core of GIS. In reality, GIS is very much dependent on visualization for its effectiveness. Without the graphic map displays and related spatial analysis the GIS offers, there would be little distinguished GIS from other information systems. Granted, the graphic displays available in GIS do not usually come close for exploiting the potential of visualization systems, but even the crude line printer images that were outputed by earlier GIS helped to trigger the visualization process in the minds of those who were studying them. Visualization systems, on the other hand, do not need geographic information to be useful; take for example, exploratory data analysis. Visualization systems can be used to aid in the exploration of any data whether it is geo-spatial or not. Thus, visualization systems provide GIS with an important tool. Visualizations are the key to effective public interaction because they are the only common language to which all participants within the same cultural context – technical and non-technical can relate (King et al.1989). Scientific visualization in the statistic and computer science literature is principally concerned with the use of graphic tools. While geographical processes and related data-sets need to deploy spatial science related technologies such as geographical information systems (GIS) to display different forms of maps. The representation of this information, either in two-dimensional (2D) or three-dimensional (3D) space is commonly referred as spatial data visualization, or geographical visualization . A formal definition of geographical visualization is that Geographical Visualization focuses on the application of scientific communication theory for mapping artefacts (Cartwright et al.2004). Three-dimensional visualizations

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

are interesting method for representing model outcomes. But most visualization techniques require expensive software, and a lot of time to create them. When a large set of visualizations is needed, or when the visualizations need to be adapted frequently, a faster and more flexible method is needed. The first step of the proposed model is to create the 3D elements. These elements are combined with the base map, and distributed to the public using Google Earth. Both freely available and commercial software are used in this process. Web-based landscape visualization tools have made considerable progress in recent years, such as Google Earth (http://earth.google.com/) covering the entire planet in 3D. Geo-visualisation is a rising field. It is based upon many approaches from many fields and disciplines, including Cartography, Scientific Visualization, Image analysis, Exploratory Data Analysis and GIS to provide theory, methods and tools for the visual exploration, synthesis and presentation of data that contains geographic information (Huang et al.2001). Visualization gives us the opportunity to view, experience and understand environmental changes before they occur. Through the ability to share this experience and potential for exploration, visualization will help communities (of whatever size) to build consensus and make decisions about their future. The relationship of people to their environment is a key contributor to environmental decisions and visualization can help us to learn more about that relationship (Lange and Bishop, 2005). For visualization this is an extremely challenging task. Real landscapes are highly complex structures often covering very large areas. Looking at the real landscape, from the visualization point-of-view , the most important variables determining the visual appearance of a landscape are terrain, vegetation, animals and humans, water, built structures as well as atmosphere and light (Ervin, 2001). Depending on the issues, the planning purposes or the landscape in question, only some of these landscape elements may be presented or need to be represented in high detail. However, each of these elements could be a major obstacle for achieving a representation with a high degree of realism (Lange, 1999). In the last 20 years, research on 3D landscape modelling has increased considerably, mainly for urban planning, but also for rural and forest landscapes (Danahy 1989; Auclair et al.2001; Bishop et al.2001; Lovett et al.2001; Orland et al.2001; Herwig and Paarm, 2002; Snyderm, 2003; Dockerty et al.2005; Paar and Clasen, 2007; Lange et al.2008).

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

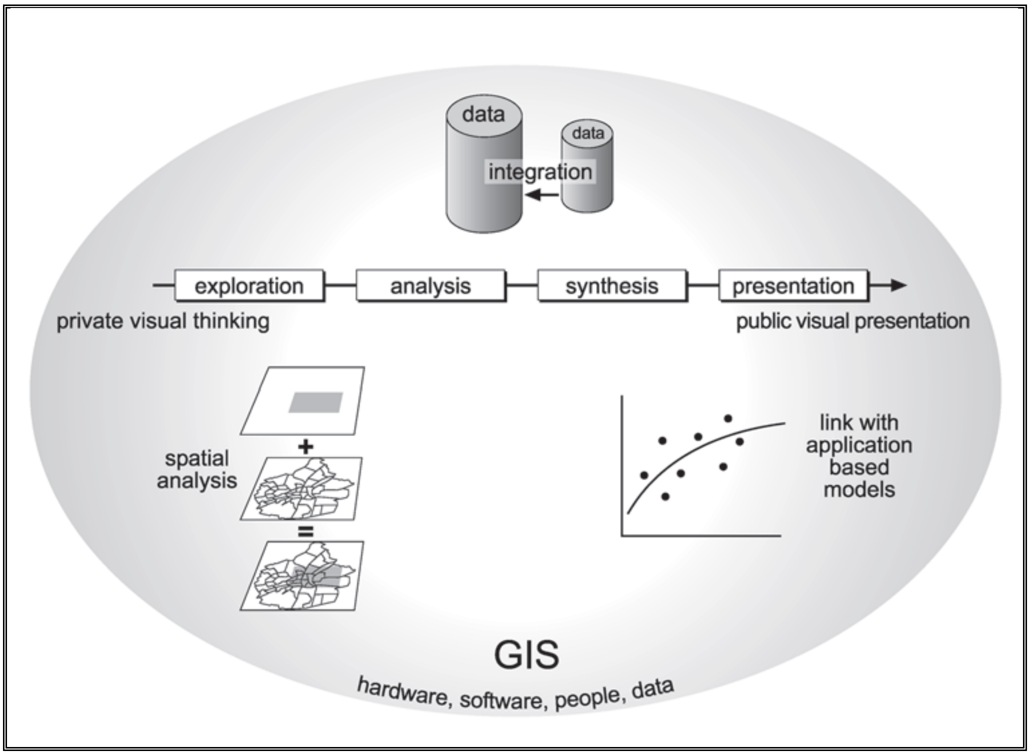

Figure 1. View on GIS: its characteristics and relation to visualization (from Kraak and Ormeling, 2010)

Within the last few decades, digital landscape representations have progressed from abstract and static representations to highly realistic visualizations capable of being explored through dynamic spatial movement with the potential to provide an immersive experience in multiple spatial and temporal scales. Punia (2008) had given the concept of landscape modelling and visualization using several cartographic techniques. Landscapes as an aesthetic object from the view of subjective preferences that highlight various perspectives towards landscape. They can be objective, which guides and facilitates data compilation by photogram- metric and survey techniques, thus beauty can be defined aesthetically on the map as real representation of the landscape as the ratio of the proportions of line, colour or tone. Various authors have shared their views for defining beauty in the landscape:

1. Expression (Langer, 1957)
2. Emotions (Collinson, 1997)
3. Feelings
4. Pleasure (Collinson, 1997)
5. Creativity and Imagination (Kneller, 1965)

Landscape Planning has (Bishop, 1994) covered a new approaches to GIS-based landscape visualization and modelling and introduced the concepts of cellular automata and autonomous agents. It addressed landscape assessment, GIS-modelling, visual representation, and perceptual issues in digital

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

landscape representation. These included questions of realism and perception of simulated landscapes as well as representational validity and criteria. There are a number of neglected or unresolved research areas requiring further exploration. These include issues of real world dynamics, human perception of landscapes, simulated sensory environments, new and emerging technologies, as well as landscape visualization for improved communication, public engagement, and decision-making (e.g. Lange and Hehl-Lange, 2005). In the last few decades we have clearly witnessed major advances in how we represent and assess the landscape, and likewise how we use simulation and virtual representation in environmental decision-making (e.g., seminal work by Zube et al.1987). Although the visual is by far the dominant human sense, focussing only on the visual aspect of landscape design that provides us only a partial "view", literally, of our environment. Certainly people who are blind or have significant sight impairments learn to perceive the world through non-visual senses, and sensory gardens and other places have been designed to heighten aesthetic experiences through auditory, tactile, olfactory and other perceptual systems. Little empirical work has been done in this respect, however, and we stand to gain significantly from dedicated and comparative studies focussing on how individuals make use of the various sense dimensions of landscape perception. Is a beautiful view of a landscape located next to a smelly waste dumpsite better or worse than a mediocre landscape view without any odorous impact? And what if some noise is added as well? Further developments in landscape visualization may spur greater informed public participation as supported by visualization technology for communication between policy makers and non-experts (e.g. mobile phone augmented reality allowing the streaming of data of planning proposals while one is on-site), improved integration of landscape quality in decision-making, and a pro-active approach to shaping our future environments. This would require further investigation into the use of 3D visualizations and the relevant phases of planning and design, the primary audience, and the level of engagement.

Representing landscape through 2D-maps does not ensure that the majority of the general public will understand the implications of any change; not everybody can read maps or reconstruct mentally a 3D landscape from a 2D-map image. There is thus a need to use Information Technology (IT) as a tool for visualizing the landscape in the full three dimensions of space, as well as time, within a virtual space, and to view that virtual landscape from various points of view (Punia and Pandey, 2006). ESRI software allows GIS organizations to take a topographical map and turn it into a VRML file which can then be printed on a Z Corporation 3D Printer. This document contains two sections. The first section will go through a few steps of taking contour lines, making it into a TIN, draping a satellite image on the TIN, and then exporting it as a VRML. The second section will explain taking a SDTS (Spatial Data Transfer Standard) DEM file and translating the file into a printable VRML file using some of the tools in ArcScene. Punia and Kundu (2011) were showed how the rural landscape is integrated with 3D modelling and Geographic Information Science for Alsisar village in Jhunjhunu district of Rajasthan, India. This study is theoretical for comprehending concept of geo-visualization and technical in sense to conceptualize various methods to represent geographic space in absolute and realistic way.

Potential Benefits of Landscape Visualization:

The potential benefits of landscape visualization (Sheppard et al. 2010) that have been identified in a First Nations context, but which may also be applicable to rural communities, include:

• Better explanation of complex projects, mapped information, and technical issues to elders and other community members who may not be familiar with reading maps and interpreting other technical documentation.

• Accessing cultural/ecological values, knowledge and context from the elders and those who know the area well.

• Helping to illustrate cultural/spiritual values to western planners and decision-makers, through highlighting particular important places, features, and spatial and ecological relationships.

• Providing a check on information supplied by others (e.g. government agencies) to highlight concerns or errors that would not otherwise be discovered based on map or report information.

• Demonstrating local leadership and technological achievement, since many companies and government agencies lack the capacity to produce accurate visual simulations themselves.

• Providing a simple way to verify actual performance, once projects have been implemented, through comparison with the visualization of predicted conditions.

Area of interest:

For this study, Alsisar village in Jhunjhunu district of Rajasthan (India) is being attempted for rural landscape geo-visualization and 3D modelling. The area mainly encompasses the ancient rural old havelis along the roads. Alsisar Mahal is the major haveli, except this Indra Villa is worth mentioning. Not only the havelis but also there are some

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

antiquities in temple, well, school, health centre, archway etc.

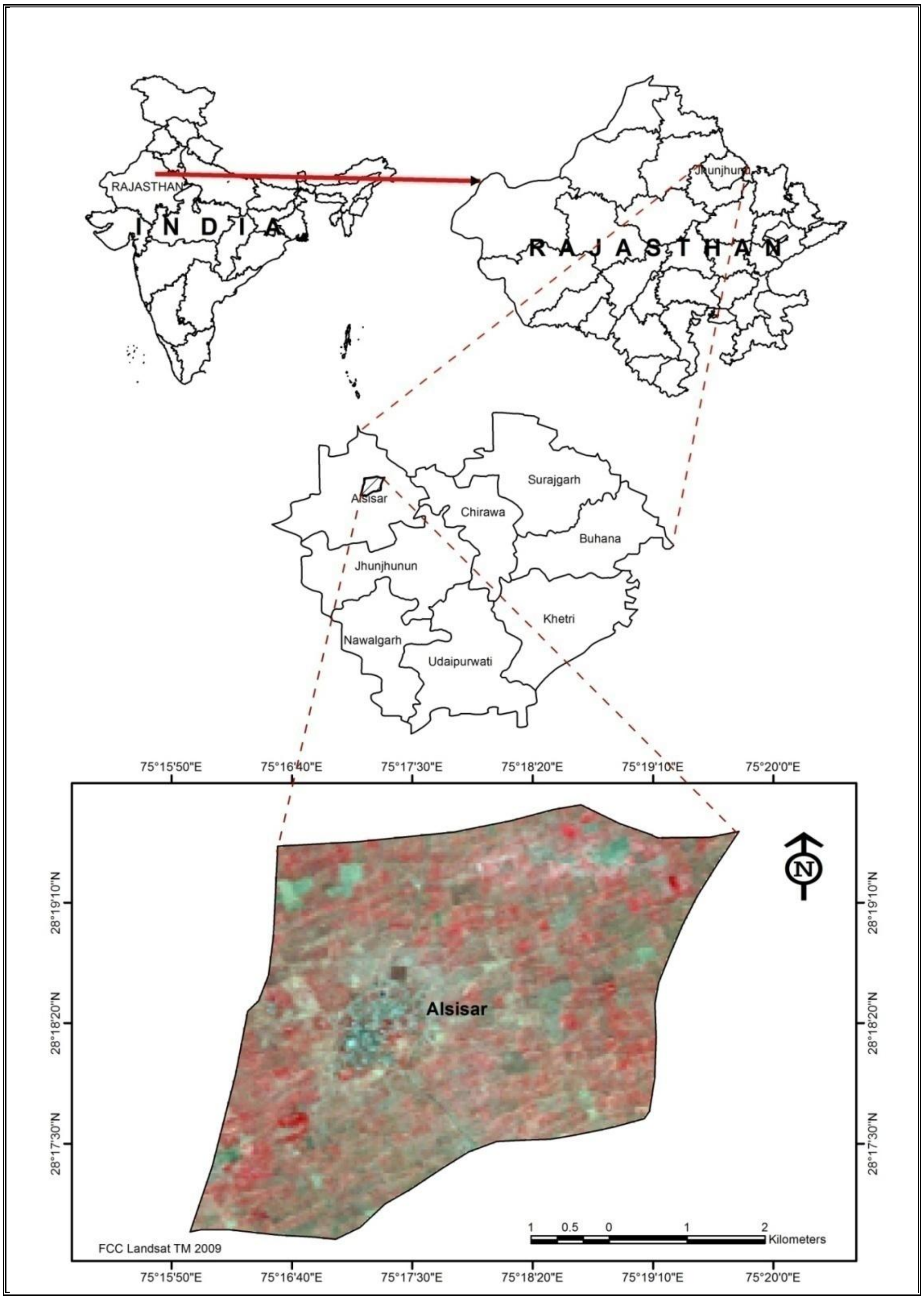

Figure 2. Location map of study site

Materials and Methods:

Data Used:

High resolution satellite image (LISS 4) and Google Earth have been used for the object identification and extraction for this study. On the other hand, Landsat TM/ETM+ data of the year 2000 and 2009 used for visualize the land-use and land-cover in and around Alsisar village. Total two scenes comprising the path and row covers the whole study area. Landsat TM/ETM+ data was used because it is inexpensive, with high monitoring frequency and covers large areas (Asis and Omasa, 2007). According to the availability, Landsat TM sensor data have been collected for the year 2009 and ETM+ sensor data has been collected for the year 2000. Both of the Landsat TM and ETM+ data was geo-referenced to Universal Transverse Mercator Projection (UTM) with WGS 84 datum. Corresponding Topo-sheets of the study site was collected from the Geological Survey of India, Dehradun, India and it was integrated with satellite image for feature identification and extraction. Pre field work leading to some initial steps like geo-coding, geo-referencing of the image using corresponding topo-sheets of the study area was performed and a base map was prepared for conducting the field survey. Besides, visual interpretation was done with the help of satellite images.

Methodology:

Google SketchUp is the finest (and most innovative) tool available for anyone to design anything from imagery or map to realistic view. We can create a 3D model easily with it. For redecorate our living room, designing a new piece of furniture, village or city modelling through Google Earth is feasible. There is no limit to what we can create with SketchUp. There are also dozens of video tutorials, an extensive Help Center and a worldwide user community means that anyone who wants to make 3D models with Google SketchUp can.

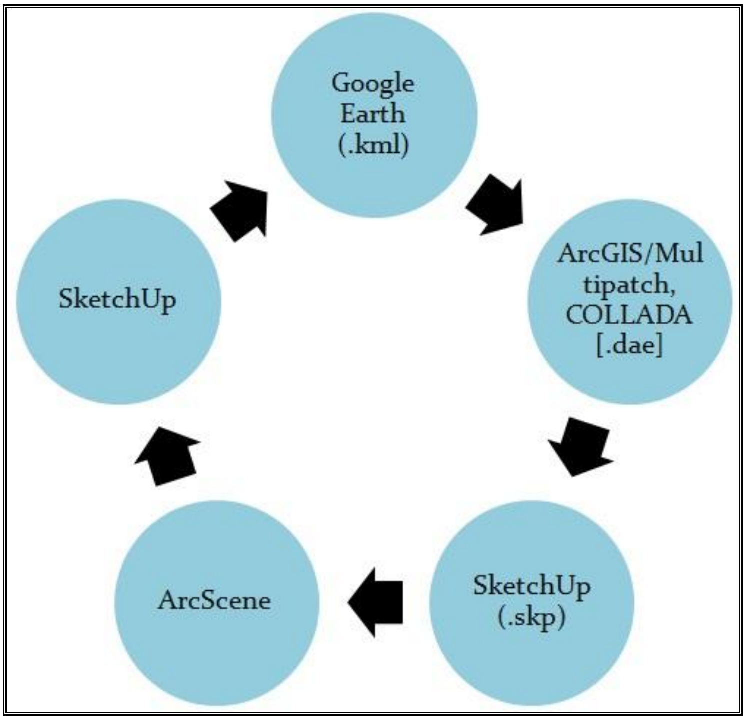

Figure 3. Integration of different work environment

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

Firstly, object has been identified from high resolution satellite image like LISS 4 and Google Earth with the help of topo-sheet. The vector database generated through Google Earth. Then objects were exported it GIS environment and again they were exported to sketchup environment. After that, the realistic shape of model was generated and exported that through sketchup environment to Google Earth for 3D visualization. Some features are extracted from Google Earth images in .kml format and are reshaped in GIS environment. Realistic 3D structures are made in sketch up environment for further integration in GIS for application based on utility. For doing this real structure, texture and dimensions are required. They were collected from field using DGPS, laser distance meter and terrestrial camera. So, it is an integrated approach using landscape elements in GIS -> 3D Model-> WebGIS functionality along with interactions at users' level to comprehend landscape.

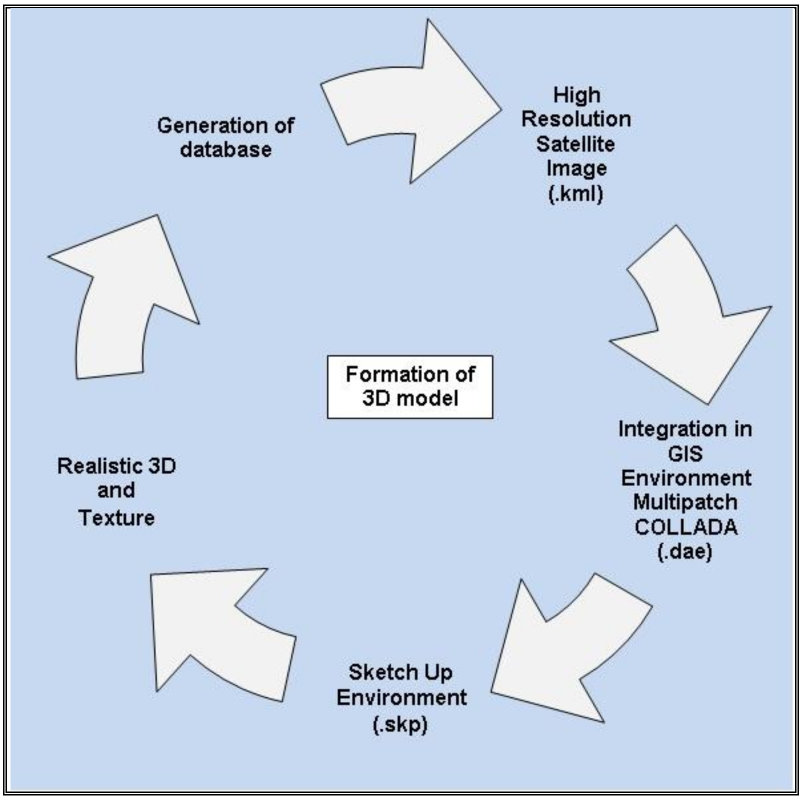

Figure 4. Flowchart of methodology

Results and Discussion:

For analysis of landscape visualization, a supervised classification based on satellite image for land use and land cover had done to recognize the all features (fig. 5). Basis on topo-sheet all land cover and land uses were identified. Land use at finer scale such as the village eco-system is

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

significant as such systems are highly dependent on the land resources. Agriculture is directly driven by availability of arable land and water resources. Thus rural communities and their livelihoods are directly dependent on the land resources, and land use change has far reaching consequences in a village ecosystem with implications for major services. Land use/ cover classes are extracted from LISS-IV of IRS-P6 remote sensing data of 04th November 2008 using supervised classification method. Main classes in the region are agriculture (mainly after monsoon rains only), settlements, wasteland (sand dunal area), forest, plantation, water bodies and current fallow.

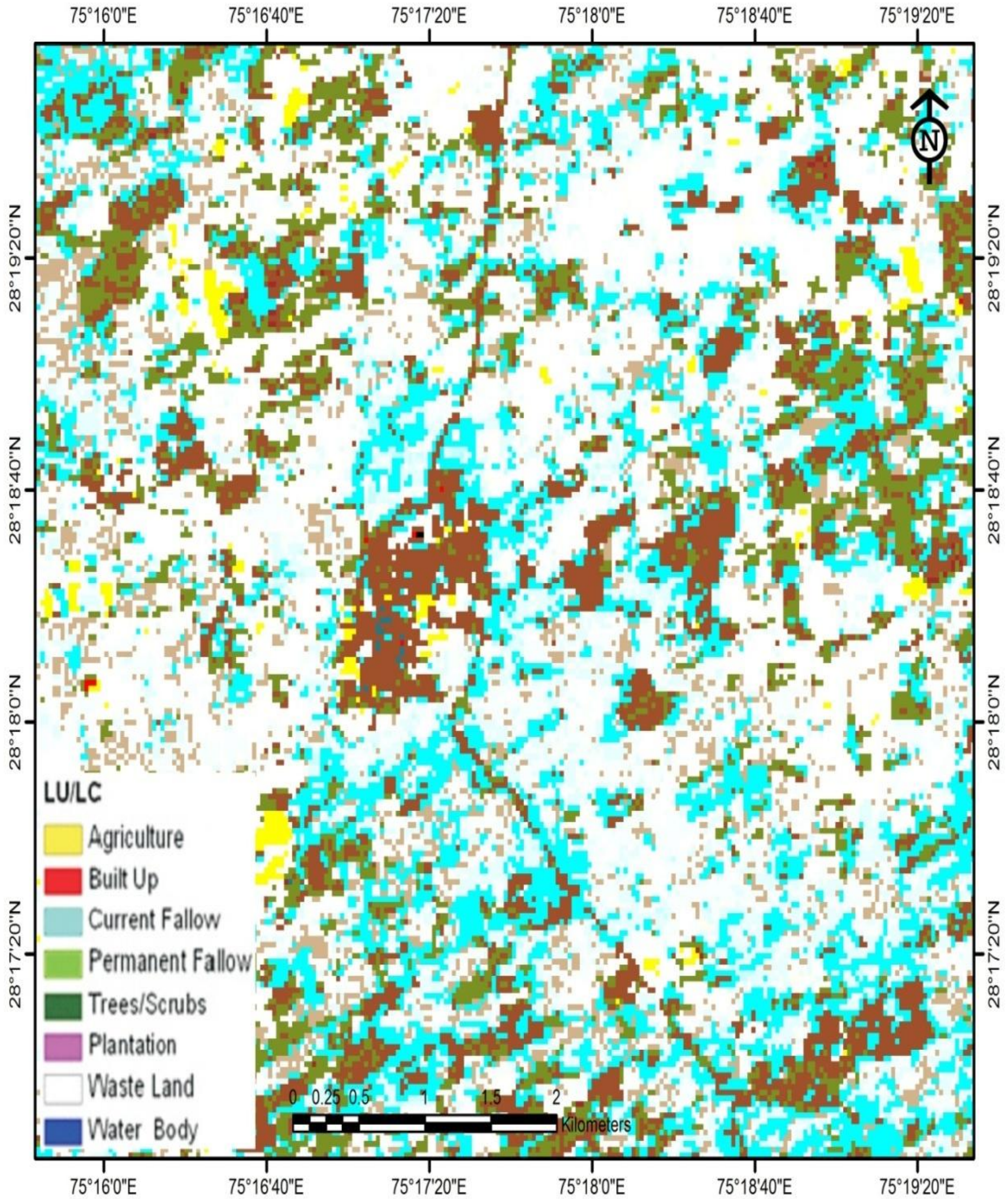

Figure 5. Landuse and landcover pattern in and around Alsisar village

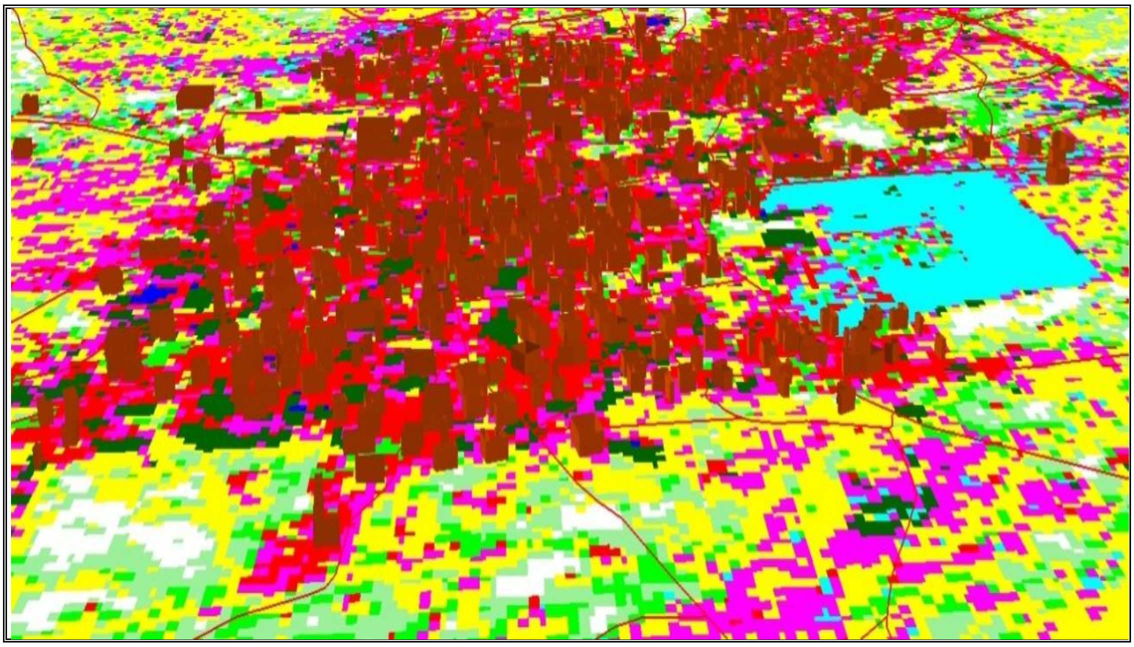

Figure 6. 3D view of buildings and roads overlaid on classified IRS P6 (LISS 4) image

From the above fig. 6 a 3D view of buildings and roads have shown which is also overlaid on classified IRS P6 (LISS 4) image. These buildings are basically shows the settlement pattern of village.

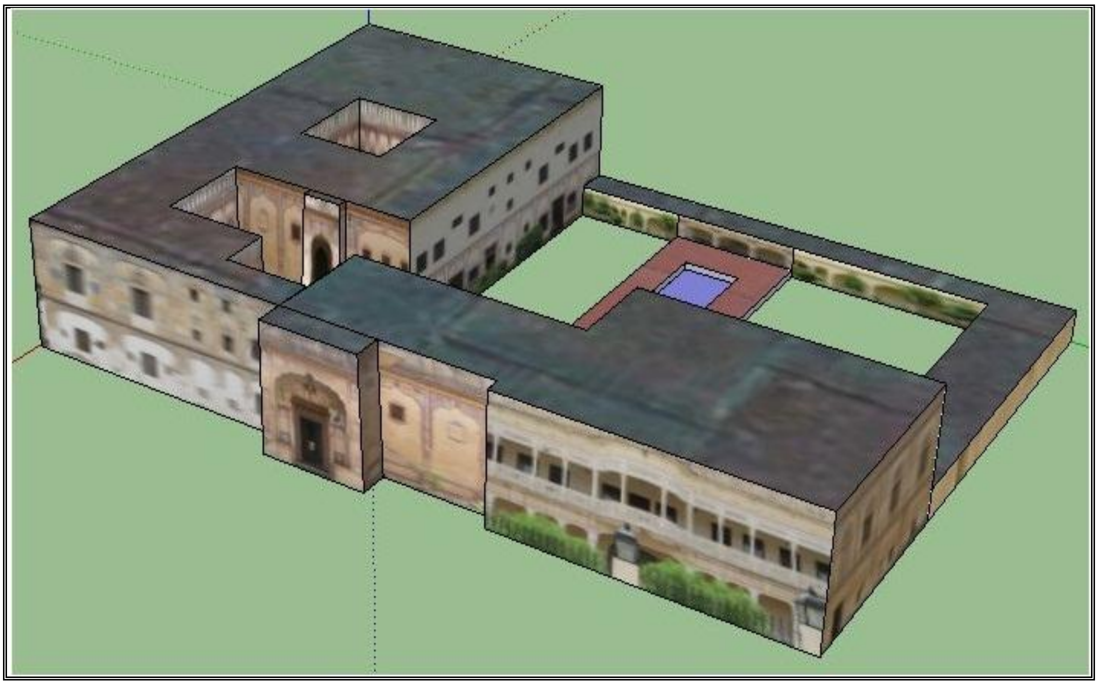

Figure 7. 3D model of indra vila

This 3D model is an antique haveli, local name Indra Villa which is more than hundred years old (fig. 7).

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

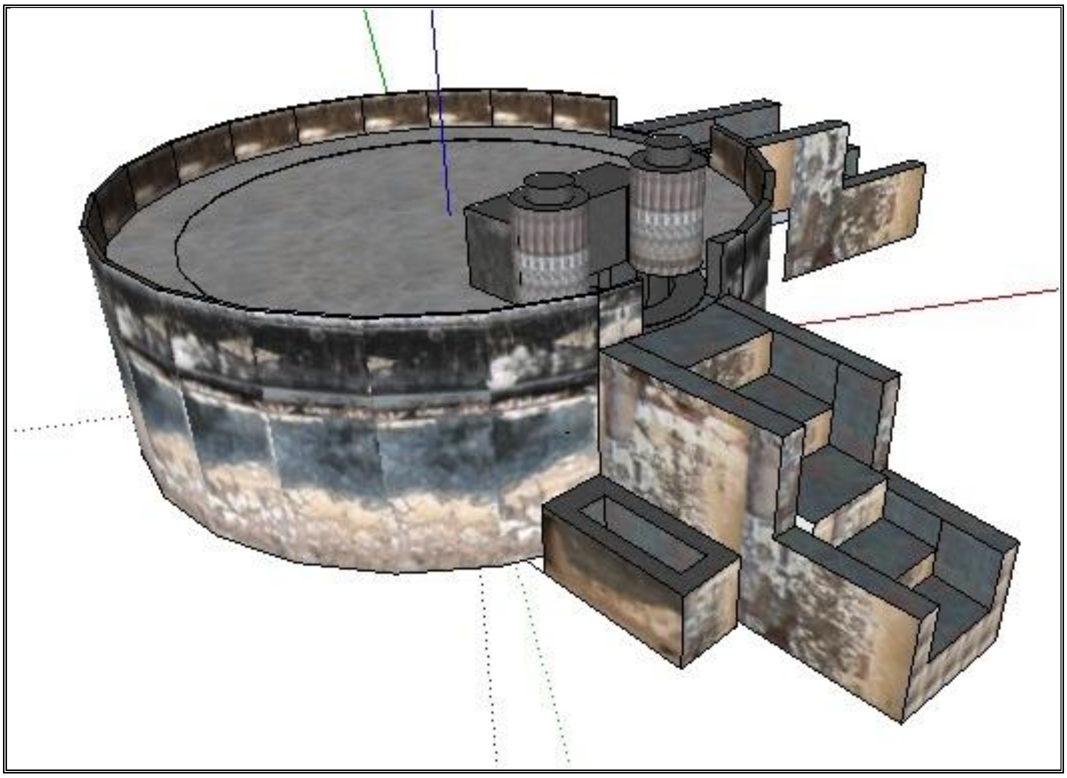

Figure 8. 3D model of antique well

This 3d model is an antique well, local name Vishnu Kuoa which is more than hundred years old and it was used by a seth (fig. 8).

Figure 9. 3D model of Alsisar gate

Neo Geographia (ISSN-2319 – 5118) Vol. III, Issue. III, July 2014

3D model of Alsisar gate is located at beginning of village. It is basically newly built, probably in 2010 was made by gram panchayat of Alsisar village, Jhunjhunu (fig. 9).

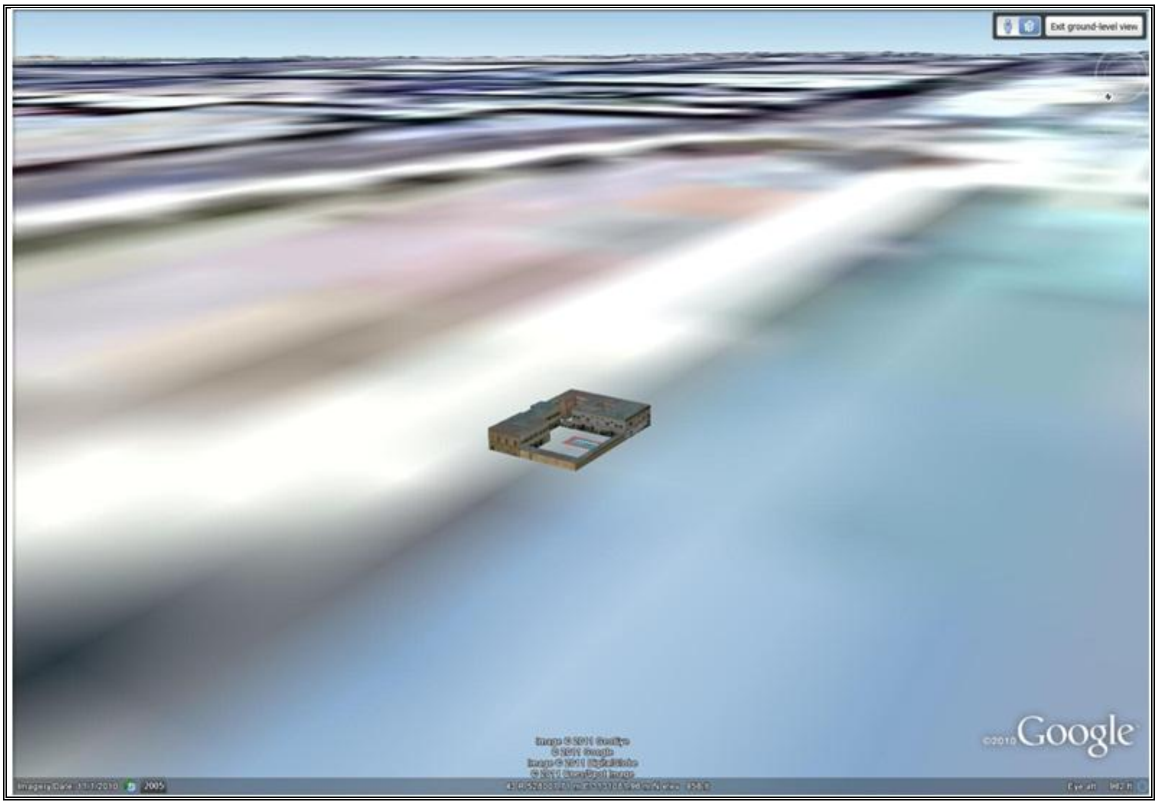

Figure 10. 3Dmodel of indra vila on google earth

Finally, the 3d model of Indra villa is directly exported in Google earth environment with exact geographical locations with the help of geo-spatial tool (fig. 10).

Conclusions:

Landscape and environments will become an important part of the future of geo-visualization. This paper has shown some representational aspects of 3D model that are important to note for current implementations and future research. In this study, a 3D model design approach to geo-visualization is adopted by creating a geographic profiling tool which shifts the emphasis from technological advances or interaction with the map to the interaction elements key to building the spatial knowledge of GIS experts and non-experts alike. In this study, some specific models were shown here to establish that how geo-spatial tool is essential to represent the real features through the 3D model and surroundings landscape.

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