EXPERT GEOPORTAL SYSTEM

A THESIS

Submitted in partial fulfilment of the requirements for the award of the degree of

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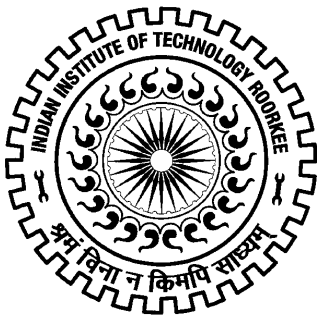
in
CIVIL ENGINEERING

by

UMESH CHANDRA



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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **"EXPERT GEOPORTAL SYSTEM"**, in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy and submitted in the Department of Civil Engineering of the Indian Institute of Technology Roorkee, Roorkee is an authentic record of my own work carried out during a period from December, 2009 to July, 2013 under the supervision of Dr. Kamal Jain, Associate Professor, Department of Civil Engineering, Indian Institute of Technology Roorkee, Roorkee and Dr. S. K. Jain, Professor, Department of Applied Mathematics, Birla Institute of Technology, Mesra, Ranchi.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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The Ph.D. Viva-Voce Examination of **Mr. Umesh Chandra**, Research Scholar, has been held on ----------

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ABSTRACT

Geoportal is the web gateway of the Spatial Data. It is the building block for providing the Spatial Information to the web user either it is a thick or a thin client. Geoportal is the web interface for finding and accessing geographic information. Various, diversified sources of information in different Geoportal arranged in the form of suited for their requirements. The information is updated and maintained by different agencies. They allow use of data free of charge for non profitable use. Most of these portals develop on a non GIS platform which are poor in decision making and many times much more facilities and features are required by GIS users.

The GIS community has a different approach to store, manage, present data for real time query based information extracts in spatial domain. One option is to create own data as created by Non GIS portals, and other is to extract real time data from Non GIS portal and use in own GIS Standard portal without illegally accessing the service provider database for non profitable use, which require advance concept as writing program to access own database is a common technology, but accessing data from a third party web portal in real time without entering into their central server requires technology to understand their framework, data storage etc. which comes under Reverse Engineering.

Present study designed and developed a system known as EGPS (Expert Geoportal System) after getting an idea from new emerging technology like web mashups. Web mashup is a cost effective solution as it works on a principle of providing new services by using the data or services already present on the web, instead of creating an entirely new system from scratch. For providing this type of solution needs a good understanding of cross domain issues, security, copyrights etc.

Expert Geoportal System (EGPS) is designed and developed by using Html, Asp. Net (server side scripting language), JavaScript (client side scripting language), Google API's (providing spatial information), GDAL (open source library) and VBA (Excel Macros) in Visual Studio 2008.

This browser based application provides different GIS functionalities like location based services, weather forecasting, growth and pattern analysis, DEM and Geotiff images by using diverse source of data already present on the web. For providing location based services, it used front end data of Makaan.com and Yahoolocal.in web applications. For providing difference images, growth analysis and pattern analysis graph, it uses temporal NDVI images provided by the Global Agriculture Monitoring (GLAM) Project website and to provide DEM and Georeferenced image, it used Google Earth API's.

Location based services provided by EGPS enhanced the capabilities of Makaan.com and yahoolocal.in website by providing answers of more complex queries like "how many apartment are present inside 5 km area", "how many hospital are present inside 25 km area" etc. by rearranging their front end data with the help of VBA programming and creating buffers of different diameter in Google Map APIs which help in better decision making. To provide Local Weather Forecasting information for an entire buffer EGPS repeatedly call the freely available weather services of wunderground.com web application by passing the location based attributes (captured from the makaan.com or yahoolocal. in a web application).

Digital Elevation Models (DEM) is data files that contain the elevation of the terrain over a specified area, usually at a fixed grid interval over the surface of the earth. EGPS uses Google Earth APIs for providing DEM file by enhancing its capabilities, as Google Earth does not provide a direct API for DEM generation, so EGPS deployed a new system where users can specify the grid interval by selecting horizontal and vertical pixel value according to their requirement. The output file is automatically saved in text (.txt) format which contains elevation values of a grid point with its latitude and longitude.

NDVI data is suitable to examine the longer term event like the growth of vegetation through a season (NDVI, 2002; Umesh et.al.,2013b). For providing real time vegetation growth and pattern analysis EGPS uses the temporal NDVI images provided by the GLAM website. A web based interface is developed for capturing the NDVI images, these images are further classified and graphs are plotted at run time for decision making. This system is more suitable for automatic forecast of the vegetation pattern change analysis; the data needed for this type of analysis is not only very costly but also not easily available.

Georeferencing is the primary essential step to define spatial data in a coordinate system to relate it to its exact location over earth defined through projection systems. As this procedure is mandatory for data modeling. So, Expert Geoportal System (EGPS) deployed a new referencing system that is used to establish the relation between raster data collected by capturing Google earth images at run time for different GIS application.

There is a large significance of this research work as providing these functionalities by creating a new web portal from scratch, not only needed a costly investment but many time increases the duplication of data on the web. It reduces the burden of managing database, need of understanding of spatial domain knowledge, purchasing of costly software etc. This study also helps in data modelling because it reduces the lengthy procedure of generation of DEM file and Geotiff images as through this software these works can be done in a single click.

This study also specifies the various issues regarding the Mashup based application like cross domain, security, copyrights etc. It also recommends some future scope as there is a need to increase computation speed and processing time of a developed system etc.

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LIST OF ABBREVIATIONS USED

AJAX	Asynchronous JavaScript and XML
API	Application Programming Interface
ASP	Active Server Pages
COM	Component Object Model
CSS	Cascading Style Sheets
DCOM	Distributed Component Object Model
DEM	Digital Elevation Model
EGPS	Expert Geoportal System
ESRI	Economic and Social Research Institute
FAS	Foreign Agricultural Service
GE	Google Earth
GIS	Geographic Information System
FGDC	Federal Geographic Data Committee
GDAL	Geospatial Data Abstraction Library
GLAM	Global Agriculture Monitoring
HTA	Html Application Page
HTML	Hyper Text Markup Language
HTTP	Hypertext Transfer Protocol
IFrame	Inline Frame
IIS	Internet Information Services
INSPIRE	Infrastructure for Spatial Information in the European Community
JS	JavaScript
JSON	JavaScript Object Notation
KML	Keyhole Markup Language
MODIS	Moderate-Resolution Imaging Spectroradiometer
NDVI	Normalized Difference Vegetative Index
NG	National Geoportal
NSDI	National Spatial Data Infrastructure
OGC	Open Geospatial Consortium
SDI	Spatial Data Infrastructure
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
TCP/IP	Transmission Control Protocol/ Internet Protocol
UI	User Interface
VB	Visual Basic
VBA	Visual Basic For Applications
XML	Extensible Markup Language

Chapter 1
INTRODUCTION

1.1 INTRODUCTION

Recent years have witnessed the rapid development and expanding use of automated mapping, Geographic Information System (GIS), and Spatial Data Communication Technologies and Standards. Such progress along with the associated growth in geospatial data collection activity by organizations and governments throughout the world has helped to create a global reservoir of electronically enabled geospatial information, which is having the real potential for the improved decision making and operations, at all the attempting levels in service of a productive and sustainable future for everyone. To help realize this potential, geospatial information resources must be positioned both academically and technically, for wide discovery, exchange, and use.

The concept of geo-portals has emerged and is advancing in a continuous fashion as a platform for organizing and presenting institutions and technology, to support geospatial information sharing. Geo-portal constructed with building blocks which include, spatial data sharing policy, regulatory permissions, standards (Open Geospatial Consortium), spatial data structures, technical architectures, stakeholder geospatial data, metadata services, and other constituent elements—are now being implemented by organizations, institutes and governments throughout the world.

There is very fine difference between GIS based website and GIS-Web portals. Let’s understand what Developed Expert Geoportal System is and how these three are different from each other.

1.1.1 GIS Website

GIS website is the site, which create and maintain its own database in order to provide the updated information to the users who need it. Their own Graphical User Interface is developed by them, to provide specific information to the needy users, for example, Global Agriculture Monitoring Website (GLAM).

1.1.2 Geoportal - Comprehensive gateway to spatial database

"A web portal aiming to provide the diverse Geospatial data on a single common platform is known as Geoportal". They provide information either by providing the hyperlinks or by using the services published by the third party application. In the first case, when a user clicks on the provided hyperlinks, Geoportal will redirect user onto some other third party website, now user can only use the information provided by this redirected site for decision making (same as a simple GIS Website). In the second case, Geoportal provider will work as service consumer, it consumed the Geospatial services provided by the third party agencies (Government or Private Agencies) by designing and developing an interface (Map Viewer etc.), to interact with third party Geospatial Services, to provide spatial information to end user.

1.1.3 Expert Geoportal System - Combined interface for spatial web portals

Expert Geoportal System is that type of system, which can use the data from third party website which are not built for providing a third party solution by publishing their web services. EGPS removes the burden of creating and managing its own database, it also eliminates the burden from third party agencies (Government and private agencies) to publish Geospatial services for Geoportal. For providing Geospatial Services, it directly uses data from simple GIS or Non GIS websites and improves their decision making capabilities for end users.

1.2 BACKGROUND

With the invention of electronic computers in the 1940s, scientists began to transform data from paper-based copies to electronic forms, a trend that has transformed scientific research procedures by allowing for easy shipping and sharing of information among colleagues (Lerner, 2001). The invention of the computer networks in the 1960s greatly simplified this sharing of electronic information, by introducing email, FTP and other electronic communication protocols which allowed scientists, educators, government officials, and the public to exchange their ideas, conduct research, and share knowledge (Holzmann & Pehrson, 1994). Computer networks grew so fast, that these became one of the defining

features of cyberspace (Smith and Kollock, 1999) by providing important infrastructural support for cyber activities. The evolution of cyberspace has resulted in an increasing number of applications in order to support research, development, and decision making (Smith and Kollock, 1999) and improved the rate of sharing of information from traditional mail-based time frames to Internet based to real-time speeds associated with mobile devices (Murthy and Manimaran, 2001) such as Location Based Services (LBS), (Kupper, 2005). A vast number of functions have been developed just to revolutionise the way of conducting daily tasks.

GIS desktop tools and applications have enabled users to view and analyze spatial data in its proper format. With the evolution of GIS, the sophistication of these analytical tools has increased tremendously, thereby increasing the cost and time required to understand and use these tools efficiently. Additionally, most end-users today are interested in the interpretation of the final results in its final format or through visual representation.

When the first web site with internet mapping based on ESRI technology started, they had relatively primitive interfaces. Simple HTML based forms without any JavaScript or DHTML was there to enable nifty features like dragging the map to pan. Some didn't even allow for any kind of direct map interaction, but rather used an address search function to centre the map and zoom it about that point (Holmstrand, 2005). Then as the browsers evolved, the web mapping interfaces also evolved, at least those one which focused primarily on GIS. Web GIS provides GIS users, an easy access to geographic information data, spatial information, GIS modelling and processing tools. It provides an open and distributed architecture for disseminating geospatial data and web processing tools on the internet. This makes it easier for large organizations to distribute maps and tools without time and cost restrictions to end user. Lots of study demonstrated the use of web GIS to improve decision making (Chandra and Jain, 2013; Kunapo et al. 2005; Sugumaran et al. 2000, 2004).

The expected usage of Geo-Information (GI) as a tool to assist in the provision of more effective solutions to the diverse problems of the information society can only be achieved, if GI is made more readily available for sharing and reuse. The GEO-Portal will present information from the diverse sources in a unified way, by providing a consistent

look and feel in terms of access controls for multiple applications. All relevant applications will share information through this common portal, thereby streamlining communication between various types of users. More specifically, a Geo-portal may be defined as," an Internet or intranet entry point with the tools for retrieving metadata, searching for GI, visualising GI, downloading GI, disseminating GI and in some cases the ordering of GI services (i.e., facilitating GI commerce) (Maguire and Longley, 2005; Tait, 2005; and Fisher, 2006)".

The Geo-portal achieves this goal, by linking the GI oriented websites and the databases. These websites can be local, regional, national, niche markets, and can be owned either publicly or privately.

1.3 THE TECHNOLOGY OF THE GEO-PORTALS: DISTRIBUTED GIS

Distributed GIS can be defined as, "GIS technology combined with the distributed computing technology and the standards of the Internet ".

The word distributed in terms such as "distributed system", referred to computer networks where, individual computers are physically distributed within some geographical area. The terms are nowadays used in a much wider sense, even referring to independent processes that run on the same physical computer and interact with each other by passing the messages on and on.

As a new development based on GIS and distributed computing, Distributed GIS (DGIS) was introduced and propelled by both, the demands for GIS in a distributed environment and the advancements of computing technologies. Increasing demand for the new geospatial applications presents new challenges for DGIS, and the solution to overcome the challenges in turn leads to the advancement of DGIS.

Distributed systems offer many benefits over centralized systems, like *Scalability* and *Redundancy*. Scalability means the system can easily be expanded by adding more machines as per the need. Redundancy says that several machines can provide the same services, so if one is unavailable, work is never disturbed or stopped. Additionally, because many smaller machines can be used, this redundancy is not needed to be prohibitively expensive.

As the integration of geospatial data, geospatial tool and distributed computing technologies, Distributed GIS computing can overcome the challenges, such as real-time

data collection and updating, real-time information dissemination, distributed information access, distributed processing services access.

Distributed computing has provided the foundational standards and technology on which, the internet and Distributed GIS are built. The internet consists of information technology standards, such as, Transmission Control Protocol/Internet Protocol (TCP/IP), Hyper Text Transport Protocol (HTTP), Hyper Text Markup Language (HTML), and eXtensible Mark-up Language (XML) as well as software, physical computing, and network infrastructure.

What is Distributed GIS?

- An integrated Client/Server Computer System.
- A Web-based interactive system.
- A distributed and dynamic system.
- A cross-platform and interoperable.

Basic components of Distributed GIS --

- The Client
  – Place for users to interact with spatial objects and analysis in Internet GIS.
  – Relies on the Web and Web add-ons
- Web Server and Application Server
  – HTTP server
  – Major function is to respond to request from browsers.
- Map Server
  – Major workhorse component that fulfils spatial queries, conducts spatial analysis and generates and delivers maps to the client bases on the user's request.

- Data Server
  – Spatial and non-spatial in a relational or non-relational database structure.
  – SQL server

Distributed GIS is simply a GIS technology that has been built and deployed using the standards and software of the internet. The great benefit of the Distributed GIS is that, many GI Systems can be linked and accessed, as a single virtual system. A key challenge for Distributed GIS is the publishing of geographic content. The publishing process takes place in two steps—

- Preparing the content and functionality to be accessed, and
- Presenting the content through the discovered application– 'Geo-Portal'.

Geoportal applications present to user, with the ability to search or browse for capabilities and content which are either used in the discovered application itself or in other applications such as a desktop GIS.

A Geoportal is implemented using three distributed GIS (SOA) components:

- A web site presents the geographic application or portal;
- Web services publish geographic functionality as a web service; and
- Data management software provides a managed relational environment for both raster and vector geographic content.

Figure 1.1 identifies the various components of a Geoportal, their relationships with one another, the enabling technologies and standards with which these are implemented, and finally the key functions implemented in a distributed GIS and used by a Geo-portal application. A geographic web site is developed and deployed using standard web development tools, and is comprised of two elements. The web site framework and the functional tools. 'The web site framework', presents the Geoportals which supports information via a graphical user interface to the user. The second element is 'the functional tools' that enable access to GIS functions such as geocoding, gazetteer linkage, and mapping and query functions. These tools do not implant the functionality they are presenting, but rather serve as a proxy to functionality which runs as geographic web services.

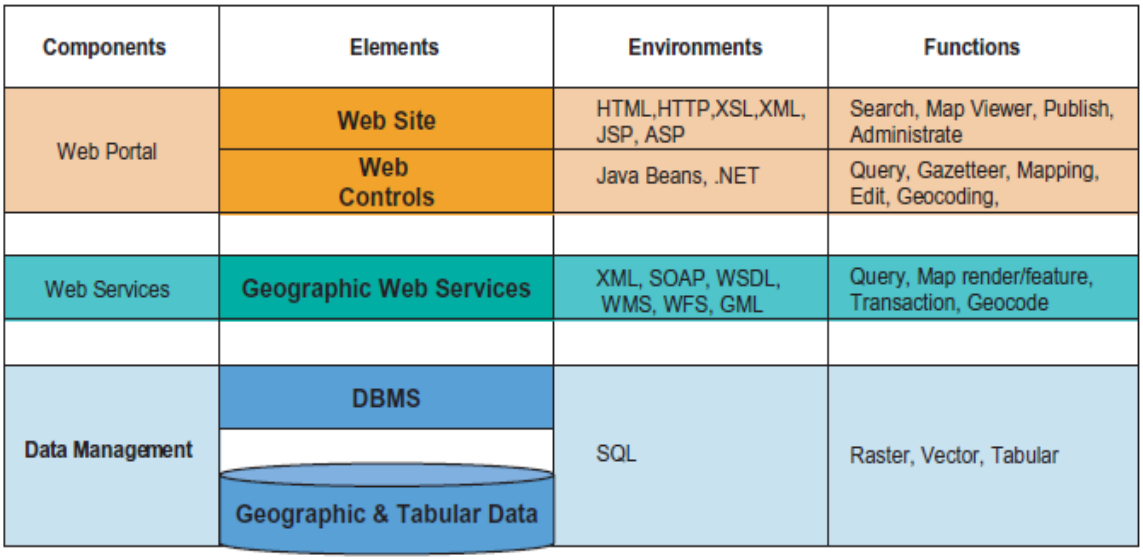

Figure 1.1: Components of a Geoportal

- **Components:** Identifies the three major components in Distributed GIS / Geoportal architecture.
  i. Web Portal
  ii. Web Service
  iii. Data Management
- **Elements:** Defines the functional elements of each component in Distributed GIS / Geoportal architecture.
  i. Web Site
  ii. Web Controls
  iii. Geographic Web Services
  iv. DBMS
- **Environment:** Refers to the information technology standards that are, used to implement each element of the architecture (Hyper Text Markup Language, HyperText Transfer Protocol, eXentsible Markup Language, XML Style Sheets, JAVA Server Pages, ActiveX Server Pages, .NET Microsoft's web services technology, Simple Object Access Protocol, Web Services Description Language, Web Map Service, Web Feature Service, Geographic Markup Language, and Standard Query Language)

- **Functions:** Identifies the specific capabilities implemented in each element of the architecture. For e.g. Search, Map viewer, Publish, Map renders, Map feature, Geocode, Raster, Vector and Tabular etc.

1.4 LIMITATION OF THE EXISTING GEOPORTALS

- The output which is given by the existing Geoportal is not in the form of particular user requirement.
- In all studies they create and maintain their own individual database.
- In all cases processing cost is very high (digitization, data volume etc.).
- Real time data and spatial information are not available simultaneously in existing Geo-portals.

1.5 PROBLEM STATEMENT

- To reduce the data dependency of Geoportal for the services provided by any research institute or center.
- Remove the burden of regular updating of data for providing updated information to the needed user.
- To avoid duplication of data, hardware and software premises.
- Increase the capabilities of existing web data.
- Improve Decision making.

1.6 OBJECTIVE OF THIS STUDY

- To design and implement an EGPS which can effectively use the distributed data from diverse sources already present on the web.
- The system should be able to use real time authorized third party data to develop required services using their database.
- To provide the real time information of desired places to the needed user with the help of Web GIS.
- To provide the information of desired place and also create its unified visual representation on the map so that one can easily and precisely understand the exact position of the required place as unified view associates attribute information.

- To do Real Time Georeferencing of the images obtained from the service provider like Google etc.
- To develop an approach to generate a Real Time Digital Elevation Model on the data obtained from the service provider like Google etc.

1.7 EXPERT GEOPORTAL SYSTEM (EGPS)

There is an enormous amount of spatial and non-spatial data present on the web and with the rapid growth of the internet it is also increasing rapidly. There is a need to create new content by reusing and integrating existing contents from diverse sources instead of creating an entire from scratch because it not only needs money, human effort and time but, also unnecessarily increases repetition of data onto the web. Now it becomes a hot topic from both research and commercial point of view, that's how to get more and more advantages from existing resources on the web.

Geoportal is basically a web site that presents an entry point to geographic content on the web or, more simply, a website where geographic content can be discovered. But when this entry point is developed with the most advance web technology like web Mash up, it is redefined with the word Expert Geoportal System or EGPS.

The present study provides a Geoportal solution by creating a web mashup application known as Expert Geoportal System (EGPS) after getting the idea from mashup technology, spreadsheet, Google API's etc. in .Net framework. It is a type of Geoportal in which results getting from one website or web application became the input for other e.g. user executes query by selecting spatial (city), or temporal attribute in third party web application and uses its results (either in the form of text or image) for decision making in the client application to achieve the final result automatically. It uses front end data or publicly accessible web service of third party website or web application by accessing their public database in real time to accomplish its objective.

Apart from it for providing the basic functionality of GIS like Georeferencing and DEM File which need lots of effort, money and training in enterprise software (like Arc GIS, Geomedia etc.). It uses freely available services of Google API's by enhancing its

capability, after capturing its image and processed with the help of open source GIS library (like GDAL) in real time.

1.7.1 Overview of the complete EGPS

To understand the complete EGPS just in a single eye, an overview life cycle is shown in Figure 1.2. With this life cycle one can quickly figure out the different input parameters, building blocks, services, processing details and finally what are the different results, the system is about to generate.

The application life cycle is basically the following as shown in Figure 1.2 above:

- The client passes the URL of the HTML web page that is hosted in this website (www.expertgeoportalsystem.com) on the web browser.
- The web page requested is loaded in the web browser. The page "onload" event calls the initialize() JavaScript function which initializes the Google Maps API and pass map start point parameters to the Google Maps Server.
- Google Maps servers receive the parameters sent by the Google Maps API and use that info to build the map for the initial location.
- The client passes the URL of the HTML web page that is hosted in the third party web site on the interface provided to third party website. The client application used JavaScript, Asp.net and Macro Programming (Web Query) for interacting with third party website and get front end non spatial data or images present on web page. Further processing is done in client application to use this data in more valuable form that is needed for better decision making.

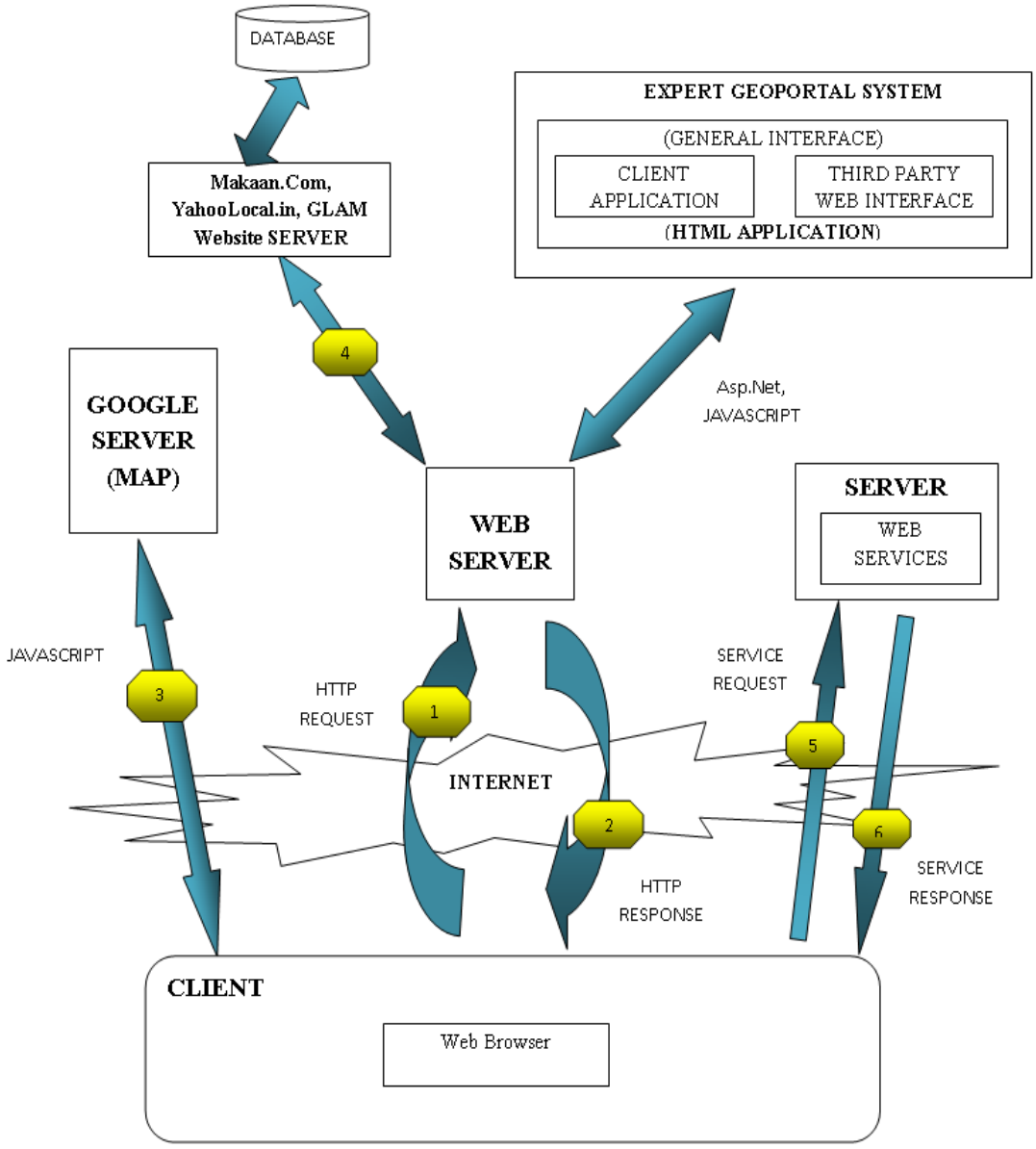

Figure 1.2 Expert Geoportal System Life Cycle

1.8 OUTLINE OF THE THESIS

Subsequent chapters are organised as follows:

Chapter 1 is the introductory chapter which introduces the background problem, and the motivation behind the thesis. It also discusses briefly the literature, the need of the study, the research objectives and the outline of the thesis.

Chapter 2 covers review about the evolution of geoportals with a brief discussion of its classification, spatial data infrastructure, common geoportal architecture and review of some existing Geoportals.

Chapter 3 gives details about various sources of data used for the present research work. The chapter also describes the technology used for this study.

Chapter 4 describes the architecture and methodology used for developing Expert Geoportal System.

Chapter 5 highlights the services provided by EGPS system. The chapter also presents system flow chart for each service which gives a direct look about the flow of the system.

Chapter 6 presents results and discussions of services provided by the developed system.

Chapter 7 concludes the thesis with main conclusions and suggest some possible areas for further research work.

Chapter 2
LITERATURE REVIEW

2.1 EVOLUTION OF GEOPORTALS

We live in an information era, known as the computer age. Information is freely exchanged and knowledge is easily accessed through our fingertips. Geographic Information in particular is one of the most critical elements underpinning decision-making for many disciplines (Clinton, 1994; Gore, 1998; Longley et al., 1999; Williamson et al., 2003; Morales, 2004) like, Environment (Dispersion Modeling (Behera et al. (2011)), Infrastructure (micro level planning (Bariar et al. (2004)). In the past we used maps to show where people and assets were located. This has now evolved (advanced) into a complex digital environment with sophisticated technology.

Over the few years, many governments and private sectors have invested tens of billions of Euros in the development of geographic information, largely to serve specific communities (forestry, agriculture, urban/rural planning, land records management, military, security service, health care, development aid, emergency services, retail, etc.), within a local, national, international and even global framework (Groot and McLaughlin, 2000). It is estimated that an expenditure of approximately $10 billion for the US SDI and $2 billion for the SDI of UK (Rhind 2000). Worldwide around €120 million each year is spent just on the management of online portals at national level providing access to Geo-information (Crompvoets, 2006) At present, the focus is increasingly shifting to the challenges associated with integrating broadly sourced geographic information, so as to create a manageable framework. This has led to the creation of Spatial Data Infrastructure (SDI).

Spatial Data Infrastructures (SDI) is a collection of technologies, policies and frameworks for facilitating the availability and accessibility geographic data. SDI Cookbook, (2009) stated that it is a basis for spatial data discovery, evaluation and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general. It is therefore meant to provide mechanisms for the discovery, retrieval, evaluation and application of geographic data. In

addition to reduced data collection costs, an SDI is essential for providing affordable, timely and effective public services. It facilitates and coordinates the exchange and sharing of spatial data (at a local, national and international level) between stakeholders in the spatial data community. With this objective in mind, countries throughout the world are developing SDI to manage and utilise their spatial data assets more efficiently. This community includes mainly mapping agencies, universities, governmental and non-governmental organisations, and both public and private institutions (Crompvoets, 2006).

According to Williamson et al., (2003) an SDI consists of three key components that link the user (people) to the data: the access network, the policies, and standards. The core components of Spatial Data Infrastructure (SDI) are given as (Rajabifard et al., 2002) -

- Policies & Institutional Arrangements (governance, data privacy & security, data sharing, cost recovery)
- People (training, professional development, cooperation, outreach)
- Data (digital base map, thematic, statistical, place names)
- Technology (hardware, software, networks, databases, technical implementation plans)

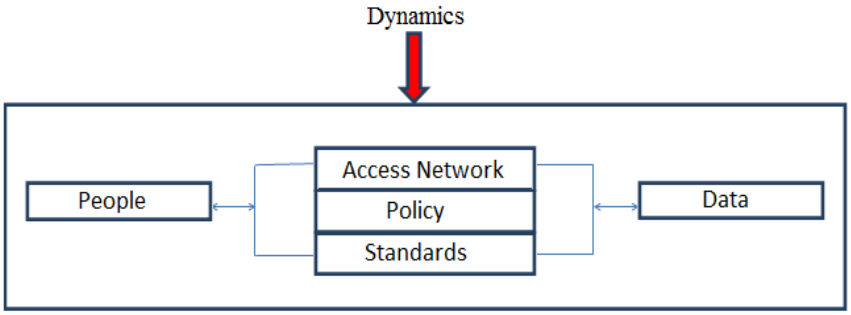

Figure 2.1: Nature of and Relations between SDI- Components (Adapted from Rajabifard et al., 2002)

The access network shown in Figure 2.1 above is like a clearinghouse which is defined later in this chapter. The nature of both categories is very dynamic due to the changes occurring in communities (people) and their needs, as well as their ongoing requirement for different sets of data.

Over the past few years, many countries have spent considerable resources on creating their own National SDI (NSDI). According to Masser (2005): National SDIs have three common characteristics, they are explicitly national in nature, refer either to geographic information or spatial data, imply the existence of some form of coordinating mechanism for policy formulation and implementation purposes.

One of the key feature of a national SDI is the national spatial data clearinghouse (Clinton, 1994; FGDC, 1997; Coleman and McLaughlin, 1998; Onsrud, 1998; AUSLIG, 2001; Crompvoets and Bregt, 2003). A spatial data clearinghouse can be stated as an electronic facility for searching, viewing, transferring, ordering, advertising and/or disseminating spatial data from numerous sources via the Internet. Such a facility usually consists of a number of servers, which contain information (metadata) about available digital data (Crompvoets, 2002; Crompvoets and Bregt, 2003). It provides complementary services and improves the exchange and sharing of spatial data between suppliers and users.

The purpose for producing a clearinghouse is that when users are looking for spatial data (or services), it is desirable to have a single source for accessing (retreiving) all the available resources. A spatial data clearinghouse is a system to provide this capability serving as a central point for sharing data among data producers and users (Phillips 1998; Noori-Bushehri and Rajabifard, 2001; Rajabifard, 2002).

To make a clearinghouse as the access network operational within an SDI, it has to be strongly linked to the other SDI-components: people, data, policy and (technical) standards (Rajabifard and Williamson, 2001). A clearinghouse can only be achieved within an SDI when there is a strong interrelation between these components. The use, management and supply of data and the content, and/or quality of this data determine its success subject to the quality of the standards, response time of the clearinghouse and legal/economic policy.

The idea of a clearinghouse initiates from the financial world with respect to the monetary transactions between banks, the clearinghouse keeps the data on mutual indebted amounts. At the end of each day, banks are informed about the final amounts to be transferred between banks. Each day there is a clearing between them (Bogearts et al.,

1997). In 1773, the first clearinghouse was established which was the London Banker's Clearinghouse.

In 1994, the US Federal Geographic Data Committee (FGDC) established the National Geospatial Data Clearinghouse. Its aimed to facilitate efficient access to the overwhelming quantity of spatial data (from federal agencies) and coordinate its exchange, with the objective of minimizing duplication (in the collection of expensive spatial data) and assisting partnerships where common needs exist (Rhind, 1999; FGDC, 2000; Crompvoets et al., 2004).

The average cost of a spatial data clearinghouse (including some services) is around € 1 500 000 a year which is spent in management and coordination costs, GIS and Internet application development, training, hardware, network server, standardisation activities, legal environment creation and metadata preparation (INSPIRE Architecture and Standards working group, 2002).

83 national clearinghouses were established on the Internet, in April, 2005 . Some examples of national clearinghouses are: MIDAS (Meta Informacni Databazovy System), Czech Republic; geodata-info.dk, Denmark; India NSDI Portal, India; Spatial Data Catalogue, Malawi; Russian GIS Resources, Russia; Geocat.ch, Switzerland; and the Clearinghouse Nacional de Datos Geograficos del Uruguay, Uruguay. These share the same objective, that of discovering and accessing spatial data, through the available metadata (Crompvoets).

A geoportal for geoinformation (computerized geographical information) focuses on the facilitation of geoinformation discovery, access of data and related services (Crompvoets, 2006). It can be seen as a one-stop shop for geoinformation (Crompvoets et al., 2004). Through the provision of a one-stop-shop, significant cost reductions related to searching, assessing and accessing geo-information can be achieved (see Groot and Sharifi, 1994; Askew et al., 2005; Maguire and Longley, 2005; Beaumont et al., 2005).

The importance of geoportals in SDIs can be assessed if we consider the geoportals as the medium through which the users access the available information. We can imagine them as shopping malls (Crompvoets, 2006) in which spatial data from government agencies and private bodies are offered in a complete way so as the user does not have to visit different "shops". As a result, geoportals have to be complete systems that will not only

offer information but will also the ways the user could use them in an efficient way. Their aim is to significantly reduce the time necessary to find, access and assess data. A geoportal may also facilitate the exchange of data between public authorities, companies, commercial and professional users by clarifying the transaction conditions. However, little is known about the user, his/her experiences related to geoportals and time saved when using these services. So far, the assessment of geoportals has mainly focused on the supplier or geoportal coordinator sides (Crompvoets, 2006; Crompvoets, 2007).

2.2 GEOPORTALS AND ITS CLASSIFICATION

In August 1991, Tim Berners-Lee published the first website, a simple, text-based page with a few links. Since then, as designers and developer have been experimenting with the way this technology work and look, the Web is in the process of reinventing itself and few decades earlier with the introduction of 'Web Portals' there is a change that may prove to be more far-reaching than any other change to hit the Web and it will change the fundamental way that people are using this.

The word portal stems from the Latin word "portal" and indicates an entrance point Annoni et al., 2004). Portals are not a fad or a new name for something that we've been doing all along. They projected the vision that turns the Web from an institution-centric repository of information and applications to a dynamic user-centric collection of everything useful to a particular person in a particular role. Instead of a single home page that proclaims identically to all who visit how grand the institution is, portals will give nearly every user a customized, personalizable, unique web page.

Considerable changes in both expectations and capabilities have taken place since GIS's birth in the late 1960s. Initially, only Desktop tools and applications have enabled users to view and analyze spatial data in its proper format but with the evolution, this technology has led to a new phase of growth for the industry that focuses on the dissemination of geographic knowledge and capabilities. Over the last six years the GIS community has become increasingly focused on the dissemination of GIS capabilities within, as well as outside of, organizations. There is recognition within the community that the web provides a new medium for participation.

Web GIS provides GIS users easy access to geographic information data, spatial information and GIS modelling and processing tools. It provides an open and distributed

architecture for disseminating geospatial data and web processing tools on the internet. This makes it easier for larger organizations to distribute maps and tools without the time and cost restrictions to the end user (Alesheikh et al., 2002).

As here prime concentration is on the web-Based GIS so present study starts categorising all web Portals in to two prime categories of GEO Portals and Non-GIS Portals. The GEO Portal will, through its single World Wide Web gateway, be an organize interface for searching and accessing the authoritative Geospatial Information and associated Geographic Services (such as display, editing, analysis, etc.) that not only serve the users by means of a simple single web-based application but also provide a package of applications which allows to work with maps in web environment based on standard web services. Again Geo-Portals can classify into three main groups, namely catalogue, application (Maguire and Longley, 2005) and enterprise Geoportals. Catalogue Geoportals create and maintain indexes of descriptive information about available geographic information resources. They offer a web-based interface that allows users to query the indexes remotely. They are therefore primarily intended for data discovery and are generally targeted towards wide audiences. Application Geoportals combine geographic information services to provide advanced GIS functions for addressing specific tasks. Enterprise GeoPortal provides the web-mapping, location and interface services for all GeoSuite enterprise solutions (Tang and Selwood, 2005). Enterprise GeoPortal supports cross-platform integration and the rapid assembly of web-based user interfaces, allowing an enterprise to deploy valuable business applications more quickly and at lower cost (Hobona, 2006).

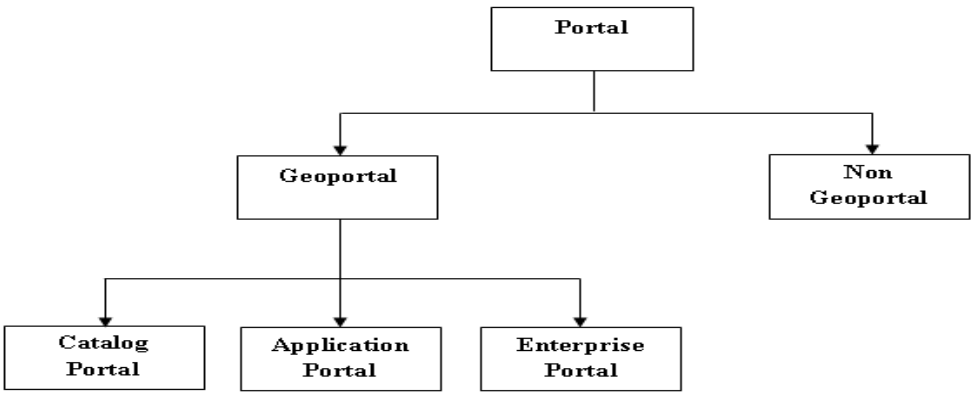

Figure 2.2: A classification of Geoportals.
(Source: The emergence of geoportals and their role in SDI, David J. Maguire et. al , 2004)

2.3 SOME EXISTING GEOPORTALS

Geo-portals offers the user a broad array of information, arranged in a way that is most convenient for them to access. The Geo-portals can be differentiated on the basis of their content and intended group of users. There are a different types of Geo-portals, that are often categorized as follows:

2.3.1 Theme Geoportals

In addition to national mapping agency a country have numerous other administrative bodies that focus on the management and monitoring of specific thematic domains, like Agriculture, Education, Hospitals, Emergency Services, Transportation, Weather, Road Networks, Cadastre, Waterways, Land Occupation, Natural Resources, etc. Moreover, numerous private and public industries also have own geospatial datasets that are vital for their activity: telecom operators, gas and electricity companies, transport and logistics companies, etc. These organizations have an official mandate or simply a crucial need to make their data available to private or public users, individuals or organizations so by means of Thematic Geo-Portals they provides an easy-to-use interface for the different level of users to discover and access most current, best quality resources available regarding a specified thematic domain.

2.3.2 International Geoportals

International or Global Geo-Portals support are the central web Portals of various international Societies, Unions, Industries, Scientific & Environmental Organizations that allow the interested persons or communities to access data and reports about their various project that have their impact throughout the globe. Thus the prime focus of this portal is worldwide data sharing and discovery.

2.3.3 The National Geoportals

The National Geoportal (NG) allows the visualization and use of National maps that have been produced following an agreement between the state and regions about the reference cartographic system dated 12th October 2000.

The strategic aim of the NG is to promote and divulge the use of the Informative Territorial Systems, allowing access to environmental information concerning the territory

to a widespread public, including non-experts, taking into consideration all the projects and activities that are now in corse on a National and European level (National Geoportal, 2013).

2.4 COMMON GEOPORTAL ARCHITECTURE

The most common architecture used by Geoportal is a service oriented architecture, in this architecture one is a service provider and the other is service consumer (Hobana, 2006). Service provider creates and use their geographic and non geographic database to provide different functionalities to the service consumers (to provide diverse functionalities different government and private agencies use their database and publish their services for general public use). Geoportal work as an interface to interact with these diverse services by following the standards of third party service provider. Service oriented architecture has many benefits as it allows the integrated used of components for different vendors. The publisher has a full right to its data services so they can impose their own security constraints; data are interoperable with several GIS etc.

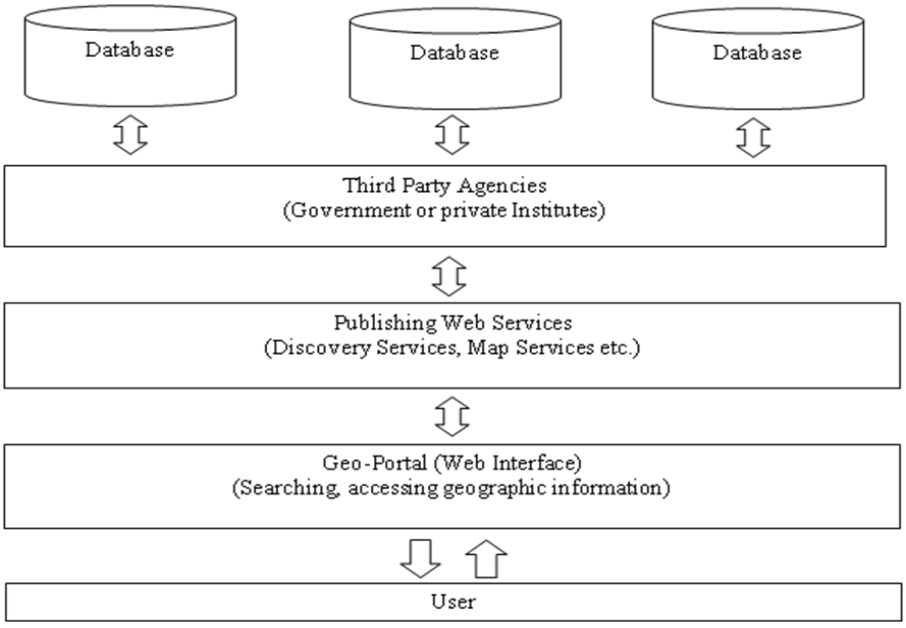

Figure 2.3: Service-based framework for Geoportals (Adapted from Rose, 2004)

The architecture shown in Figure 2.3 is divided into different tiers, the top most tier shown in it consist of third party agencies (government and private agencies) which can create and managed their geographic and non geographic database for general public uses. Geographic database includes data referenced to the locations of earth, for example, draught, weather, flood etc., Non Geographic database includes attribute data, for example, river

name, point id etc.. Middle tier consist of a series of services (discovery services, map services). It offers functionality for accessing, querying and retrieving information from the data repositories and presenting it to the user. Bottom tier consists of web interfaces (Geoportal) to interact with different types of services for providing facilities like searching, accessing geographic information, viewing data and other contents etc. An architecture shown in Figure 2.4 is a more techno- centric it will show three tier architecture in a more technical way, it clearly identifies the services and functions provided by each tier.

Table 2.1: A techno-centric view of a Geoportal architecture (adapted from Tait, 2005)

Components	Environments	Functions
DBMS	SQL	Raster, Vector, Tabular
Geographic Web Services	XML, SOAP, WSDL, WMS, WFS, GML	Query, Map renders/feature, Transaction, Geocode
Web Portal	HTML, HTTP, XSL, XML, JSP, ASP, JAVA BEANS, .NET	Search, Map Viewer, Publish, Administrative Query, Gazetteer, Mapping, Edit, Geocoding

2.5 REVIEWS OF SOME EXISTING GEOPORTALS

Table 2.2 shows a list of some existing Geo-portals with their data sources and associated services, it is clearly visible from the table, for providing diverse services, Geo-portals use the shared diverse spatial data provided by different agencies, that need a costly and specific investment by these agencies, if these agencies deny or unable to provide services it may direct affect the future of Geo-portals (ESRI, 2010; Oana et.al., 2010; Chandra et.al., 2013(a,b); Gershenzon and Ash, 2008).

Table 2.2: Some Existing Geoportals and their Data Dependency for Specific Services

Name	Data Sources	Services
Croatia Multipurpose Spatial Information System Geoportal	Governmental bodies and Private sector	Searching, ordering using Geospatial data etc
Lithuanian Geographical Information Infrastructure	10 government institutions and State-owned enterprises	Searching, Ordering etc.
Romanian INIS Geoportal	Centre for Geodesy, Cartography, Photogrammetry and Remote Sensing	Discover and select Geospatial information resources.
Kosmosnimki Geoportal	Earth Remote Sensing Data	Searching, Ordering etc.

Bhuvan (Indian Geoportal)	Earth Remote Sensing Data	Download data, Thematic services
Karnataka Geoportal	Spatial data generated by various state agencies.	Searching, Data Discovery etc.

2.5.1 Croatia Multipurpose Spatial Information System

This Geoportal (www.geo-portal.hr) is launched by the State Geodetic Administration (SGA) of the republic of Croatia for providing diverse Geospatial services (Searching, Ordering etc.). It works on the INSPIRE (Infrastructure for Spatial Information in the European Community) directive by using the technology provided by ESRI. The Geoportal launched by Croatia Multipurpose Spatial Information System is a key component of effective use of Government and Private Sector Spatial database.

The major functionalities of the Croatia Multipurpose Spatial Information System allow end users to:

- **Metadata Search: -** There are two levels of metadata search – one is a simple search, and the other is an expert search based on more specific fields.
- **Map Viewer: -** It is used to view the geographic content of the available services.
- **Authorization and Authentication: -** The Geo-portal authorization system is a role based system. Roles are groups of users which have different rights to some portal resources.

2.5.2 Lithuanian Geographical Information Infrastructure

LGII launched Geoportal (http://www.geoportal.lt) in April 2009 for public use by using the database of 10 most important government and state owned institute. LGII ensure the interoperability between these institutes by connecting them via centralized national metadata system and the national geographic data system based on a uniform reference data model and standards.

2.5.3 Romanian INIS Geoportal

This is the complex project completed by four important government institute of Romania i.e. the National Center for Geodesy, Cartography, Photogrammetry and Remote Sensing complaint with INSPIRE, for providing diverse Geospatial services like data discovery and exchange of geospatial data resources for the general public use.

The major functionalities of the Romanian INIS Geoportal (http://geoportal.ancpi.ro):

- User can discover and select Geospatial information resources according to their particular requirement.
- User can view live data or maps maintained on a web-accessible server.
- User can search and discover metadata records directly from a variety of external applications.
- User can publish their own Geospatial data to other users.
- Register as a portal user.

2.5.4 Kosmosnimki Geoportal

It is the Russian Geoportals Based on Earth Remote Sensing Data. The satellite images of it being prepared by the specialists of SCANEX R&D centre. For Kosmosnimki Geoportal (http:// kosmosnimki.ru) they developed their own new remote sensing data display technology by creating their own ground receiving station for providing operational updating of satellite imagery, and develop multiple modules to satisfy the requirements of the users.

2.5.5 Bhuvan (Indian Geoportal)

Indian Space Research organization (ISRO) launched Bhuvan (www.bhuvan.nrsc.gov.in) in 2009; it displays Indian Earth Observation capabilities in Multi- platform, Multi-sensor, and Multi- temporal domain. It is a browser based application which displays 2D/ 3D virtual globe. Its main emphasis is in Indian region. It displays satellite imagery of varying resolution of India's surface; enable users to visually view things like cities and vital places of interest either looking vertically down

or at an oblique angle. The level of resolution depends on the points of importance and popularity, but the majority of the Indian landscape is covered up to at least 6 metres of resolution.

According to the facilities provided by Bhuvan, its products are divided into three types Bhuvan 2D, Bhuvan 3D and pocket Bhuvan. Bhuvan 2D is an OpenLayer based web mapping service application, it offers powerful, user friendly mapping technology to organize the satellite and map data. Bhuvan 3D allows users to fly to diverse locations on the terrain and experience 3D navigations. Portal Bhuvan is a portable application which is used to access Earth browser through smart phones.

Services provided by Bhuvan:

- It allows users to browse, select and download satellite data.
- It allows users to browse, select and query thematic datasets through thematic services.
- User can add their own points of interest.
- Users can plot areas, view terrain profile, chart routes and overlay images.
- It is beneficial for academic purposes.
- To provide help to the users, different types of help document are also available,

2.5.6 Karnataka Geoportal

Karnataka Geoportal (http://www.karnatakageoportal.in) is the first State Geoportal launched in India. It is the Gateway for spatial data generated by various agencies in the state. It uses OGC/ ISO standards for making an interoperable system so that it can be accessible from a variety of GIS packages.

Services provided by Karnataka Geoportal.

- **Map viewer:** It displays state division and district boundaries. It contains different general mapping tools like zoom, pan, full view etc. User can also switch on and off layers according to its requirement. It also contains query modules to generate query for decision makings.
- **Product catalogue/metadata**: It permits the user to search the published web services in the Karnataka state spatial data infrastructure data repository.

- **Register Services:** It also permits users to register published web services of KSSDI repository, so user can access register services for viewing and querying.
- **Searching and Data Discovery:** User can search or discover data according to its requirement.

2.6 SUMMARY OF LITERATURE REVIEW

As far as all the Geo-portal created till now, provided the GIS functionality by using the data or services provided by the research institute or data centre from where they are collaborated thus there is an existing data dependency of these geo-portals on the institute and different data providing agencies. Spatio-temporal Data publication on geo-portal implemented through a complex service oriented architecture that needs a costly infrastructure, so as and when these institutes unable to share their data repository with the development agency, geo-portal will no longer be able to provide an updated data to the user. This detailed literature review concludes a need for the replacement of existing Geo-portal architecture so that the data dependency can be resolved and an independent concept of 'Expert Geo-Portal' builds on the top existing infrastructure.

Writing program to access own database is a common technology, but accessing data from a third party web portal in real time without entering into their central server requires technology to understand their framework, data storage etc. which comes under reverse engineering. Developed EGPS implement this technique (Reverse Engineering) and reduce this data dependency by providing a mashup solution which uses the data from diverse source already present on the web for fulfilling its objective.

Chapter 3

DATA AND TECHNOLOGY USED

3.1 INTRODUCTION

This chapter defines the diverse sources of data and technologies used by EGPS for providing different GIS functionalities. It demonstrates the data provided by the third party websites after passing the spatial or temporal attributes on the third party interface. Later on, in the chapter technologies used in designing and developing an EGPS system is defined. It also identifies the problem associated with the current technologies for providing desired solutions to the needed user.

3.2 DATA USED

For providing different GIS functionalities, instead of creating its own new database, EGPS uses publicly accessible data from diverse sources as shown in Figure 3.1 i.e.

- To provide location based services; it used front end data of Makaan.com and Yahoolocal.in web applications.
- To provide difference images, growth analysis and pattern analysis graph; it uses temporal NDVI images provided by Global Agriculture Monitoring (GLAM) Project website.
- To provide DEM and Georeferenced image; it used Google Earth by using its APIs and enhancing its capabilities.

- To provide local weather forecasting information; EGPS uses freely accessible web services provided by wunderground.com.

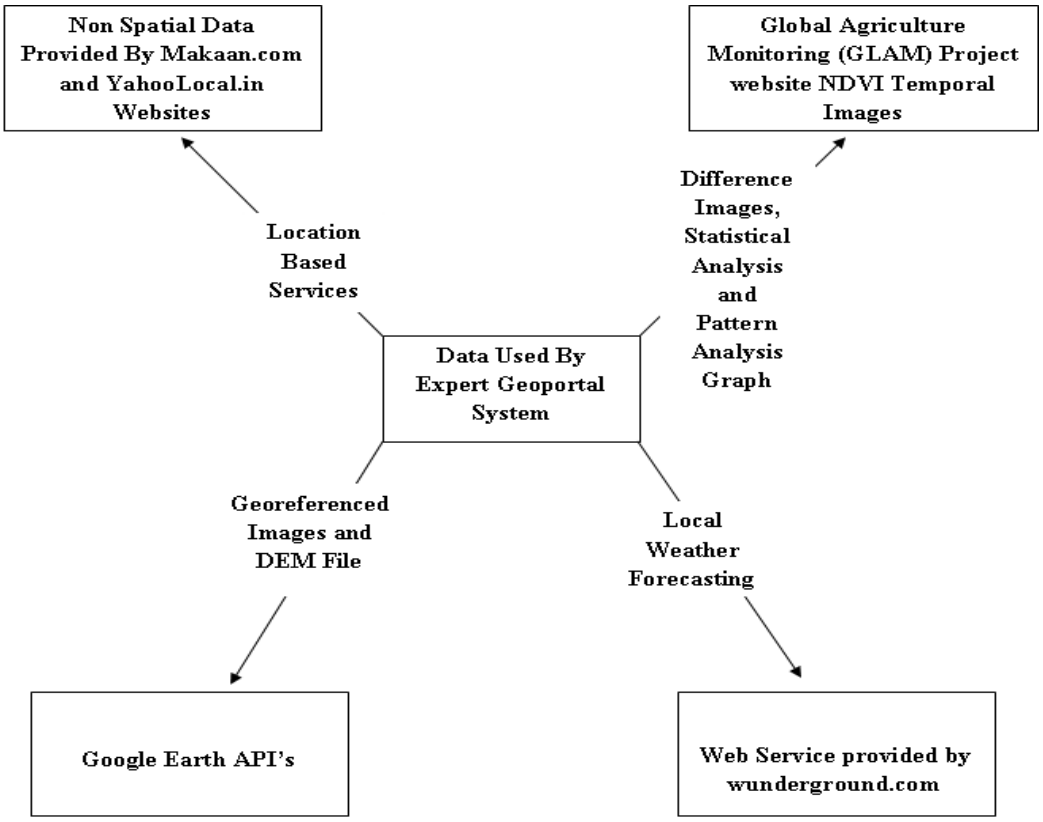

Figure 3.1: Data used by EGPS

3.2.1 Makaan.com

Makaan.com website was started with a mission to connect appropriate buyers and sellers of real estate properties. This website is dedicated to help its users make wise and profitable decisions relating to selling, renting, buying and leasing of properties in India and key global

geographies as stated by makaan.com. Even it also shows the location on a Google map, but one at a time and it is poor for decision making. Makaan.com arranged its front end data in a tabular form to provide user relevant information (Makaan.com, 2013).

3.2.1.1 Introduction

In makaan.com user can search property by passing attribute's value like city name, budget, minimum bedroom etc. as shown by **Different Options Available** box in Figure 3.2.

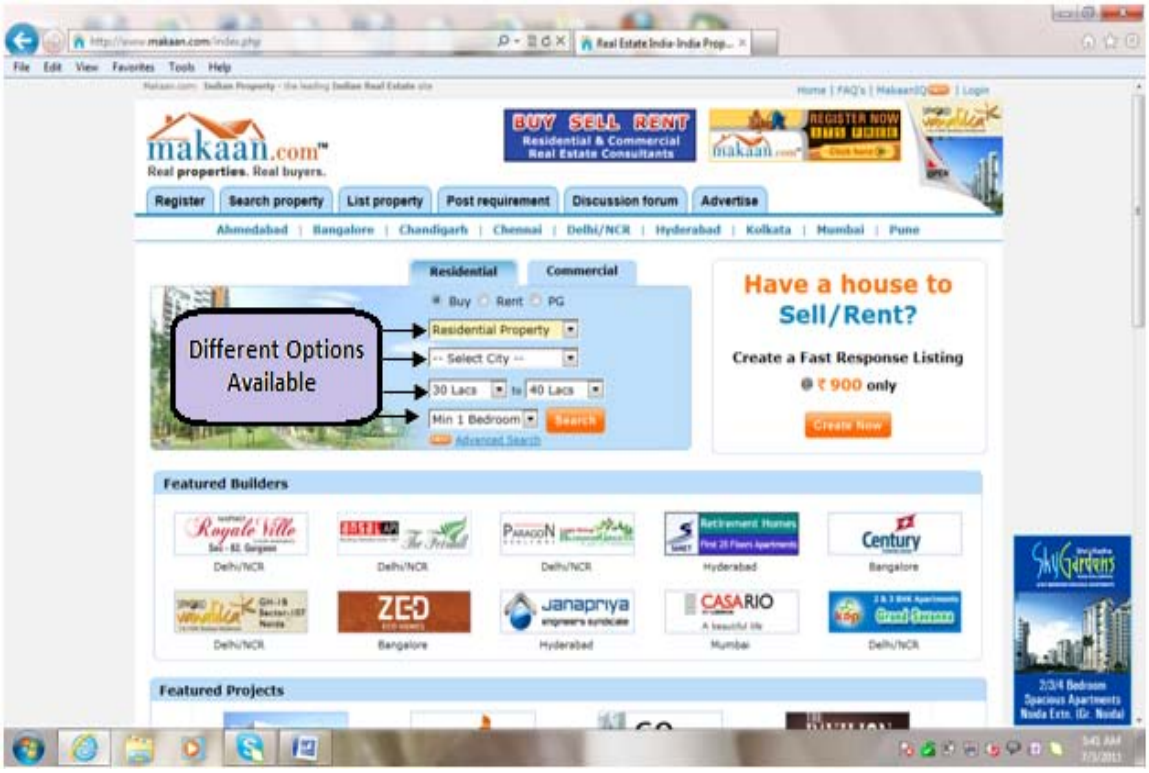

Figure 3.2: Makaan.com home page having option to pass attribute value according to user requirement

3.2.1.2 Non Spatial information provided by Makaan.com

On passing attributes (city name, budget etc.) makaan.com server will provide Real Estate property names with their address and other attribute values (cost, number of bedrooms etc.). User can use these informations for e.g. Independent/Builder floor for sale in Indirapuram, Ghaziabad provided by makaan.com to purchase properties as shown in Figure 3.3.

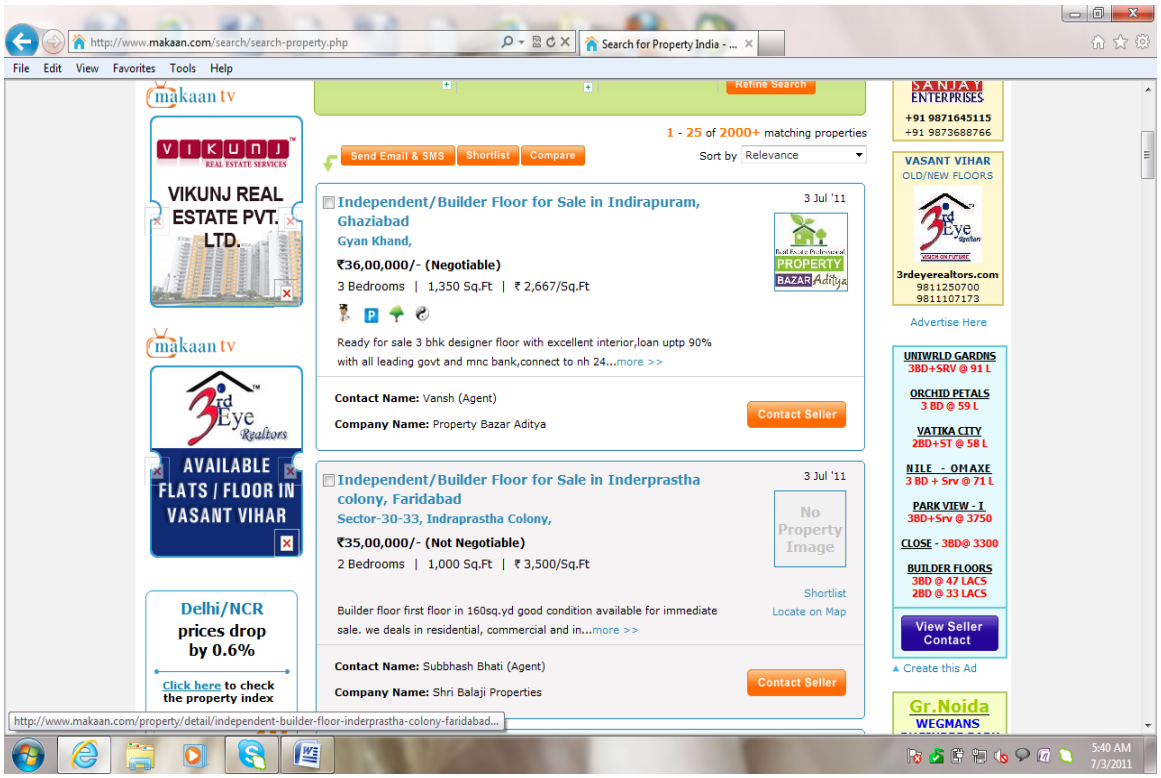

Figure 3.3: Makaan.com web page showing non spatial information according to attribute value passed by user

3.2.2 Yahoolocal.in

Yahoo India had launched a public beta version for its local search services. When it was running it covered sixteen cities (e.g. Bombay, Bangalore, Chennai, Delhi etc.) which helped users to search Restaurant, Pubs, Events, Movies, Reviews, Shopping Malls, Health Listings and more. Yahoo local queries contain not only information about "what" the site visitor is searching for (keywords like, the name of a consumer product or a business category) but also "where" information, such as a name of city, address of street and postal code. YahooLocal.in arranged its front end data with the help of div tag (i.e. not in tabular form) of HTML for providing user relevant information (Yahoolocal.in, 2012).

3.2.2.1 Introduction

In yahoolocal.in user can search restaurant, pubs etc. by selecting a city name first **[A]** and then narrowing their search by selecting option from category list **[D]** or by passing

attribute on a search boxes like Business **[B]** and locality of city **[C]** provided in a homepage of yahoolocal.in website as shown in Figure 3.4.

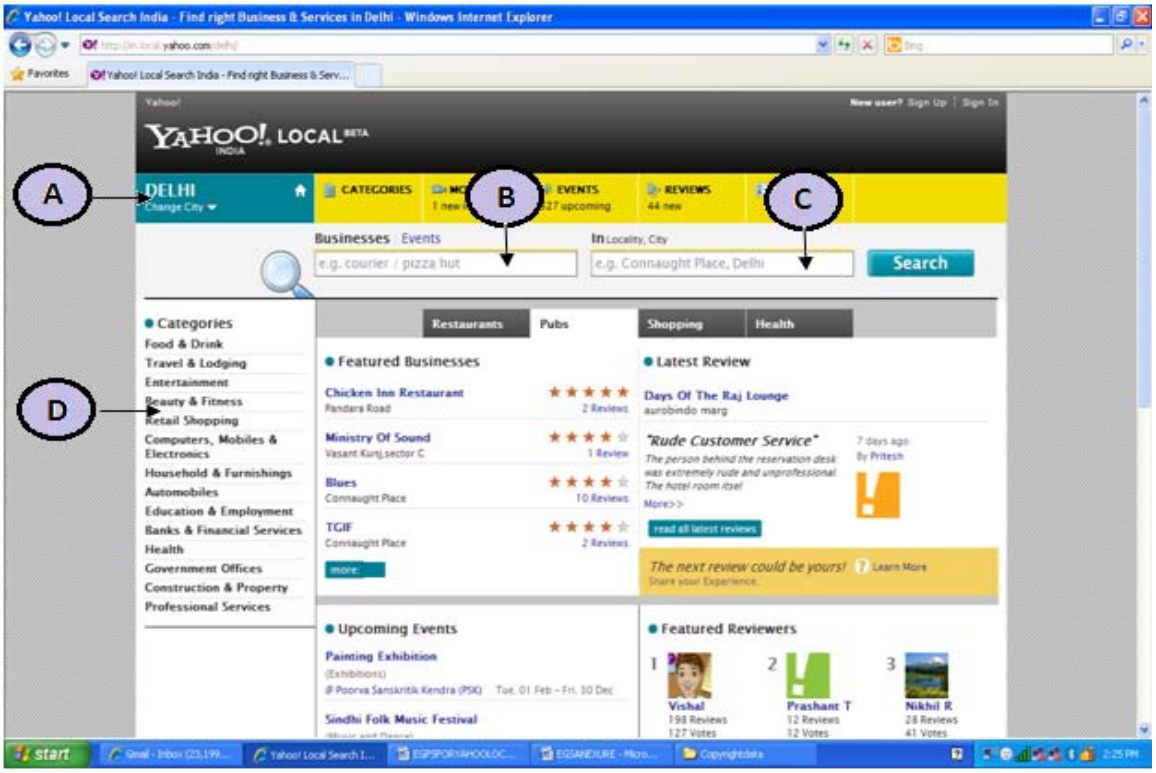

Figure 3.4: Yahoo local.in home page having the option to select city, category and passing attributes on a search box according to user need

3.2.2.2 Non Spatial information provided by Yahoolocal.in

After selecting a category or by passing attributes on search boxes yahoolocal.in server provides non-spatial information like Restaurant name, Hotel name etc. with its attribute's value (Phone number etc.) .User can use this non-spatial information (e.g. Pan Asian Restaurant) as shown in Figure 3.5 for making the best decision according to his/her requirement.

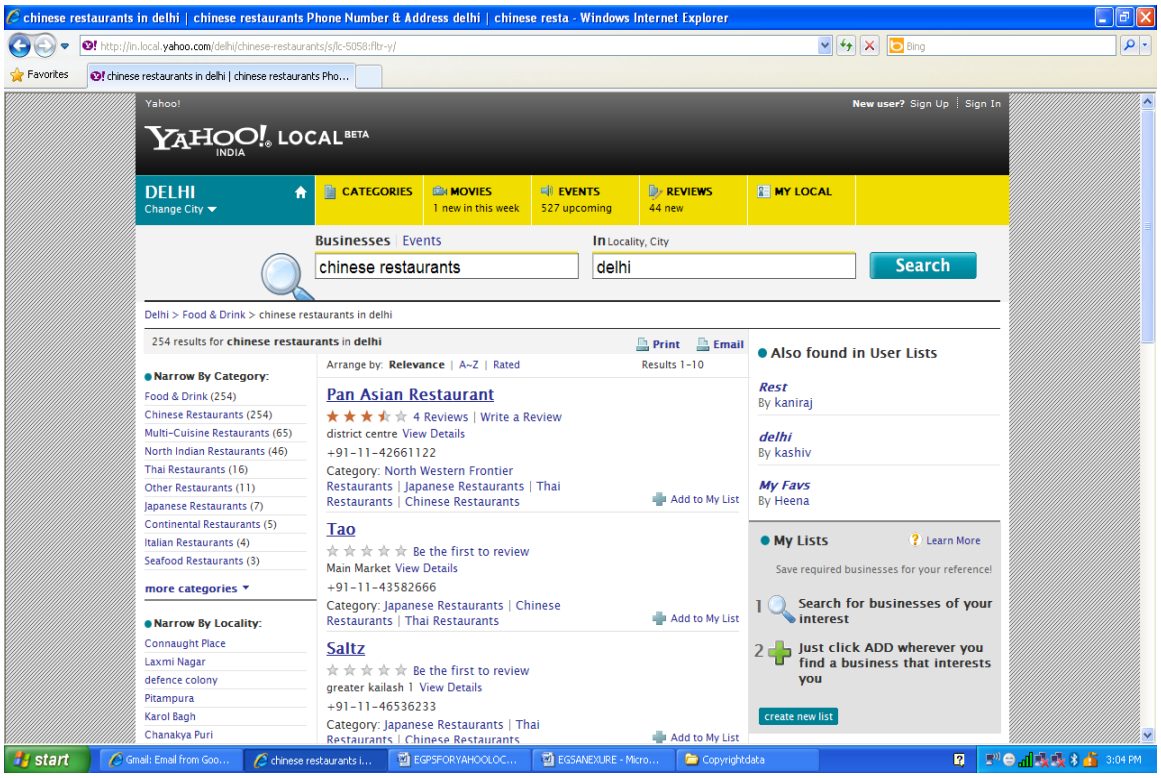

Figure 3.5: Yahoolocal.in web page showing non spatial information according to attribute value passed by user

3.2.3 GLAM Project Website

In this project a Global NDVI time-series database, with a spatial resolution of 250 meters has been assembled using a 16-day compositing period, allowing for inter-annual comparisons of growing season dynamics. This MODIS NDVI dataset is automatically reprojected and mosaicked to suit the Foreign Agricultural Service (FAS) region of interest. The time-series data are accessible to FAS analysts through a powerful web interface and analysis tool (GLAM, 2013).

3.2.3.1 Introduction

In this website user can search NDVI data from the year 2000 to 2012 of 8 or 16 days interval.

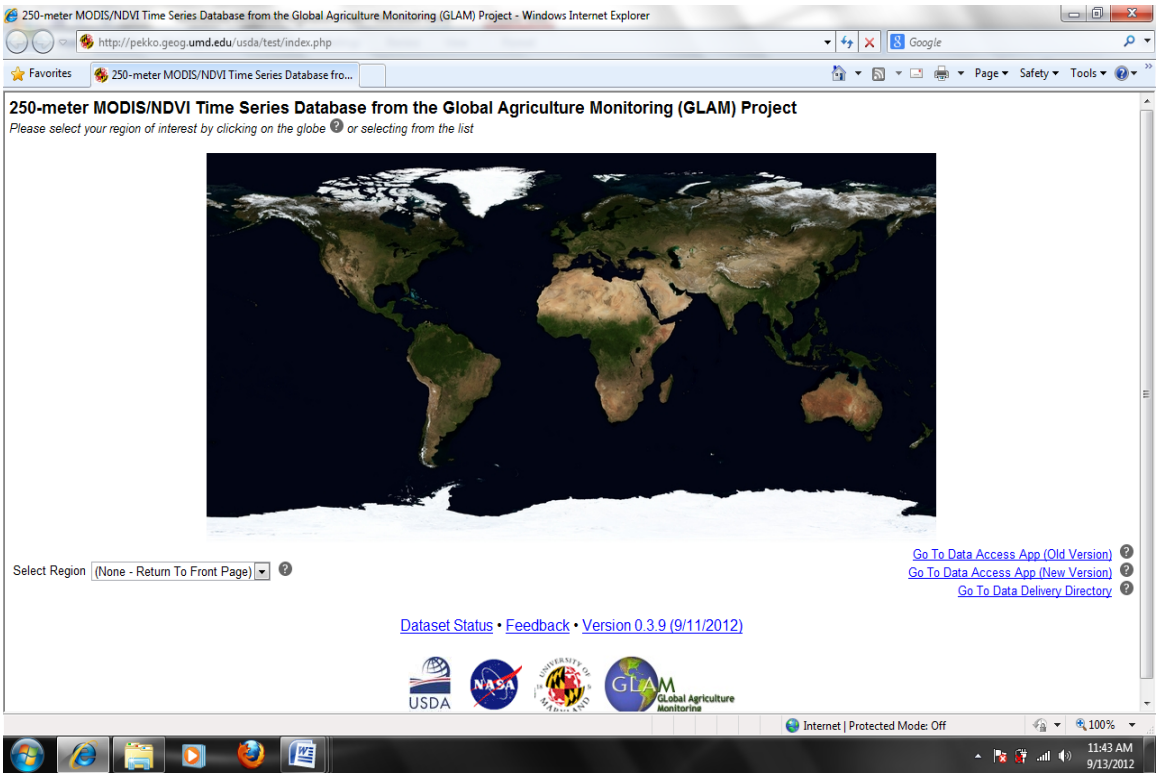

Figure 3.6: GLAM project website home page having the option to select a region.

3.2.3.2 Information provided by the GLAM Project Website

On selecting attribute like region **[A]**, product type **[B]**, data source **[C]** and regional image date **[D]**. Web server (GLAM Web server) provides regional image of 2.5 kilometer/ pixel from where user can select area according to its requirement and get detail image of 250 meter/pixel for decision making as shown in Figure 3.7 and Figure 3.8.

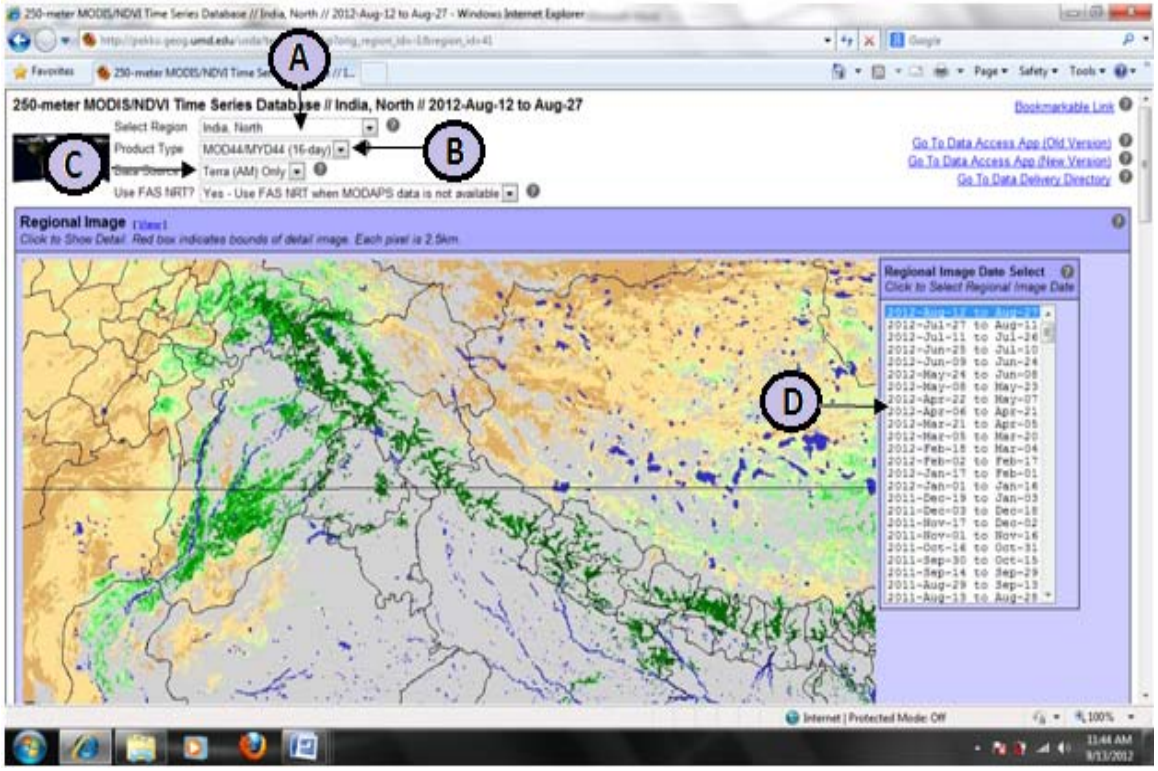

Figure 3.7: GLAM web page showing information (regional image) provided according to attribute value passed by user

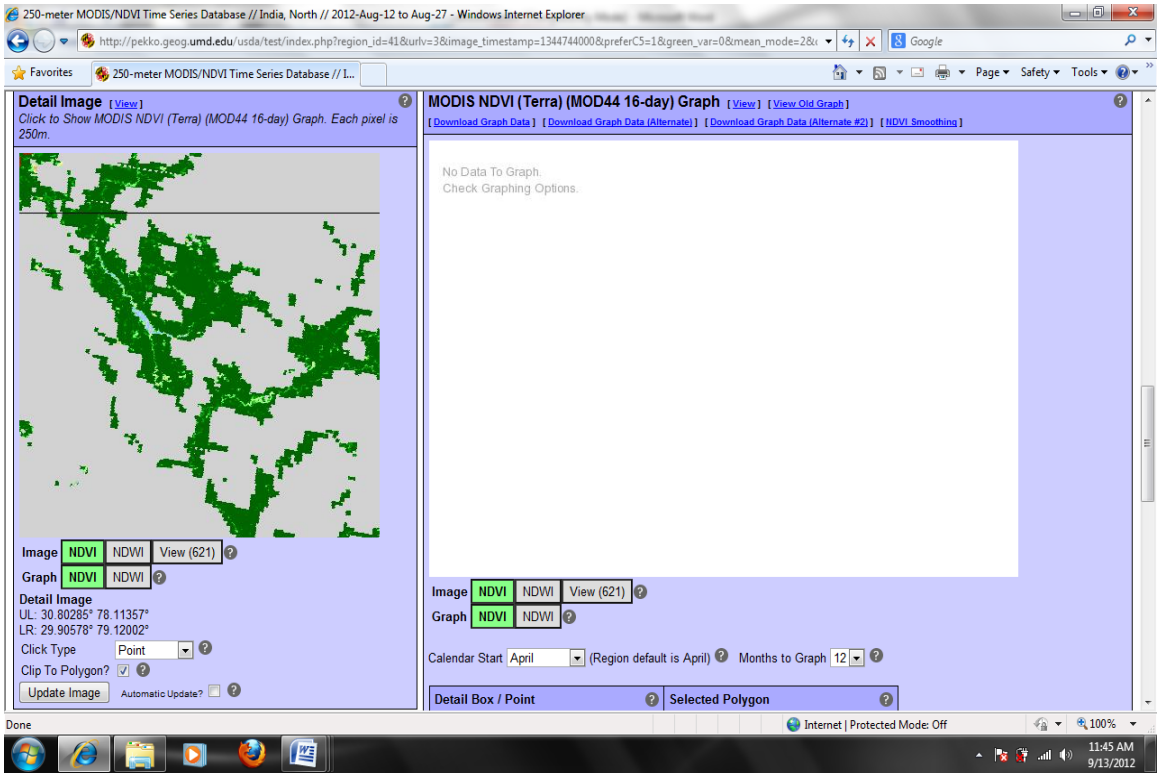

Figure 3.8: GLAM web page showing a detail image (250 meter/pixel) provided according to attribute value passed by user

3.2.4 Google Earth

Google Earth is a service provided by Google to incorporate Earth globe like feature through the browser by downloading its simple plugin. Google Earth provides capabilities of searching location by just passing location name, pin-code, and latitude and longitude value on the search box given on the provided GUI.

Google Earth also providing latitude, longitude and elevation values of the position when user moves cursor on the screen, Google Earth uses Georeferenced image to provide coordinate values of the point but if user capture the screen shot image by saving a Google Earth image, it will save in some of the raster formats (JPEG, PNG etc.) specified by the user.

But these capabilities giving by Google Earth is not sufficient for the GIS community as if the GIS user wants to save latitude, longitude, and elevation values of a cursor present position he/she has to manually save it. Google earth is not suitable for generating a DEM file for a specified region which need coordinates value at a fixed grid interval, as it is a very lengthy procedure because the user has to manually saves coordinates value of grid interval points by editing a text file at run time. The GIS user main concern is to save a Google Earth image is in the Georeferenced format (Geotiff) as creating Georeferenced images through simple raster image (by saving it in some raster format) needs softwares (ERDAS, ArcGIS etc.) as well as spatial domain knowledge.

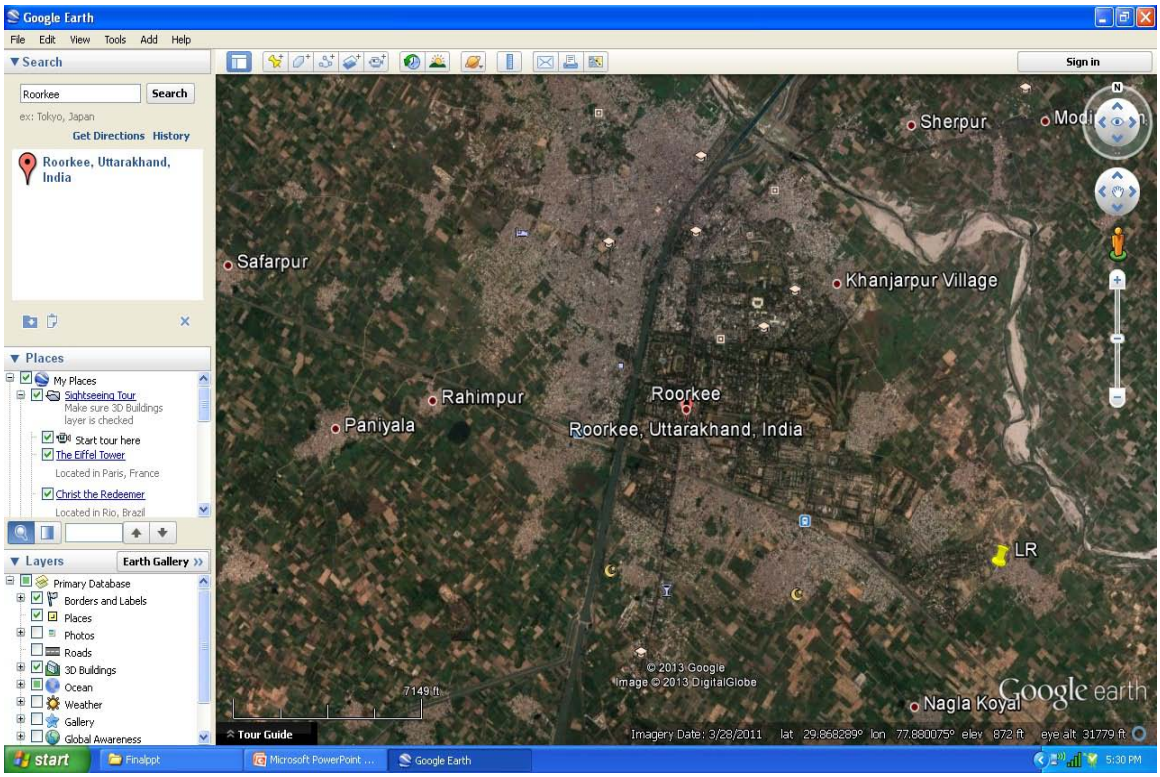

Figure 3.9: Google Earth showing Roorkee area

3.2.5 Wunderground.com

For providing real time weather forecast information for a selected region EGPS uses freely available weather forecast web service of wunderground.com "http://api. wunderground.com/auto/wui/geo/ForecastXML/index.xml?query=". It provides real time weather reports for cities across the world along with local weather reports for Web sites and newspapers. Its API allows developers and users to access data from Weather Underground to integrate the data and functionality into other applications. They offer a variety of plans and pricing, though most use is free (Wunderground.com, 2013). Various options provided by wunderground.com is shown by option [**A]** and **Different Options Available** box in Figure 3.10.

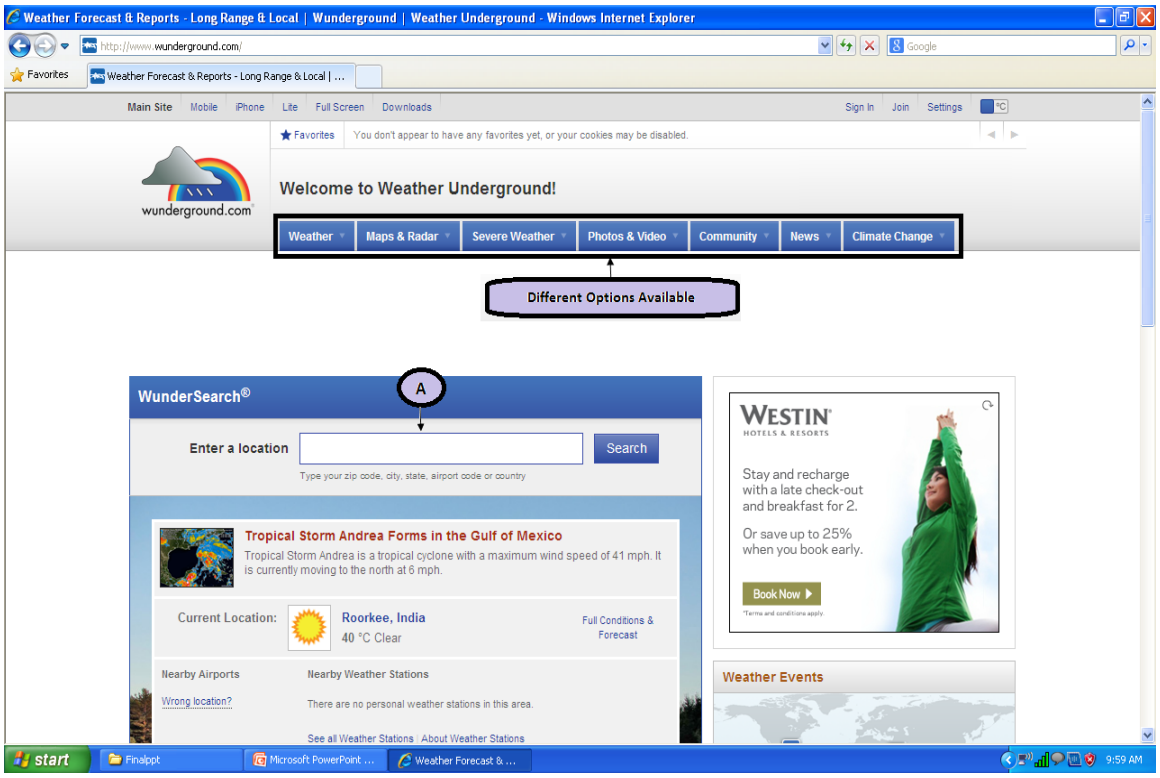

Figure 3.10: Home page of wunderground.com website

3.3 TECHNOLOGY USED

To achieve defined objectives of an EGPS, there is a need to combine some new emerging technologies which can use the diverse spatial data present on the internet, and provide a new result for the GIS Community. This section defines and describes the different technologies used for developing and designing of an EGPS. This section also specifies the problems associated with these technologies.

3.3.1 Web Mashups

To make existing web data more useful for personal or academic use a content aggregation technology is needed. Mashups are newly loosely defined web 2.0 technologies, it can operate on pure xml content and also on presentation oriented content (HTML) etc. (Mashup, 2013).

A mashup is a web application or web page in web development that combines and uses data or functionality from two or more sources to create new services. The term indicates easy, fast integration, often using open application programming interfaces (API)

and data sources to produce enhanced results that were not necessarily the original reason for producing the raw source data (Mashup, 2013).

Mashup site is a website that combines information, processing, or visualizations from several web sites to give the information the user which could not easily obtain by manually browsing the base web sites separately (Ennals and Gay, 2007).

Brandon Beemer, (2009) stated various issues related to developing web mashup sites like cross communication, heterogeneous (e.g. mashing a web service with a legacy system) and application (e.g. Business process) integration, choice of the best possible mashup resources for too many present on the web, the ability of end users to create custom mashup Applications etc.

With these emerging new concepts the recent development of Google Map, Yahoo Map, MapQuest APIs, and other have pushed map mashups almost to the top among other types of mashups, such as news mashups, search and shopping mashups, and video and photo mashups (Li and Gong, 2008)

There are already thousands of known mashup sites e.g. Makaan.com which uses a map from Google Maps to visualize real estate properties available for sale, rent etc.,yahoolocal.in and many more. Though creating a simple mashup site is easier with the advance technology but still there is an associated problem that these are not suitable for providing answers to the nested query or for better decision-making e.g. Buffer Analysis, Local Weather Forecasting, Statistical analysis, Pattern analysis etc. by integrating two or more websites.

3.3.2 Google API's

With the launch of Google maps on April 2005 followed by Google earth on July 2005, it got tremendous success in the field of Web GIS for providing spatial information to the naive user through different functionality by using simple javascript function and services. According to the literature almost 25% of existing Geoportal uses Google Api's for providing relevant spatial information due to its simple structure and ease to embed in web pages. This addition is made possible by means of Application Programming Interface (API). An API is a set of programming instructions and standards for accessing a Web-based software application or Web tool (Roos, 2011).

As far as accuracy point of view APIs data provide different resolution at different places ranges from the meter's to millimeter and it is also updated continually, Google earth also provides historical data for temporal analysis apart from simple function like zoom in , zoom out , view etc. While Google maps and earth APIs provide a lot of functionalities but for academic as well as commercial purposes one needs much more from it such as Georeferencing, DEM generation which take time, efforts and enterprise solution.

3.3.3 Spreadsheet

A spreadsheet is an interactive computer application program for the organization and analysis of information in tabular form. The paradigm of computing, which was dominant as spreadsheets became popular was that of desktop computing, where there is one user, using one machine, editing one file. The recent trend in computer science has been towards distributed applications. A distributed application typically is used by many people, uses data drawn from a variety of files or databases, and runs on many machines (Burfoot, 2002).

Most spreadsheets (Excel, Lotus) applications typically also allow the user to import data from outside sources such as the web or an external database. One example of this is Microsoft Excel's "web query" feature, which downloads an HTML page, attempts to find a table, and enters the contents of this table into the spreadsheet (Burfoot, 2002). This feature is useful in the case of web application as they are created by individual or enterprise for providing specific task by using different styles as it is a tedious job to programmatically combine them so there is a great need of some technology which somewhat or somehow wraps it.

There is lots of existing literature which supports spreadsheet (like excel, lotus etc.) Spreadsheet technology provides a convenient tool for wrapping purposes to standalone application. Wrapping is a very important task as they can quickly pull data from numerous sources and allow the business managers to experiment with information and even make up unique charts without the need to directly manipulate the business's database server or servers (Rietta, 2005).

One of the main features of spreadsheets is its avoidance of unnecessary separation between a program and the data it is working with (Ennals and Gay, 2007). Fujima et al. (2007) provided a method for embedding various Web resources in cells on a spreadsheet as

visual components in order to reuse by proposing C3W framework (clipping, connecting, and cloning for the Web).

3.3.4 Microsoft .NET Framework

The Microsoft .NET Framework introduces a completely new model for the programming and deployment of applications. .NET is Microsoft's vision of "software as a service", a development environment in which one can build, create, and deploy applications and the next generation of components, the ability to use the Web rather than own computer for various services (Marco, 2006). Microsoft introduced great technologies like COM, DCOM, and COM+ etc. to enable reuse of Software. Although these technologies are very powerful to reuse Software, they required a huge learning curve. According to this aspect, Microsoft realized that it's time to come up with a new Technology, a better one, an easier one, a new Framework, within which each Programming Task is easy accomplished (Walther and Sams, 2008).

Microsoft changed all complex tasks with the new .NET Framework. That was a huge advantage for all developers. Most of the Win32 API was now accessible through a very simple Object Model. Most of the features and functions of C++ were added to Visual Basic. A new Programming Language C# was introduced, which offered flexibility and productivity. ASP+ which replaced ASP also known as ASP.NET (Kalata, 2002; Marco, 2006). ASP.NET provides the most scalable and easiest way to deploy, build and run web services. ASP.NET server controls allow an HTML-like style of declarative programming that let individual to construct great pages with few line codes than with classic ASP. C#, C++ and VB code can be used in other languages i.e. code written in VB can be simply used in C# or in VC++. Also additional advantage is that one can step between the languages in the debugger.

3.3.4.1 Microsoft .NET Compilation Stages

The Code written in Microsoft Microsoft .NET isn't compiled directly to the executable, instead Microsoft .NET uses two steps to compile the code. First, the code is compiled to an Intermediate Language called Microsoft Intermediate Language (MSIL). Second, the compiled code will be recompiled with the Common Language Runtime (CLR), which converts the code to the machine code. The basic Idea of these two stages was to make the code language independence (Marco, 2006).

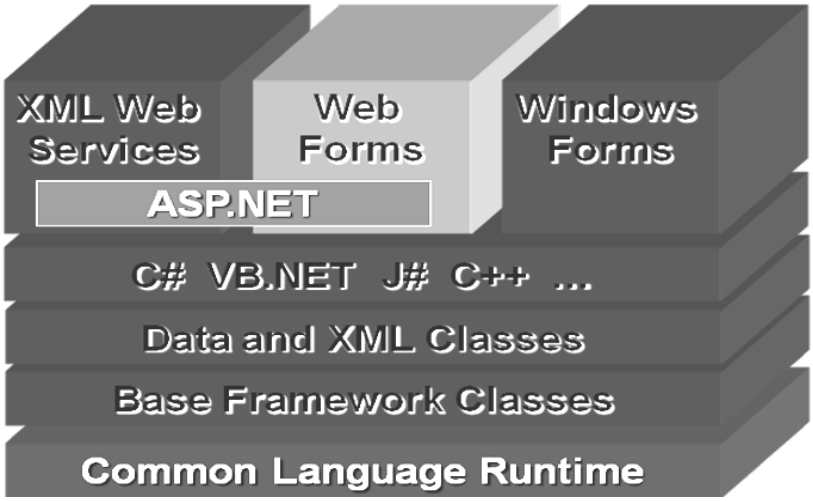

Figure 3.11: Microsoft .NET Architecture (Kalata, 2002)

3.3.4.2 Components (Layers) of the Microsoft .NET Framework

The top layer includes user and program interfaces. Windows Forms are a new way to create standard Win32 desktop applications, based on the Windows Foundation Classes (WFC) produced for J++. Web Forms provide a powerful, forms-based UI for the web. Web Services, which are perhaps the most revolutionary, provide a mechanism for programs to communicate over the Internet using SOAP (Marco, 2006). Web Services provide an analog of COM and DCOM for object brokering and interfacing, but based on Internet technologies so that allowance is made for integration even with non-Microsoft platforms.

Web Forms and Web Services, comprise the Internet interface portion of .NET, and are implemented through a section of the Microsoft .NET Framework referred to as ASP.NET. The middle layer includes the next generation of standard system services such as ADO.NET and XML (Esposito, 2006; Liberty and Hurwitz, 2006). These services are brought under the control of the framework, making them universally available and standardizing their usage across languages.

3.3.4.3 .Net Framework Advantages

- .Net is Language independent, so if the team has multiple skill expertise C#, VB.NET, C++, developers can still work on the same project with different skill set.
- MS technologies provide RAD (rapid application development) to deliver projects faster, customers always prefer faster delivery.
- Debugging is very effortless therefore, can fix the bugs quickly.
- Deployment is very easy and simple.
- Ajax implementation is simple & easy.

3.3.4.4 ASP.NET

ASP.NET is a server side scripting technology that enables scripts (embedded in web pages) to be executed by an Internet server (Kalata, 2002).

- ASP.NET is a Microsoft Technology
- ASP stands for Active Server Pages
- ASP.NET is a program that runs inside IIS
- IIS (Internet Information Services) is Microsoft's Internet server
- IIS comes as a free component with Windows servers

3.3.4.4 Overview of ASP.NET and Web Forms

Microsoft ASP.NET is the next generation technology for Web application development. It takes the best from Active Server Pages (ASP) as well as the rich services and features provided by the Common Language Runtime (CLR) and add many new features. The result is a robust, scalable, and fast Web development experience that will give great flexibility with a little coding (Kalata, 2002; Liberty and Hurwitz, 2006). Figure 3.12 shows an overview of ASP.NET.

Web Forms are the heart and soul of ASP.NET (shown in Figure 3.13). Web Forms are the User Interface (UI) elements that give Web applications their look and feel. Web Forms are similar to Windows Forms in that they provide properties, methods, and events for the controls that are placed onto them. However, these UI elements render themselves in the appropriate markup language required by the request, e.g. HTML. If one uses Microsoft Visual Studio® .NET, one will also get the familiar drag-and-drop interface used to create UI for Web application. Web Forms are made up of two components: the visual portion (the ASPX file), and the code behind the form, which resides in a separate class file.

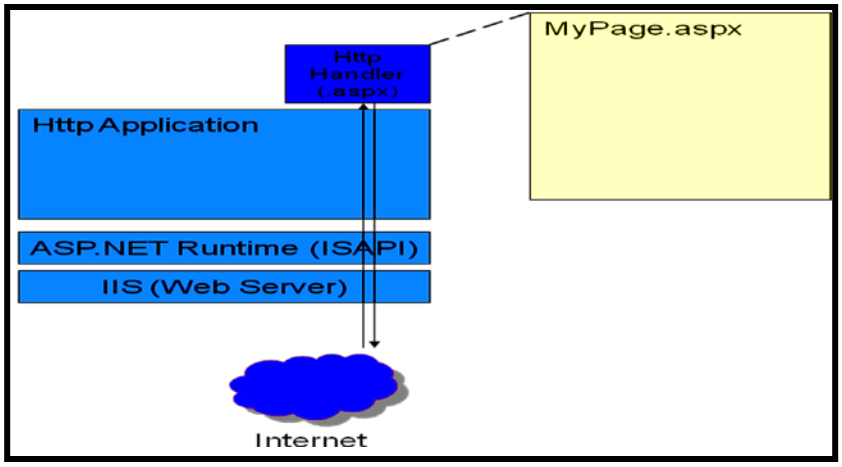

Figure 3.12: Overview of ASP.NET (Kalata, 2002)

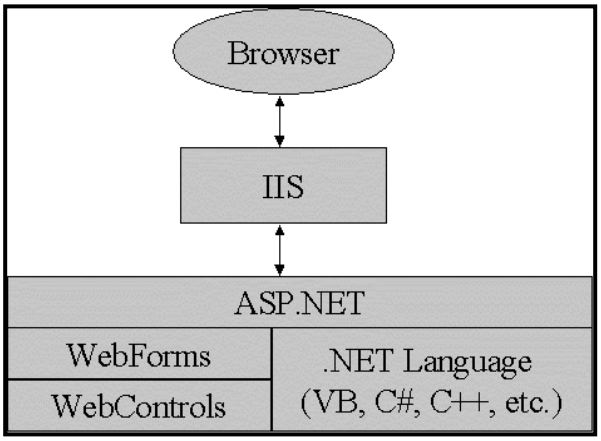

Figure 3.13: Web Forms are a part of ASP.NET (Esposito, 2006)

3.3.5 GDAL - Geospatial Data Abstraction Library

GDAL states as Geospatial Data Abstraction Library, is an open source library released under the permissive X/MIT style free software license for writing and reading raster geospatial data formats. For all supported formats, as a library, it presents a single abstract data model to the calling application. For data processing and translation, it uses variety of useful inbuilt command-line utilities (GDAL, 2013).

3.3.6 Hyper Text Markup Language

HTML (Hypertext Markup Language) is a structured markup language based on SGML (Standard Generalized Markup Language). HTML describes the layout and structure of a Web document using various tags and attributes. It contains collection of “Markup” symbols or text codes which includes data types, character references, elements, and attributes, inserted in a file planned for display on a World Wide Web browser or a design of web pages. Hypertext is an normal text that has been dressed up with additional features, such as links, images, multimedia and formatting to other documents or text files. The markup language is a representation for writing text markup tags that describe the structural elements of a page of the text and tell the Web browser how to demonstrate a Web page’s video, sound, images and text files for the user. (Abdulrahman, 2008; HTML, 2013; Introduction to HTML, 2013).

3.3.7 HTML Application

Recent browser (Internet explorer, Mozilla) is very specific towards security constraints like cross browser scripting etc. they rigorously follow the same origin policy “ It is an important security notion for a number of browser-side programming languages, such as JavaScript. It allows scripts running on pages originating from the same site to access each other's properties and methods with no particular constraints, but prevents access to most properties and methods across pages on different sites” (Same origin policy, 2013). So it is one of the prime issues in mashup web application how to extract or use data of third party website. To resolve this and make our application simple we use HTML application (The usual file extension of an HTA is .hta.) .An HTML Application (HTA) is a Microsoft Windows program whose source code consists of HTML, Dynamic HTML, and one or more scripting languages supported by Internet Explorer, such as VBScript or JScript. The HTML is used to generate the user interface, and the scripting language is used for the program logic. An HTA executes without the restrictions of the internet browser security model; in fact, it executes as a "fully trusted" application or run in a fully trusted mode (HTML Application, 2013).

3.3.8 JavaScript

Netscape introduced JavaScript, a scripting language that is validated, compiled and executed on the fly, in the beginning of the 90’s. Meanwhile it had been accepted by webmasters and programmers, and implemented in all of the major web-browsers. The syntax is closely related to C++ and Java. Though it is a language relatively easy to learn, it

is a quite complex and powerful programming language. One of the not well known but existing features is object-orientation, including inheritance and encapsulation. One should not mix up JavaScript and C#, these are two completely different implementations. We use JavaScript is used for client-side dynamic content creation, interactivity, event handling and animation, mainly through the DOM.

3.3.9 Web Service:

A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. Web Service must be loosely coupled, location transparent, and protocol independent (Endrei et al., 2004). For providing local weather forecasting information publicly accessible web service of http://api.wunderground.com/ is used in our application.

3.3.10 JavaScript Object Notation (JSON)

JSON is a lightweight data-interchange format compared to XML. It is notably used by APIs all over the web and is a fast alternative to XML in Ajax requests. “Its format is simple which is easy for persons to write and read and also easy for machines to generate and parse. It is independent programming language which uses conventions that are known to programmers of the C-family of languages, including Python, Perl, Java, JavaScript, C#, C++ and C ” (Introducing JSON, 2013).

3.3.10.1 Used of JSON

- To represent configuration information
- To implement communication protocols

3.3.10.2 Structure of JSON

JSON has two structures:

- **A collection of name/value pairs.**

In several languages, this is recognized as an object, record, struct, dictionary, hash table, keyed list, or an associative array. E.g.: An object with three properties named "a", "b", and "c" {"a": 1,"b": 2,"c": 3}

- **An ordered list of values.**

It is recognized as an array, vector, list, or sequence in most languages. E.g.: An array of three integers and one string value [1, 2, 3, "value #4 with"]

These are universal data structures supported by most modern programming languages.

3.3.11 Keyhole Markup Language

There are several powerful tools that realize data storing, modeling, displaying and managing in the area of markup languages. One of the tool is the Keyhole Markup language (KML) that permits users to get results and understands these services in Google Earth (GE) based on particular geographic features (Abdulrahman, 2008). . KML was first known as Keyhole and originally developed for use with Google Earth. Its development was engineered by Keyhole, Inc. which Google acquired in 2004. Google earth is a 3d interface of tremendous capabilities that permits users to view and navigate all types of data that can be denoted on a map such as 2D or 3D models. KML file types are used by programs such as ArcGIS Explorer, Flickr, Google Earth, Google Maps, Google Mobile, Live Search Maps, Microsoft Virtual Earth, Marble (KDE), World Wind and Yahoo Pipes. .kml or .kmz are the file extension or suffix which are uses by KML files.

3.3.12 Extensible Markup Language

The Extensible Markup Language (XML) is a subset of SGML (Standard Generalized Markup Language). To move the Web to its next phase of evolution by adapting present ISO standards for markup, formatting and linking is the main aim of XML. XML has been designed for ease of implementation and for interoperability with both SGML and HTML. XML is very powerful because no limits on namespace or structural depth. It is easy to implement and small enough for Web browsers.

The Extensible Markup language (XML) is a general purpose markup language for documents containing structured information mainly used to facilitate the sharing of structured data across different information systems, particularly via the internet. XML is extensible because it is not a fixed format like HTML, which is a single,

predefined markup language. XML is a meta-language for describing other languages, which lets users design their own markup languages for unlimited dissimilar types of documents (Abdulrahman, 2008). XML provides key features needed for a new generation of Web applications (Bosak, 1999):

- **Extensibility:** Users can define new tags as needed. According to requirement new tags can be defined by user.
- **Structure:** Hierarchical data can be modeled to any level of difficulty.
- **Validation:** Data can be checked for structural accuracy.
- **Media independence:** The similar content can be published in several media.

3.3.13 Asynchronous JavaScript and XML

AJAX, formerly named as Atlas, is an extension of ASP.NET for developing and implementing AJAX functionality. It includes both client-side and server-side components that allow the developers to create web applications that are capable to update data on a website without a complete reload of the page. The following are the advantages of using AJAX are:

- **Asynchronous-** Enables asynchronous calls to the web server without making the users wait for the data.
- **Minimal transfer of data-** Minimizes the network traffic and performing the operations quickest by sending only a part of modified data to the web server.
- **Minimal processing of the Web server-** The server is not required to send a full page back to the user only the necessary data need to be sent which minimizes processing on the Web server.
- **Context-** AJAX-based applications implement partial page postbacks instead full page postbacks, which reduces the data traffic between the client and server.

3.3.14 Cascading Style Sheet (CSS)

Cascading Style Sheets are a fairly old technology as far as the Web is concerned. The first ideas about CSS were presented as early as 1994, and three major versions of the technology have been developed since then. CSS is a file that defines the display pattern of a Web

Form. CSS can specify fonts, colors, styles (bold, italic), size and the rest. It is a text document that can be created by using any text editor that has the .css extension. After defining presentation styles in the CSS file attach this file to the web form. CSS is used because the World Wide Web Consortium (W3C), the international organization responsible for web standards, plans to phase out the <font> tag in future versions of HTML, in favor of CSS. Style sheets give more choices in formatting, such as line spacing, paragraph indentation, borders and content placement. CSS have a built-in cascading order of importance (most to least): User defined styles, Inline styles, embedded styles, link styles, imported styles and default browser styles (Powell, 2010; Academic Technology and Creative Services, 2009).

3.3.15 Document Object Model

DOM represents a structured Web form in an object-oriented model. DOM is a language and platform independent interface that permits scripts and programs to access and update the contents of a Web form. DOM is recommended by W3C to page manipulate page contents at runtime.

DOM takes the path of a Web form as a parameter and represents it in a tree structure (called document tree) by defining every element as a node its inner memory. It maintains the relationship between the nodes of the document tree, such as parent node, child node, and the rest (Kogent Solution, 2009).

Chapter4

CONCEPT PLAN AND ARCHITECTURE

4.1 INTRODUCTION

This chapter describes defined concept plan and the general architecture of EGPS system. The EGPS concept plan defines the step by step process of developing and designing of this complex web based application, it also shows how this web application is different from simple web based application that was built with some specific objective in their mind.

The EGPS architecture is different from general architecture used in Geoportal system till now, as it is not fully Service oriented architecture but it is influenced with the new emerging technology like Web Mashup i.e. Web 2.0 solutions, which help EGPS to use the publicly accessible third party web data which is not built for providing a third party solution by publishing their web services.

4.2 CONCEPT PLAN

Expert Geoportal system concept plan is a guideline for the system to provide Geoportal services, with specific components such as phases, tasks, methods, techniques and tools. Important factors in the research methodology are as follows:

Instead of creating its own new database EGPS uses publically accessible data from diverse 3rd party sources that will be presented in front of the users in a self designed GUI with the Google APIs and different Web development technologies. System development is certainly a complex procedure that is shown here in the concept plan diagram Figure 4.6. Developed system provides these services:

- Location Based Services
- Weather forecasting
- Real Time Digital Elevation Model
- Real Time Vegetation analysis
- Image Georeferencing

In this complete development life cycle, all the procedures that are followed starting with the literature survey to the successful implementation of EGPS are presented as step by step concept plan diagram shown in Figure 4.1. This diagram not only create a quick view of

development approach but also help to understand what sort of data, methods and technologies that are responsible for development of an Expert System rather than a simple web based Geoportal.

4.2.1 Description of Concept Plan Used

The entire Concept plan used in EGPS system is divided into phases:

In the first phase a general web based interface is created for interacting with the third party website like makaan.com, yahoolocal.in and GLAM website etc. shown by [**A]** in Figure 4.1, this interface contains two parts one for opening third party web application and another for client application which contains buttons, dropdown list etc.

In the second phase a specific adapter class is developed for individual web application, this class is specifically built to save the front end data (Text, Images etc.) provided by third party web application, if there is any change occurs in the third party website data format, style etc. then only this adapter class need to be rebuilt.

In the third phase the text data or images captured from third party website is rearranged or classified in the client application for providing various different GIS functionalities for better decision making.

Apart from it, as it is Mashup based application, for providing some more functionality like DEM file and Georeferenced images, client application has the facilities to directly call the map services like Google Earth APIs as shown by [**B]** in Figure 4.1. Moreover it can also directly call the published web services (weather forecasting services etc.) of third party web service provider like wunderground.com etc. as shown by [**C]** in Figure 4.1 to offer interoperable combined results for better decision making.

After getting the data from diverse web resources further processing like rearranging the data, converting it into spatial form etc. is done in a client application which is defined in details in next chapter.

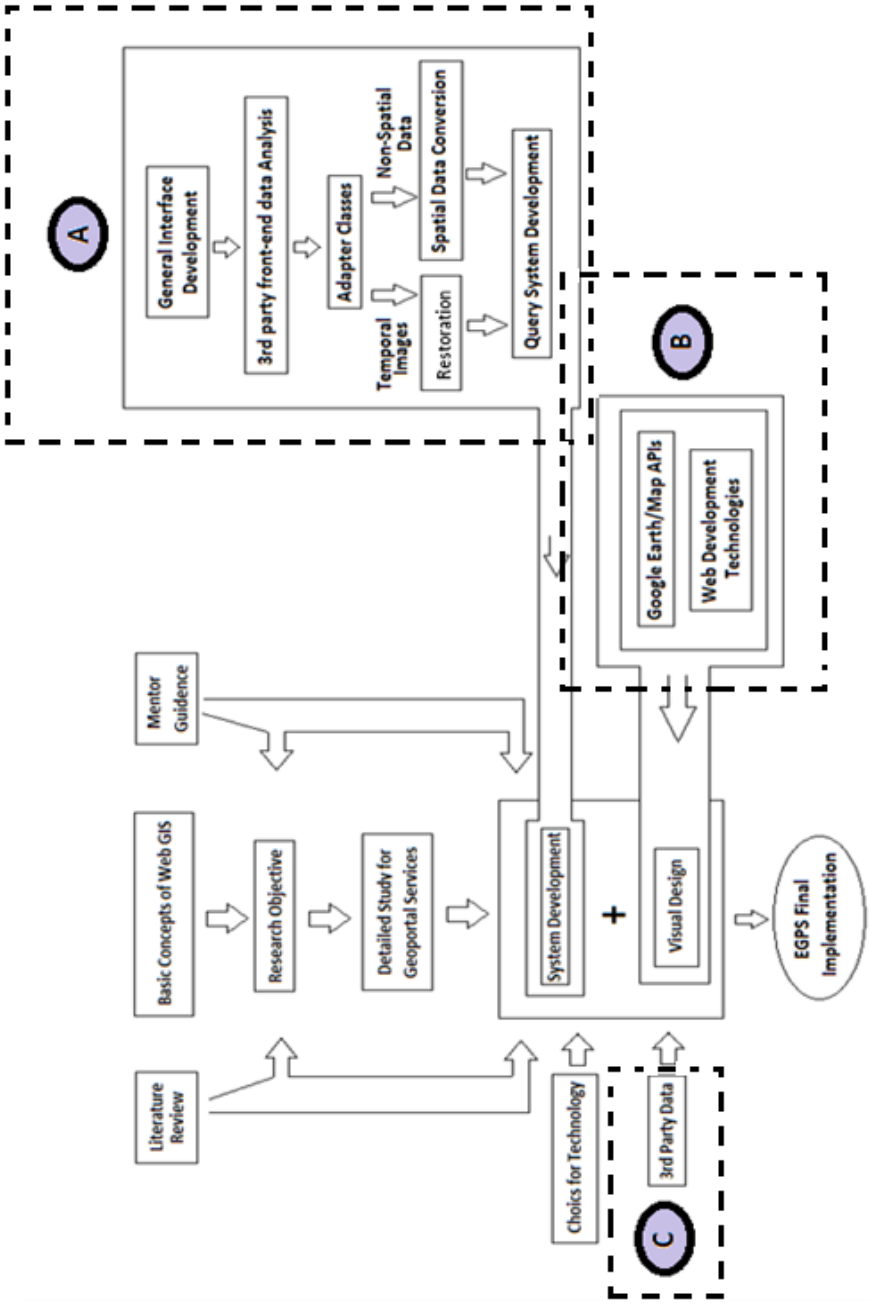

Figure 4.1: Concept Plan

4.3 ARCHITECTURE

“The architecture of a system defines its broad outlines and the precise mechanisms that draw a simplified structure in front of the developers to create a flexible and reusable system”.

A standard system is defined in terms of some modules, that usually known as tiers. By breaking up a system into tiers, developers merely have to add or modify a particular layer, rather than have to rewrite the whole application, if he/she decides to change technologies or scale up (Multitier Architecture, 2013).

Architecture basically comprises of four things Figure 4.2:

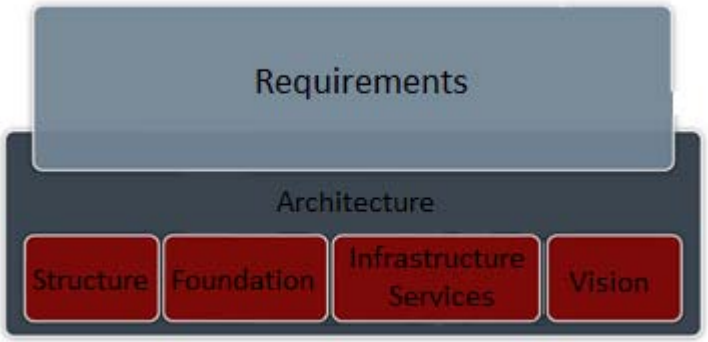

Figure 4.2: Architecture and its Components

- **Structure**: The building blocks (components) and how they relate to and/or interact with one another.
- **Foundations**: A stable basis on which to build something.
- **Infrastructure services**: The essential services that are an integral part of whatever is being built. With a building, this might be power, water, cooling, etc. With software, this might be security, configuration, error handling, etc.
- **Vision**: It's crucial to understand what to build and how that process will be undertaken. Vision can take the form of blueprints, guidelines, leadership, etc.

Architecture is inherently about structure, but it's also about vision and creating sufficient foundations to deliver a set of requirements, regardless of whether those requirements are related to a physical building or a software system.

4.3.1 Expert Geoportal System Architecture

As Geoportal is a web based application so its architecture shown in Figure 4.3 is none other than client server architecture but the word expert gives it a new meaning that extends its behaviour form a simple client to an extended one with some extra capabilities and functionalities. Server is also not limited to simple web server with a specific feature of invoking desired HTML/AJAX based services but improved to have interfaces for Google Map/Earth APIs and some newly defined services with a well known database interface for newly conceptualized temporary database.

4.3.1.1 Client

Client is divided into two major categories that are:

- **User Interface:** This part shows what are the different possible views of the EGPS system available for users. This further categorised into three groups:
  i. **UI Presentation:** Simple HTML web site interface for user interconnection with system. This part demonstrate what are the different options available for users among them user can select any of the available option for further processing. For the development of this HTML & CSS platform is used.
  ii. **Map Display:** As EGPS system is majorly a web based decision support system, so it used Google map/earth for taking input from user and to demonstrate processed result. Here according to user's activities map is updated and for this JavaScript based query system is used.
  iii. **UI Behaviour:** This phase is a collation of different functions responsible for specific user behaviour. JavaScript and XML Script is totally governing these function and regularly update the server on the basis of user request.
- **Application Communication Protocol:** Application communication Protocol is divided into two communication protocols that are well known and well defined as HTML Interface (Defined for simple HTTP request and HTML response) and AJAX Engine (Defined for updated HTML pages as per the requirement of user defined in the form of various input parameters set at Map Display and User Behaviour).

4.3.1.2 Web Server

A Web server is a program that, using the client/server model and different web technologies like Hypertext Transfer Protocol (HTTP), JavaScript, JSON, and AJAX serves the files whose request is made from Web pages of users.

EGPS Web Server uses the following technologies:

- Active Server Pages
- ActiveX Contents
- JavaScript
- VB Script
- HTML Application Page
- External Library (GDAL)

Beyond these technologies a Request-Response Handler is also there (EGPS) to handle real time client request and to entertain them with a certain set of services. This Request-Response Handler is broadly categorised into two specific set.

- HTML Response Handler
- AJAX Response Handler

AJAX Response Handler is responsible for all interactive function calls with Google map and earth rendering request. Its work can be categorised into three major parts as:

- Map/Google Earth runtime Rendering
- 3rd party Data Fetching
- Invoke an HTML Application Page

4.3.1.3 Google App Engine

Google App Engine is a unique hosting platform that lets us to build applications and run them in Google's data centres using the massive global infrastructure. App Engine offers a development environment that uses familiar technologies (Java and Python) and provides a

powerful and robust set of APIs to users while maintaining security and independence from other apps.

- **Google Maps API:** The Google Maps API is the smart bits of Google technology that helps user to use the power of Google Maps and set it directly on client site (Google Maps APIs, 2013). It lets us add relevant content that is useful to visitors and customise the look and feel of the map to fit with the style of site. Almost 150,000 sites are already using the Google Maps API.

- **Google Earth API:** The Google Earth API enables developers to embed Google Earth applications into web pages with JavaScript code. With the Google Earth API plug-in installed, these applications can run interactively in web browsers. The API can display place marks, lines, polygons, overlays, and 3D models on the imagery, just as the standalone versions of Google Earth can. The plug-in supports several of the Google Earth layers, including terrain, roads, borders, and buildings.

4.3.1.4 3rd Party Data Fetching (Fetching Web Services)

Here initial 3rd party data source is for Weather forecasting data. On the request of buffering web server will fetch the weather data of specified zone for the user.

4.3.1.5 Invoke a HTML Application Page

An HTML Application (HTA) is a Microsoft Windows program whose source code consists of HTML, Dynamic HTML, and one or more scripting languages supported by Internet Explorer, such as VBScript or JScript. The HTML is used to generate the user interface, and the scripting language is used for the program logic. An HTA executes without the constraints of the internet browser security model; in fact, it executes as a "fully trusted" application (HTML Application, 2013).

The usual file extension of an HTA is `.hta`.

HTML Application Page is responsible in EGPS for three external web page invocation that are:

- Makaan.com
- yahoolocal.in
- NDVI web Portal

When user makes an AJAX request for Location based services or NDVI request HTML Application Page executes that invoke a two framed web page in which first is for external web interface and second is local developed. From the first frame an initial request is made to get primary working parameters that are transferred to second page either directly or by using temporal database further processing is done to get the desired result on locally developed web environment.

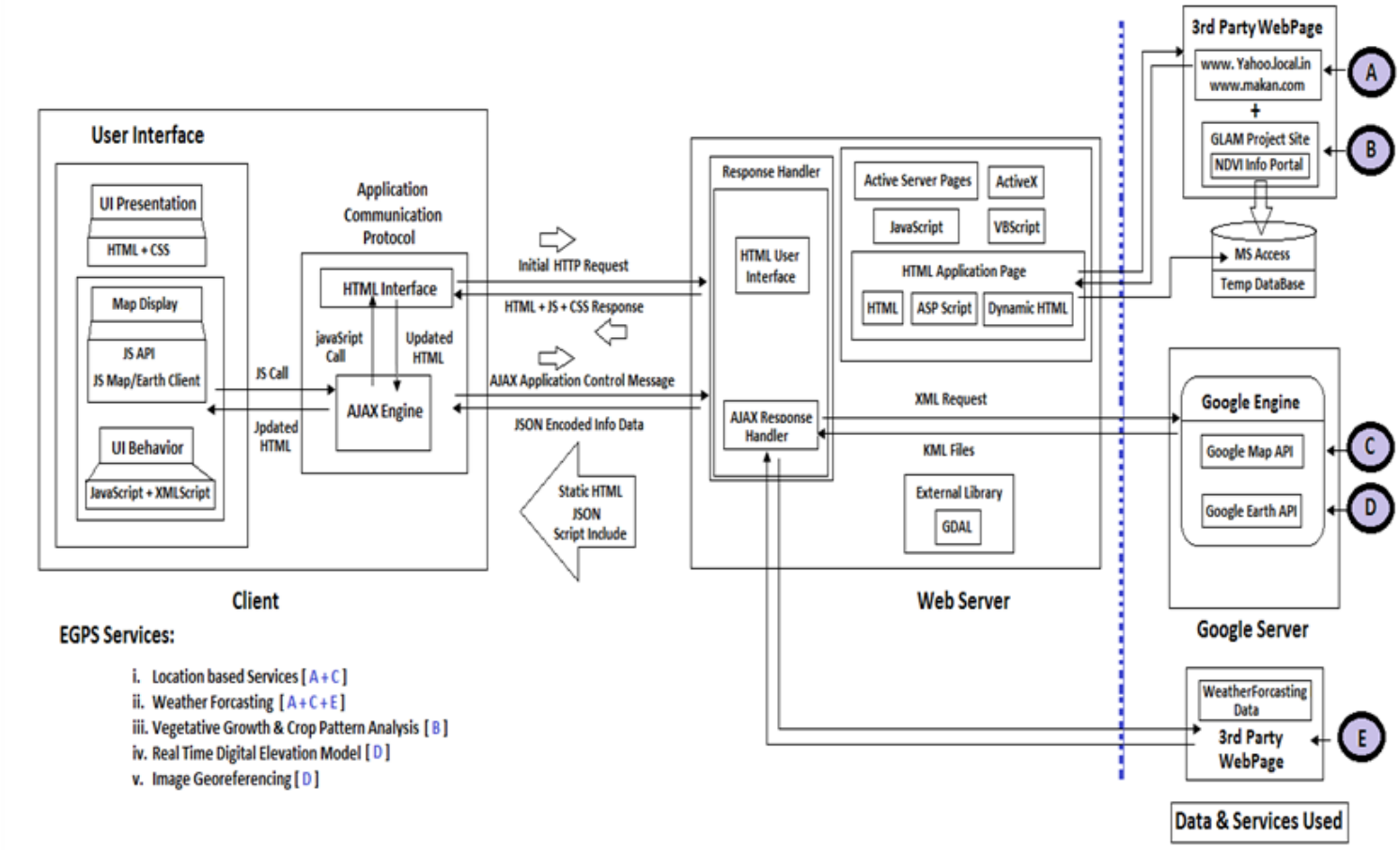

Figure 4.3: Architecture of Expert Geoportal System

Chapter 5

EGPS SERVICES AND PROCESS DIAGRAMS

5.1 INTRODUCTION

This chapter describe the services provided and process diagrams of an EGPS system, EGPS system mainly provides five types of services which is defined and described here. The process diagram gives the fundamental idea of how the user can use these services, to get the required results, these process diagrams simplifies the view and gives a direct look about the flow of the system, for simple understanding of the entire processing of the developed system to the end users, it also helps the user in step to step monitoring of the results.

5.2 EGPS SERVICES

Developed system provides mainly five basic services that are shown in Figure 5.1:

- Location Based services
- Weather Forecasting
- Vegetative Growth and Crop Pattern Analysis
- Real Time Digital Elevation Model (DEM)
- Image Georeferencing

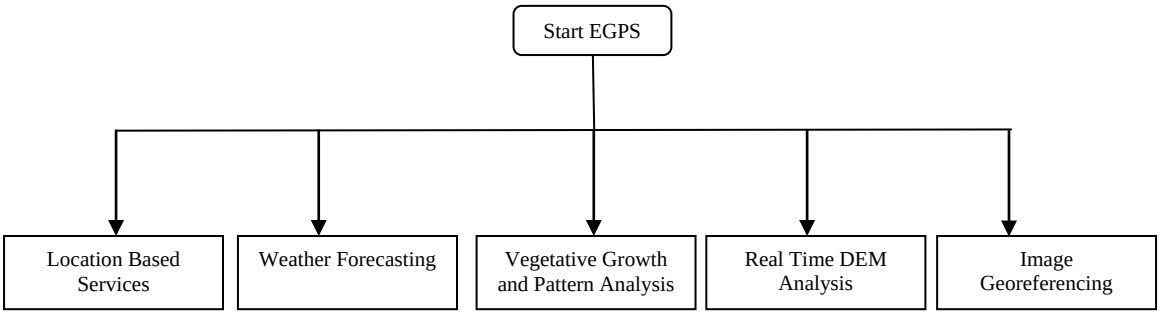

Figure 5.1: Services provided by EGPS

5.2.1 Location Based Services

Services which use the location coordinates of the end-user to improve the relevance, context, and value of the application are defined as location based services (LBS).

Where am I? Where are my friends? What is here around me?

The idea behind LBS is to answer these and other questions. In designing LBS the user's need for information have to be met in order to make the services useful. Such services includes like directions to restaurants, hospitals, malls etc. and other retail establishments in proximity. However, now the services may not only be offered by carriers alone.

The location based services can be classified into four types as depicted in the figure 5. 2.

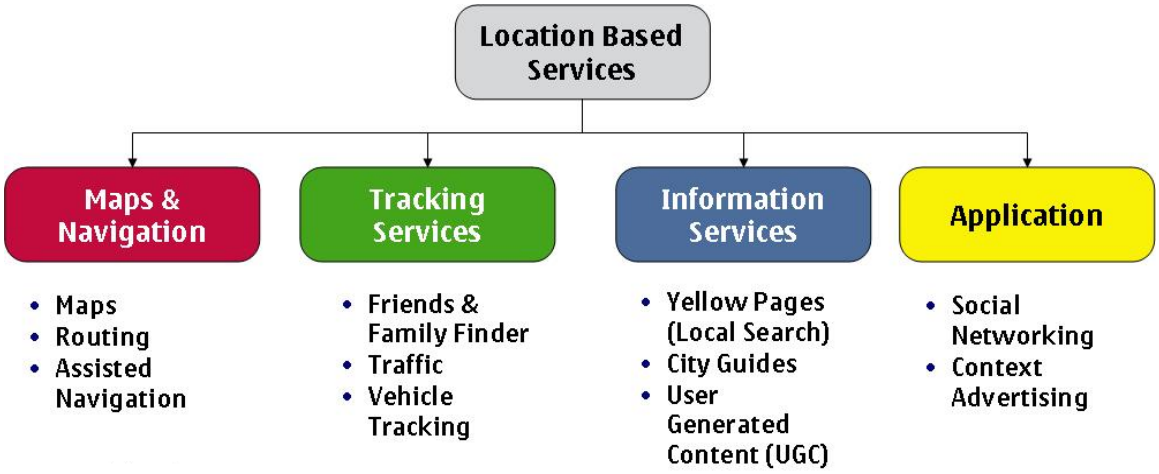

Figure 5.2: Classification of Location Based Services
(Source: http://www.telecomcircle.com/wp-content/uploads/2009/06/)

Maps and Navigation are the basic services, these services are the basic hygiene and increasingly it may not be possible to monetize them. However, there is huge potential from the tracking (mobile phone tracking, PDA tracking (Hadley et al., 2003)), information & application services and context advertising would be a way to monetize these services with maps serving as the basic framework. The revenues from the applications utilizing location would help fund the navigation services. Free services and applications would help increase the initial adoption.

5.2.1.1 Technology behind the location co-ordinates

A key requirement for location based services is to get the co-ordinates of a location with as much accuracy as possible. Cell-ID was one of the first methods of collecting location data but different methods have evolved over the years due to efforts to increase accuracy of data, reduce cost of acquiring data and carrier's reluctance to part with the location data. The key methods are listed below:

i. Cell-ID: This method estimates the position of a handset based on the knowledge of its serving base station. The accuracy of this method is around 100-500 meters.

ii. Global Positioning System (GPS): A GPS receiver calculates its position by measuring the distance to at least three GPS satellites. The accuracy here is around 10- 20 meters. Arrowsmith et al. (2005) used GPS receiver to find travel routes.

iii. Uplink Time Difference of Arrival (U-TDOA): Handsets are positioned by measuring the time difference of arrival of the same signal from the handset at different base stations in the network. U-TDOA can deliver positions accurate to about 50 meters.

iv. Hybrid (A-GPS): Assisted GPS (A-GPS) technologies improve performance of GPS by aiding the receiver by providing data such as time, satellite ephemeris or initial location estimate. Network-based hybrid positioning technologies, for instance Cell-ID in GSM/UMTS networks and AFTL in CDMA networks, are primarily used as fallback methods when GPS location fails, or as course position determining methods for A-GPS.

Apart from the above, there are alternate methods that have emerged like Skyhook and Google. Each of the cell towers and Wi-Fi points have a unique ID number which form a part of the databases of Skyhook and Google. The unique IDs are then mapped against the GPS co-ordinates and hence anytime a user is attached to a particular cell-site, the location co-ordinates of the cell site are pulled out of the database to determine the location of the user. Google is able to provide its local search services using this method of determining the user location.

5.2.1.2 Problem Statement and Solution Provided

To provide location based services (Local Search (restaurant location, hospital locations etc.)) an easy way used by existing portal is creating their own new database by taking latitude and longitude values of the desired locations and then used this database with any third party map provider (like Google, yahoo etc.) for providing a visual representation on

the map. To create and update this new database needed huge investment both in the form of money, human efforts and time.

To provide location based services, EGPS use an alternative approach that can use the data that is already present in the non spatial form of the web, without the burden of managing and creating own database. EGPS used publicly accessible database provided by makaan.com and yahoolocal.in web applications, former having its front end data arranged in tabular form while latter with the help of simple *div* tag i.e. randomly distributed.

Developed EGPS is a web browser based application which uses Asp.net, JavaScript, Web Query to interact with these third party websites and the result of this, in a first step, whole third party web page is saved as an HTML page on the server (see Appendix II, Figure1, Figure 2 and Figure 3), to remove the problem of dynamic uploading of the web page (in this case page content changed but the URL remains same). In the second step client application used Web Query to wrap the front end data of third party website into Excel spreadsheets (see Appendix II, Figure 4). As Excel data are in random form so this data is rearranged in the next step with the help of VBA programming (see Appendix II, Figure 5) and creating a temporary database in real time. To show spatial information on the map EGPS used Geocoding "It is the process of converting informal locations, such as street addresses, into formal geographic coordinates. Locations are given a unique set of coordinates to mark their exact place on earth as stated by" function present on Google Map API's. The developed EGPS enhanced the decision making capabilities of these third party website (makaan.com and yahoolocal.in) by providing answers of complex queries like "how many apartments are present inside 5 km area" etc. which were absent in the present form.

The main results of the present work include:

- Reference database from makaan.com, Yahoolocal.in and Temporary local database.
- Real time information of desired places using Web GIS.
- No unauthorized access to database of makaan.com and Yahoo local. in.
- Decision support using Expert System.
- Provide exact position on the map with its latitude and longitude.

- Multiple options of user query e.g. buffers of user specified diameter covering more answers to the query.

5.2.2 Weather Forecasting

The application of science and technology, to forecast the state of the atmosphere for a specified location is known as weather forecasting (Weather Forecasting, 2013). It is a crucial application in meteorology, as weather is a continuous, data- intensive, multidimensional active process. Weather forecasting remains a formidable challenge because of its data intensive and frenzied nature (Latha et al., 2010). Weather forecasting is very important for agriculture, to plan outdoor activities, for human safety purposes special forecasts deal with the probability of severe thunderstorms, tornadoes and hurricanes etc.

5.2.2.1 Problem Statement and Solution Provided

To provide weather forecasting information of a desired location, an easy approach used by different existing applications are that they simply used third party web services in their web application by passing the Spatial (latitude and longitude) or non Spatial (location name, pincode etc.) attribute either manually or using their own database in the format specified by third party web service provider.

EGPS deployed a new concept where it automatically uses the non-spatial attributes from the third party websites (makaan.com and yahoolocal.in) converted it into spatial attribute through repetitively calling Geocoding functions provided by Google APIs. These Spatial attributes are then repetitively passed into the weather forecasting web service of wunderground.com for getting the weather forecast information of the whole buffer zone specified by the user according to its requirement. This application helps the automatic weather forecast of the whole buffer region especially helpful in hilly region where there is a change in weather condition occurs in a small area.

5.2.3 Real Time Digital Elevation Models

The data files that have the elevation of the terrain at a fixed grid interval, over a specified area on the surface of the earth is know as Digtial Elevation Model (DEM). The intervals between each of the grid points will always be referenced to some geographical coordinate

system. This is usually either in latitude-longitude or UTM (Universal Transverse Mercator) coordinate systems. The closer together the grid points are located, the more detailed the information will be in the file. The details of the peaks and valleys in the terrain will be better modeled with small grid spacing than when the grid intervals are very large. DEM file not contained elevation values of those locations which are other than the specific grid point locations. Consequently, those points (valley and peak points) will not be recorded in the file which are not concident with the grid.

It has long been known that the DEMs have a potential for solving theoretical and applied problems in earth science. DEMs also have a major role to play in Geographic Information Systems (GIS), hydrological modeling (O'Callaghan and Mark, 1984, Wheeler et al., 2007), estimating canopy height (Iqbal et al., 2013), flood mapping (Sugumaran, 2000), glacier change analysis (Haq et al., 2013) analysis of visibility (Lee and Stucky, 1998) and hazard mapping (Gruber and Haefner, 1995 and Jain et al., 2006). Geomorphometry (Pike, 2000; Ravibabu et al., 2003; Sujata and Prustry 2007) to hydrological modelling (Kenward et al., 2000) and the physiographic correction of digital satellite imagery (Goyal et al., 1998; Nag and Kudrat, 1998).

5.2.3.1 Problem Statement and Solution Provided

To provide Real Time DEM, EGPS used the data provided by Google Earth, it provides coordinates (Latitude, Longitude and Elevation) values of the current cursor position, but these coordinates will change as the cursor moves (moving mouse). If the user wants to save the coordinate values of the present cursor position, he has to manually attach a marker in that place and save the marker coordinate value in the text file or in a database. So, Google Earth is not suitable for generating a DEM file for a selected region, it needs a coordinates value at a fixed grid interval, and this procedure is very lengthy in Google Earth because the user has to manually saves coordinates value of grid interval points by editing a text file or database at run time.

As Google Earth also does not provide a direct API's for DEM file generation and this procedure is very important for data modelling so, the Developed Expert Geoportal System (EGPS) deployed a new portal where users can specify the grid interval by selecting horizontal and vertical pixel values from given dropdown lists according to their requirement and click on save coordinate button (shown in Figure 6.37). The output file is

automatically saved in text (.txt) format, which contains elevation values of a grid point with its latitude and longitude.

The main benefits of this work include:

- Developed EGPS generates an acceptable Digital Elevation Model (DEM) at real time.
- Developed EGPS has multiple options for user e.g. user can specify grid interval according to its requirement.

5.2.4 Image Georeferencing

To establish the object existence in physical space in terms of coordinate system or map projection is known as Georeferencing (Hill, 2006; Georeference, 2013). To determine the spatial location of Geographical features and establishing the relation between vector or raster images and coordinates, Georeferencing is used. For e.g. Search the Geographical coordinates of an address of a street or name of a place or establishing the accurate position of an aerial photograph in a map. Thus, in the area of GIS and other cartographic methods, this process is very important for data modelling. Georeferencing is must when GIS applications require combining diverse sources of data, as it needs a common referencing system (Georeference, 2013).

Georeferencing is a process of aligning geographic data to a known coordinate system so it can be viewed, queried, and analysed with other geographic data. It might also include scaling, rotating, shifting, skewing and warping, rubber sheeting, or orthorectifying the data in some areas (Georeferencing Historic Images Using ArcGIS, 2013).

5.2.4.1 Problem Statement and Solution Provided

Images are of two types. Images not having projection system are called non georeferenced images or simple images. Images having projection system are called georeferenced images. Non georeferenced or simple image can be translated to georeferenced images by using GIS software's like ERDAS, Arc GIS etc. but it need specific domain knowledge and also this procedure is lengthy and time consuming.

To provide Georeferenced images, Developed EGPS used the raster images provided by Google Earth, Google Earth uses Georeferenced image to provide coordinate values of the point, local search etc. But if user captures the screen shot image by saving a Google

Earth image. It will save in some of the raster formats (JPEG, PNG etc.) specified by the user.

Georeferencing is the primary essential step to define spatial data in a coordinate system to relate it to its exact location over earth defined through projection systems. As this procedure is mandatory for data modelling and also Google Earth does not provide a direct API to capture a georeferenced image.

Developed Expert Geoportal System (EGPS) deployed a new referencing system that is used to generate georeferenced images collected by capturing a Google Earth image at run time for different GIS application, (e.g. For change detection, assess damages after a natural disaster etc.). In this application user passes the location name on a given text box and click on save coordinates button (shown in Figure 6.29) a Text file is automatically save which contains coordinate (Latitude, Longitude and Elevation) values for a complete selected region at a default grid interval, "Text file is used for getting coordinates values of three particular points i.e. Top Left, Top Right and Bottom Right. Top Left and Top Right jointly used for calculating the width of the pixel, Top Right and Bottom Right together used for calculating the height of the pixel". "GDAL is used as an open source library for writing raster geospatial data by creating a World File which required parameters **Top Left, Width, Height, Projection** and **Rotation."**, to generate Georeferenced image. Text file is used to provide three initial parameters Top Left, Width, Height. Referenced projection system WGS 84 is used as fourth parameter. Further an inspection method (hit and trial) is used to prepare a pattern graph (See appendix II, Figure 10) that observed and suitable value for rotation parameter is computed.

After clicking on Geotiff button present on the client application, server used this text file and GDAL library and the resulting output image automatically saved in a Geotiff (. tiff) format which contains the spatial information.

The main benefits of this work include:

- Developed EGPS generates an acceptable georeferenced image in real time.
- Developed EGPS reduces the lengthy procedure of georeferencing of an image.

5.2.5 Vegetative Growth and Crop Pattern Analysis

Vegetative Growth and Crop Pattern Analysis are crucial to identify the overall agro-environment and agro-spatial diversity of the area, they help the planners and policy makers to measure the potential use of agricultural land, suitability analysis of crops and future cropping pattern planning of the area (Rahman and Saha, 2009).

Cropping pattern is the fraction of area under diverse crops at a point of as it changes over space and time. The cropping patterns of an area are directly influenced by the geoclimatic, socio-economic, historical and political factors (Dubey, 1985; Husain, 1996).

Vegetation and crop pattern analysis help to identify the cause and effects of ecological changes; Ellis et al. (2005) measured long term ecological changes using current and historical images for china.

5.2.5.1 Problem Statement and Solution Provided

Vegetative Growth and Crop Pattern Analysis require the temporal images of a selected region, these images are not readily available, after arranging (acquiring) these images from any service provider (Google etc.). It needs further processing (image classification etc.) in any third party software (ERDAS, Arc GIS etc.). This whole process required money, human efforts, specific domain knowledge, time and are not suitable for automatic forecast of vegetative pattern changes.

To reduce this lengthy procedure and to provide cost effective solutions for Vegetative Growth and Crop Pattern Analysis, EGPS used the temporal NDVI images of 250 meter resolution provided by the GLAM website by capturing the full screen of the GLAM website in a raster (PNG) format (see Appendix II, Figure 6), and by clipping a detail image of 250 meter resolution from it (see Appendix II, Figure 7). This detail image is further classified into eleven different classes (see Appendix II, Figure 8) as images captured from web contain billions of colors digitally, representing only eleven classes in original image. Difference image (see Appendix II, Figure 9) is generated by selecting two images of different time periods in which the vegetation which does not changes shown by same color in difference image and the vegetation that convert into some other type are shown by the

average color pixel value taken from two images, pie chart are plotted at run time for showing vegetation growth statistics i.e. Percentage amount of sparse vegetation change into other type like bare land, dense vegetation etc. the percentage amount of particular vegetation are shown by their respective colors.

To generate pattern analysis graph user captured significant amount of classified images, a database is also created automatically which contains the percentage amount of the particular vegetative type present on the classified image, and pattern analysis graph is plotted between the percentage amount of vegetation and period for decision making.

5.3 PROCESS DIAGRAM

For these services this section gives us a direct look about the flow of the system so that just only by having a view of these processes-diagram one can easily understand the complete processing of the developed system and why it is known as Expert Geo Portal System. Beside this, these diagrams also help to easily understand the basic building blocks for each and every service and the systematic progress from input to resultant output at each step can also be monitored just by having an eye over these diagrams.

5.3.1 Process Diagram for Location based Services

Description of Process Diagram as shown in Figure 5.3:

I. The client passes the URL i.e. www.expertgeoportalsystem.com on the web browser then the requested web page is loaded in the client browser.

II. When user click on the location menu button, location page request is sent to the web server, an HTA page is received back as response to the user which contains two Iframes - IFrame1 for third party website and IFrame2 for client application.

III. The client passes the URL of the desired third party website i.e. www.makaan.com or Yahoolocal.in on the interface provided for third party website.

IV. The requested web page (third party) loaded in the interface provided for third party website, user can select the options (searching property, malls, hotel etc.) and also pass the attributes (cost range, city name etc) on the interface present on third party website according to its requirement. Third party server processes the request and sends results back to the user.

V. Now IFrame2 is enabled, when client click on the GetData button, the concerned request is sent and as a response the whole third party web page is saved as an HTML page.

VI. The client application used JavaScript, Asp.net and Macro Programming (Web Query) for interacting with third party website and get the front end non spatial data of web page into an Excel Sheet. VBA Programming is done for rearranging the Excel Sheet data into valuable information. This information is exported into temporary database and then called into our client application in a dropdown list with numerous location attribute values.

VII. When user select particular location attribute then non spatial information is converted into spatial information with the help of Google API Geocoding function.

VIII. If Geocoding is successful then the desired location shown on the map else error message is generated.

IX. When user click on buffer analysis button, buffering request is sent and a buffer zone is displayed on Google map according to attributes (radius, current location etc.) specified by user.

X. When user request for weather forecasting information the web service of wundergound.com is called and local weather forecast information is shown with buffer zone on the client application.

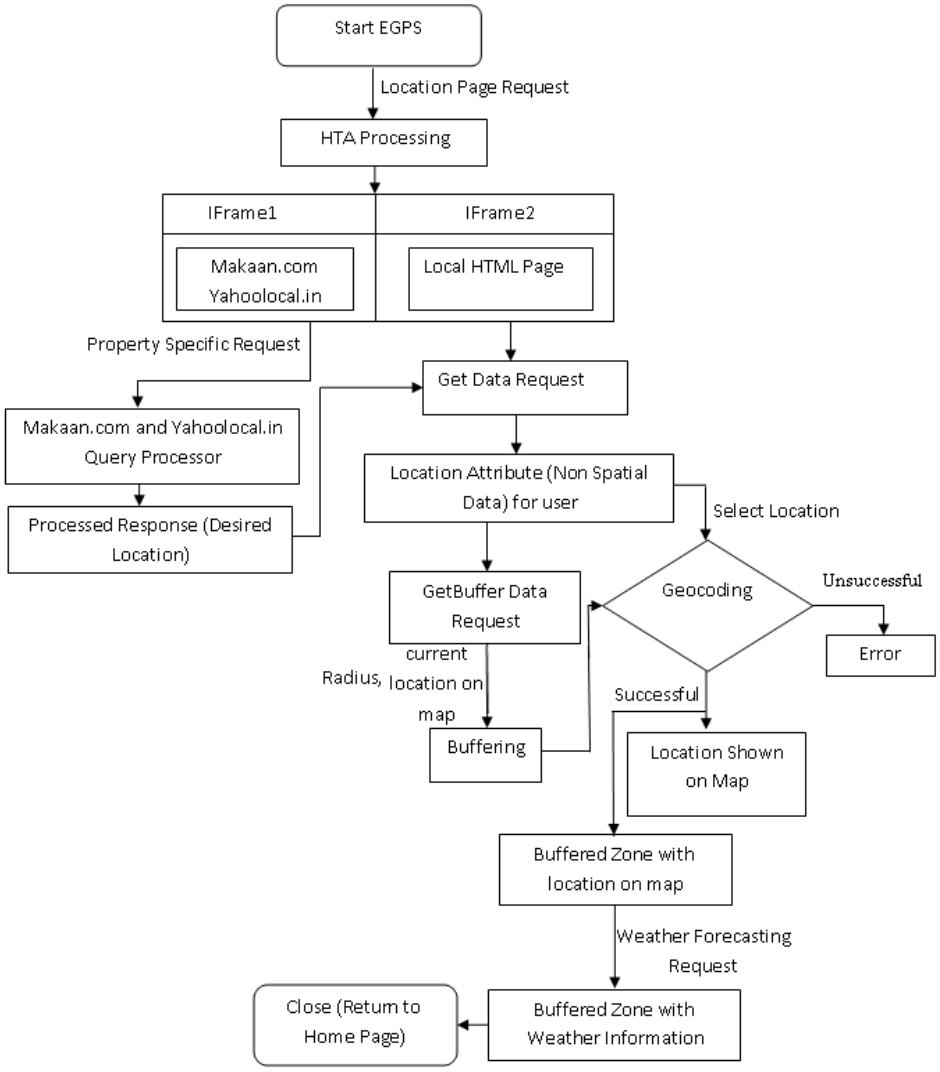

Figure 5.3: Process diagram for Location Based Services

5.3.2 Process Diagram for Real Time DEM

Description of Process Diagram as shown in Figure 5.4:

I. The client passes the URL i.e. www.expertgeoportalsystem.com on the web browser then the requested web page is loaded in the client browser.

II. When User click on the DEM menu button, DEM page request is sent to the web server as a response DEM web page is received back to the user which contains Google earth plugin.

III. Location filter request is sent and as a response to this request specified zone is displayed on Google Earth API.

IV. User will specify horizontal and vertical pixel values (Grid Interval), text file name and press the save coordinate button then, the request for DEM text file is send which results the DEM file containing latitude, longitude and elevation value with the given name.

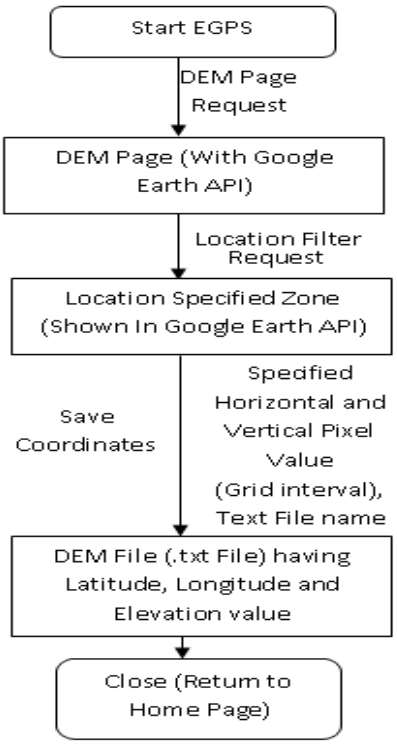

Figure 5.4: Process diagram for Real Time DEM

5.3.3 Process Diagram for Real Time Vegetative Growth and Crop Pattern Analysis

Description of Process Diagram as shown in Figure 5.5:

I. The client passes the URL i.e. www.expertgeoportalsystem.com on the web browser then the requested web page is loaded in the client browser.

II. When user click on the NDVI menu button, NDVI page request is sent to the web server, an HTA page is received back as response to the user which contains two I frames- IFrame1 for third party website and IFrame2 for client application.

III. The client passes the URL of the desired third party website i.e. (GLAM project website) on the interface (IFrame1) provided for third party website.

IV. The requested web page (third party) is loaded in the interface provided for third party website, user select the desired location on the map, location specific request is sent to the third party web server as a result desired zone is displayed on the browser.

V. When user select temporal attribute on the third party interface then, detail image1 of 250 meter resolutions is shown on it.

VI. When user send request for image1 to the web server through the client application page by clicking GetImage1 button, the detail classified image1 is shown on image control1.

VII. User again select temporal attribute on third party interface then, detail image2 of 250 meter resolutions of another time is shown on it.

VIII. When user send request for image2 to the web server through the client application page by clicking GetImage2 button, the detail classified image2 is shown on image control2.

IX. When user sent a difference image request to the web server as a response an image (difference image) is send back which is shown on image control3.

X. On selecting vegetation type of dropdown list present on Growth analysis module, a pie chart is generated, which shows selected vegetation type convert into which other type of vegetation.

XI. When user click on save image button, then an image is downloaded and a database is also created and updated which contains percentage amount of particular vegetation present on the downloaded classified images.

XII. When user select vegetative type of dropdown list present on the Pattern analysis module after downloading significant amount of images, then a pattern graph is generated after using the database that is useful to depict seasonal dynamics.

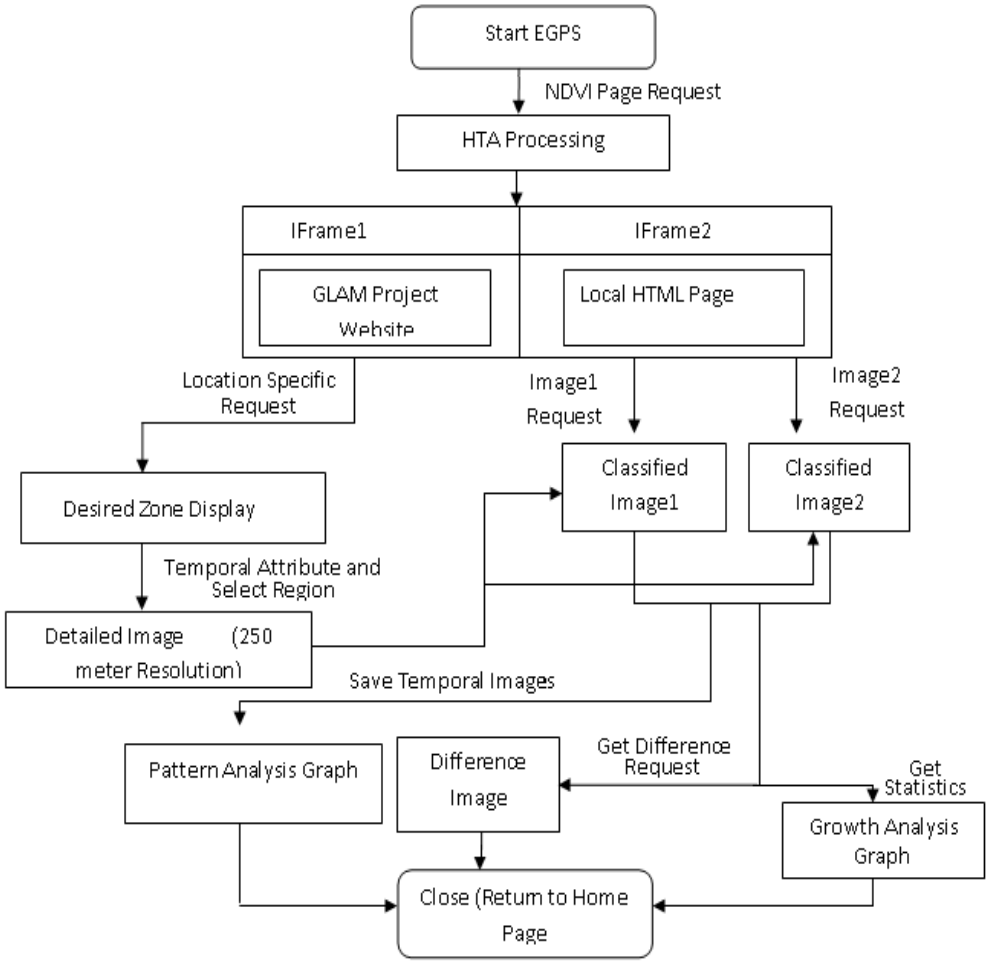

Figure 5.5: Process diagram for Real Time Vegetative Growth and Pattern Analysis

5.3.4 Process Diagram for Image Georeferencing

Description of Process Diagram as shown in Figure 5.6:

I. The client passes the URL i.e. www.expertgeoportalsystem.com on the web browser then the requested web page is loaded in the client browser.

II. When User click on the Geotiff menu button, a Geotiff page request is sent to the web server as a response Geotiff web page is received back to the user which contains the Google earth plugin.

III. Location filter request is sent and as a response to this request specified zone is displayed on Google Earth APIs.

IV. When user sent request for centre coordinates as response latitude, longitude and altitude value of centre point return back to the client application.

V. When user sent request for save coordinates as response a text file is saved which contains latitude, longitude and elevation value at a particular grid interval (i.e.100 pixel).

VI. When user request for Georeferenced image, server process the request by using text file and GDAL Library, as a result a Georeferenced image is automatically saved.

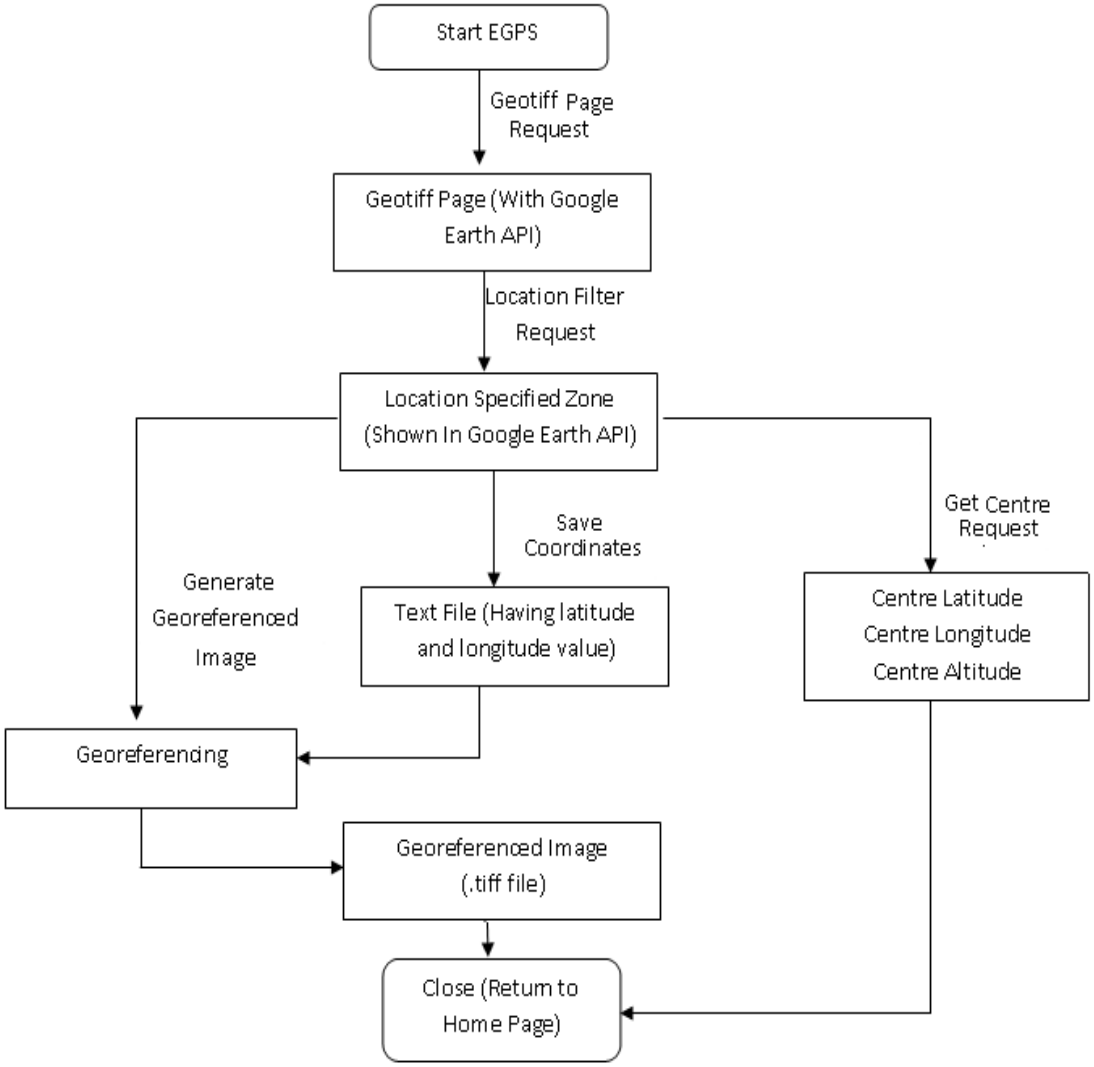

Figure 5.6: Process diagram for generation for Georeferenced Image

Chapter 6
RESULTS AND DISCUSSIONS

6.1 INTRODUCTION

This chapter shows the results obtained after using the data from diverse sources in EGPS, it demonstrates the services and capabilities of the EGPS system for better decision making in comparison to simple web based applications which are built with some specific objectives in their mind.

To accomplish the defined objectives Expert Geoportal System (EGPS) is designed and developed by using Html, Asp. Net (server side scripting language), JavaScript (client side scripting language), Google API's (providing spatial information), GDAL (open source library) and VBA (Excel Macros) in Visual Studio 2008, after going through lots of trial and errors as the interaction with server site is not documented by any service provider using different technologies to import the information. Home Page for this system is shown in Figure 6.1 which consists of a menu bar with options of Home, Location etc. for navigation purpose. The whole functionality of EGPS system is encapsulated into four modules known as:

I. Location Based Services (Location)
II. Vegetative Growth and Crop Pattern Analysis (NDVI)
III. Image Georeferencing (Geotiff)
IV. Real Time Digital Elevation Model (DEM)

Each module is defined by an option on a menu bar with the name of the button mentioned in brackets.

Figure 6.1: Home page of Expert Geoportal System

6.2 LOCATION BASED SERVICES

To provide location-based services EGPS used publicly accessible database provided by Makaan.com andYahoolocal.in web applications. Makkan.com arranged its front end data in tabular format while yahoolocal.in data is randomly arranged with the help of HTML div tag.

6.2.1 Application page

When user click the location button of a menu bar, HTML application (HTA) is executed, the system opens with two Iframes for opening two different web pages, one for third-party website and other for client application. HTA is used to resolve security constraints present on Internet explorer, so cross site scripting is done. The startup window is shown in Figure 6.2.

Iframe1 shown in the Figure 6.2 is used by EGPS for browsing third party (makaan.com or yahoolocal.in) web application, Iframe2 is used as a user interface to the client application which contains buttons, dropdownlists, textboxes and Google Map etc.

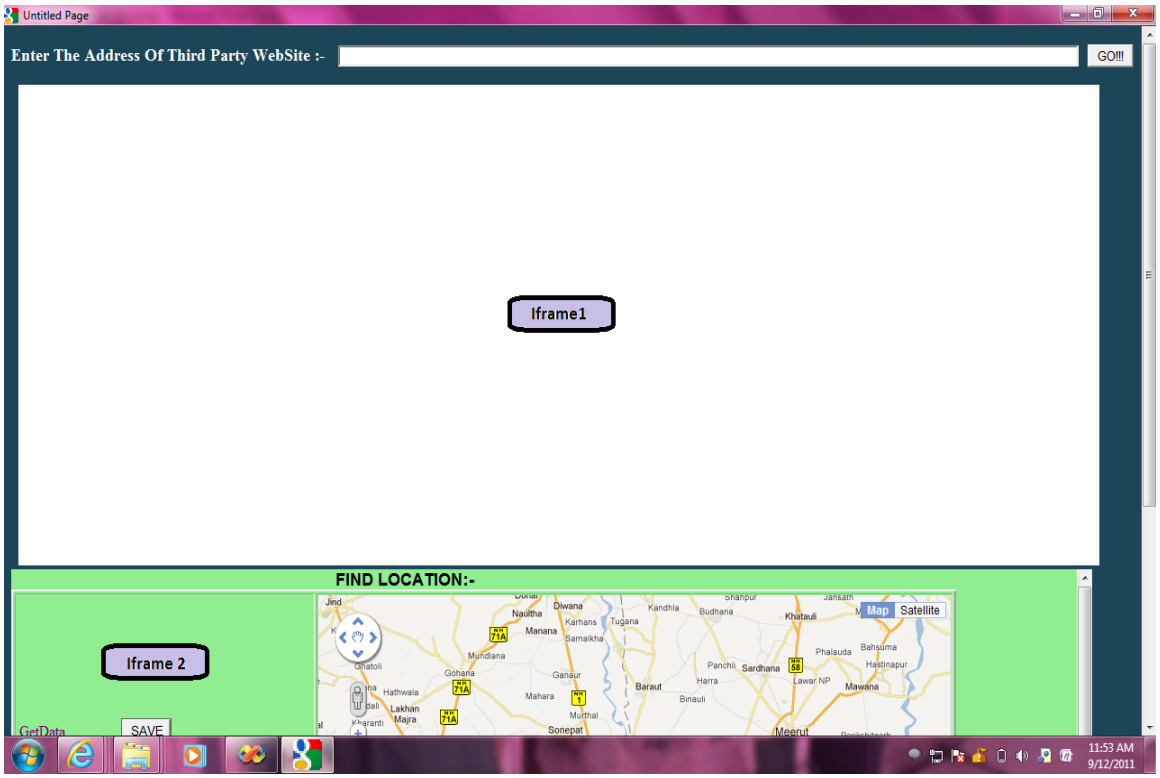

Figure 6.2: Application page showing two Iframes

6.2.2 Results obtained for makaan.com

The results obtained by using front end data provided by makaan.com are shown from Figure 6.3 to Figure 6.11**.** These figures shows step by step results obtained for makaan.com web data.

Figure 6.3 shows the makaan.com search property page which contains options for selecting property type (Residental, Commercial), city name, budget, area, locality etc. User firstly specifies these attributes according to their specific requirement.

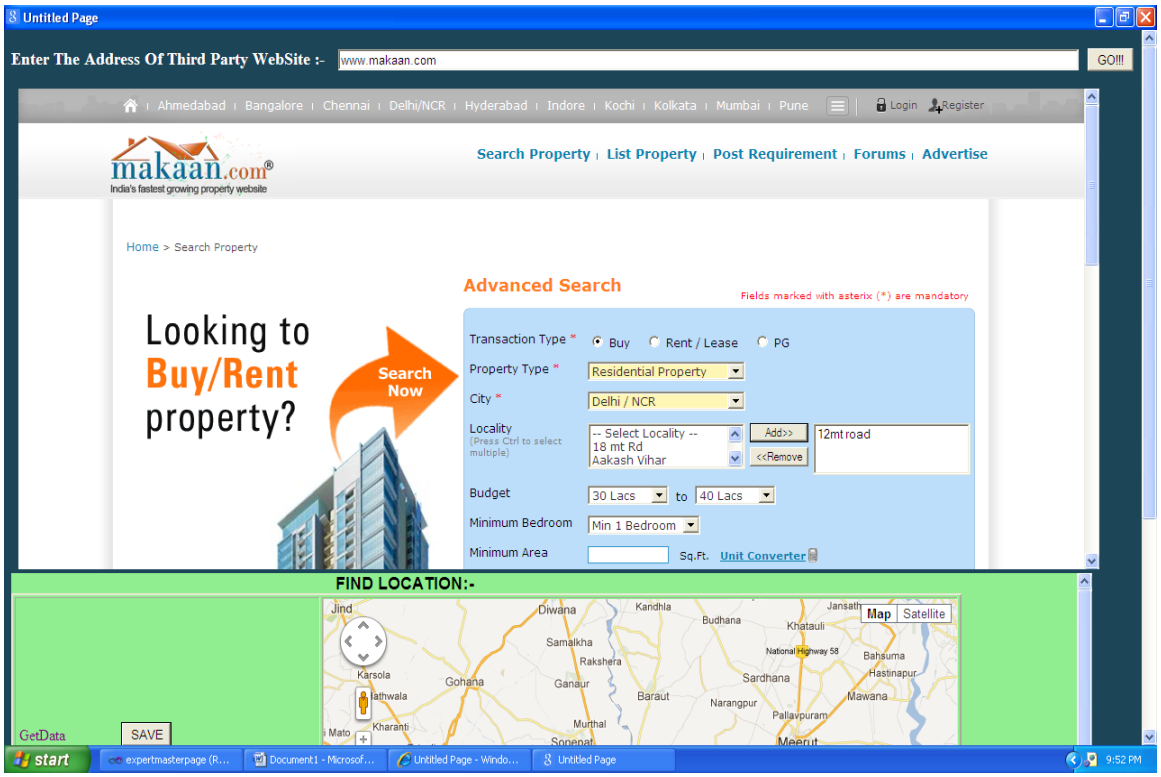

Figure 6.3: Application page shows search property web page of makaan. com after passing Url by the user

Figure 6.4 shows the web page of makaan.com which contains non spatial information e.g. “Apartment for sale in Bhopura, Ghaziabad”, “Apartment for sale in Mahavair Enclave, Delhi West” provided by makaan.com server after processing the attribute values passed by user on to the web page shown in Figure 6.3.

When user click on save button of the client application web page as shown in Figure 6.5. The application used JavaScript, Asp.net and web query for interacting with the makaan.com website and get its front end non spatial data present on web page shown in Figure 6.4 on an Excel sheet. Further, VBA programming is done for rearranging this Excel data (see Appendix II, Figure 5) into proper format before exporting it into a dropdown list box present on the client application as shown in Figure 6.5.

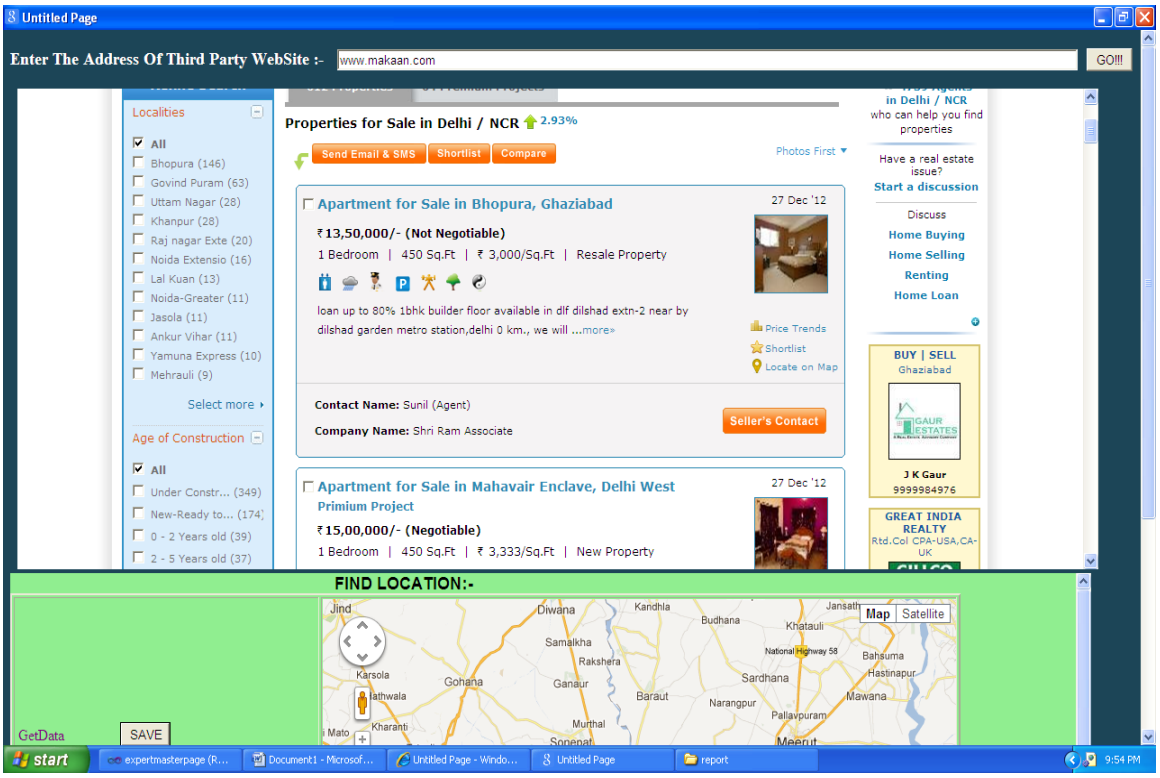

Figure 6.4: Application page showing non spatial information on makaan.com

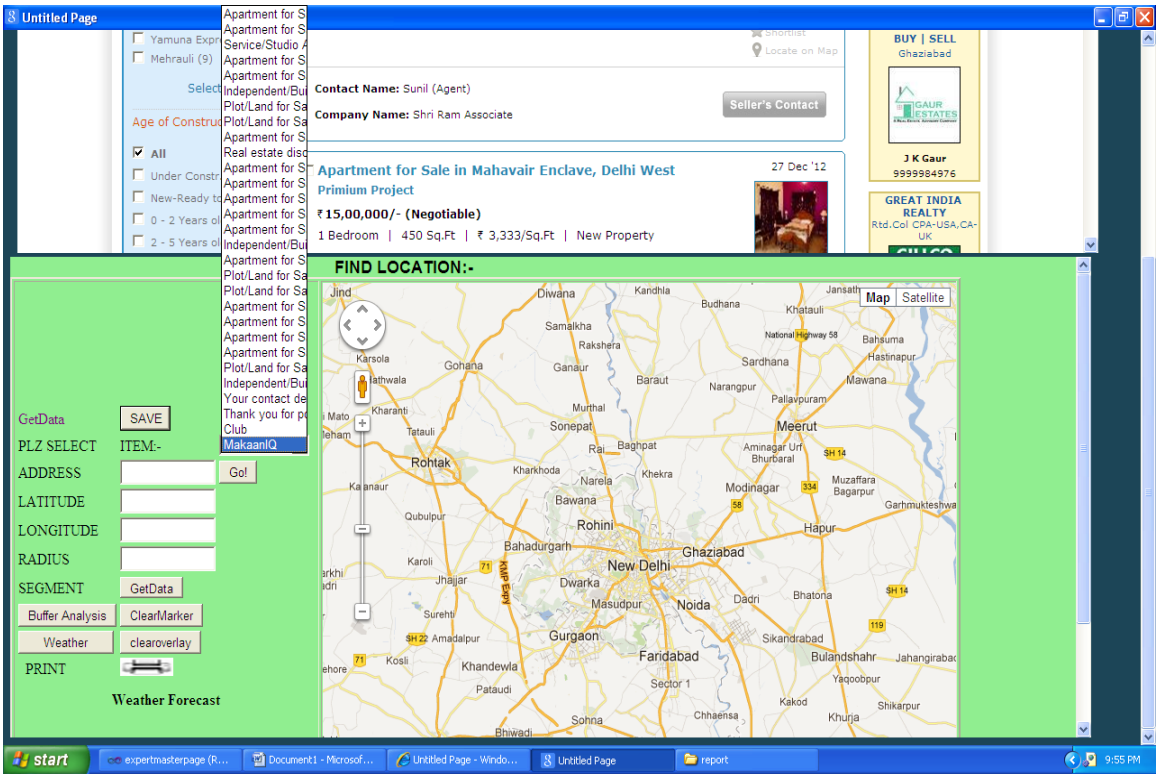

Figure 6.5: Dropdown list showing non spatial information provided by makaan.com

6.2.2.1 Show location

It is used to show a single location on the map with its latitude and longitude as shown in Figure 6.6.

When user click on the Go button present on the client application as shown in Figure 6.6, the geocoding function of the Google map API executed as a result non spatial value selected by user from dropdown list shown in Figure 6.6 is automatically converted into spatial value and the marker corresponding to that value shown onto the map, with its latitude and longitude value in the text boxes present on the client application.

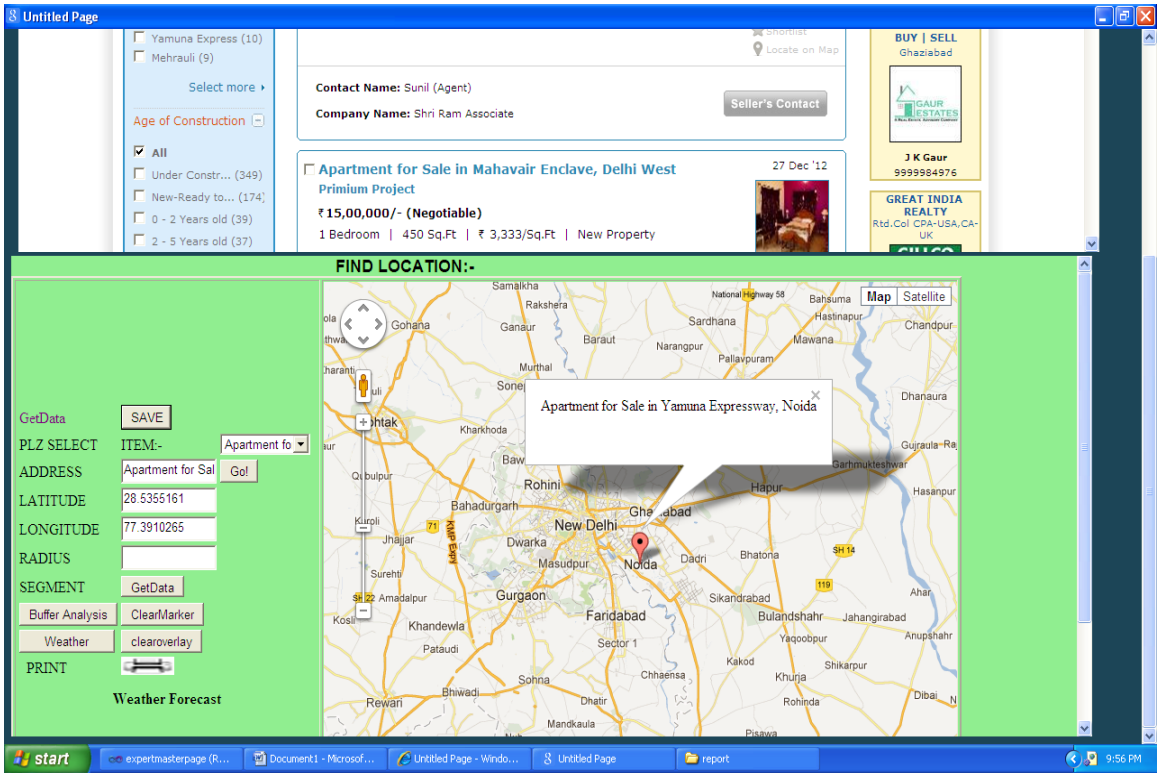

Figure 6.6: Application page showing the location on the Google Map

6.2.2.2 Buffer Analysis

Buffer analysis is used for identifying areas surrounding geographic features. The process involves generating a buffer around existing geographic features and then identifying or selecting features based on whether they fall inside or outside the boundary of the buffer. It is used for better decision making, this feature is not present on makaan.com website. The expert geoportal system provides this facility to its user in which, from the selected position

of his/her choice user can specify a buffer zone of any radius in km to find real estate properties in that buffer zone and then he/she can make the proper decisions to select one which is most appropriate as shown in Figure 6.7 and Figure 6.8.

When user specify radius , its current location and click on the Buffer analysis button present on the client application, after getting data by clicking on GetData buton as shown in Figure 6.7, a buffer zone is created around its current location of given radius and only those values of markers is shown whose distance is less than or equal to the radius precise by user as shown in Figure 6.7 and Figure 6.8.

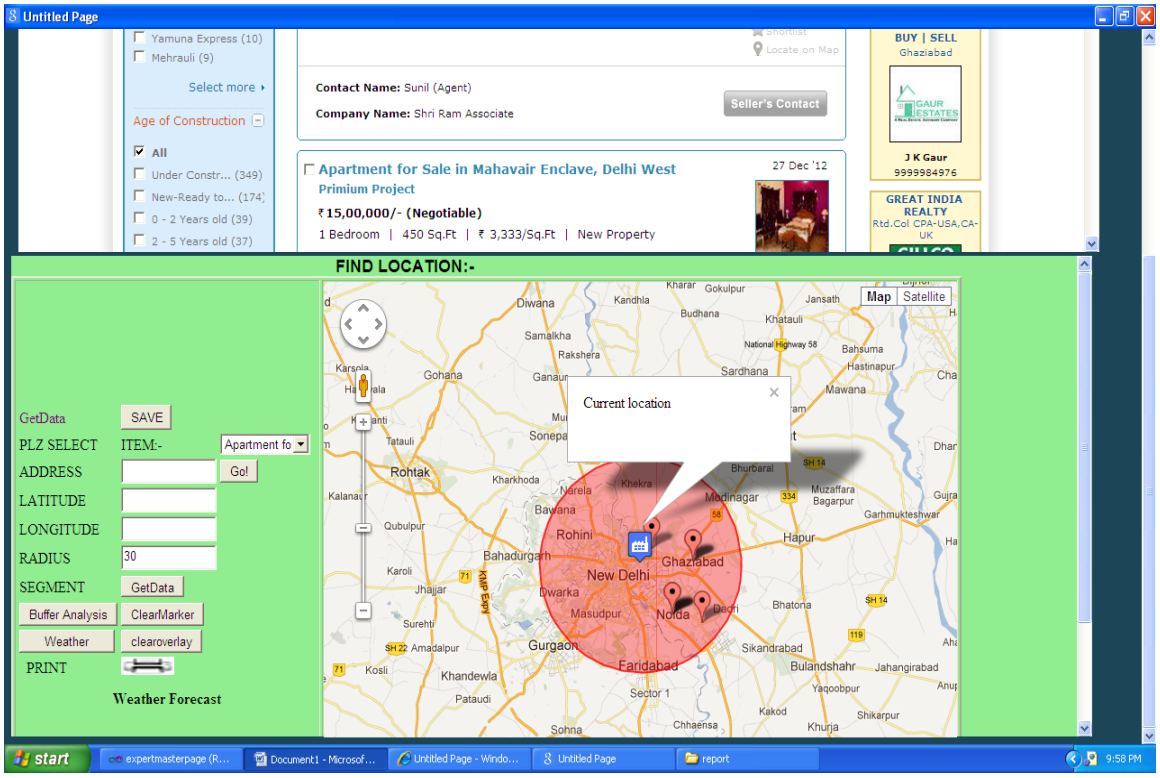

Figure 6.7: Application page showing buffer on a Google Map

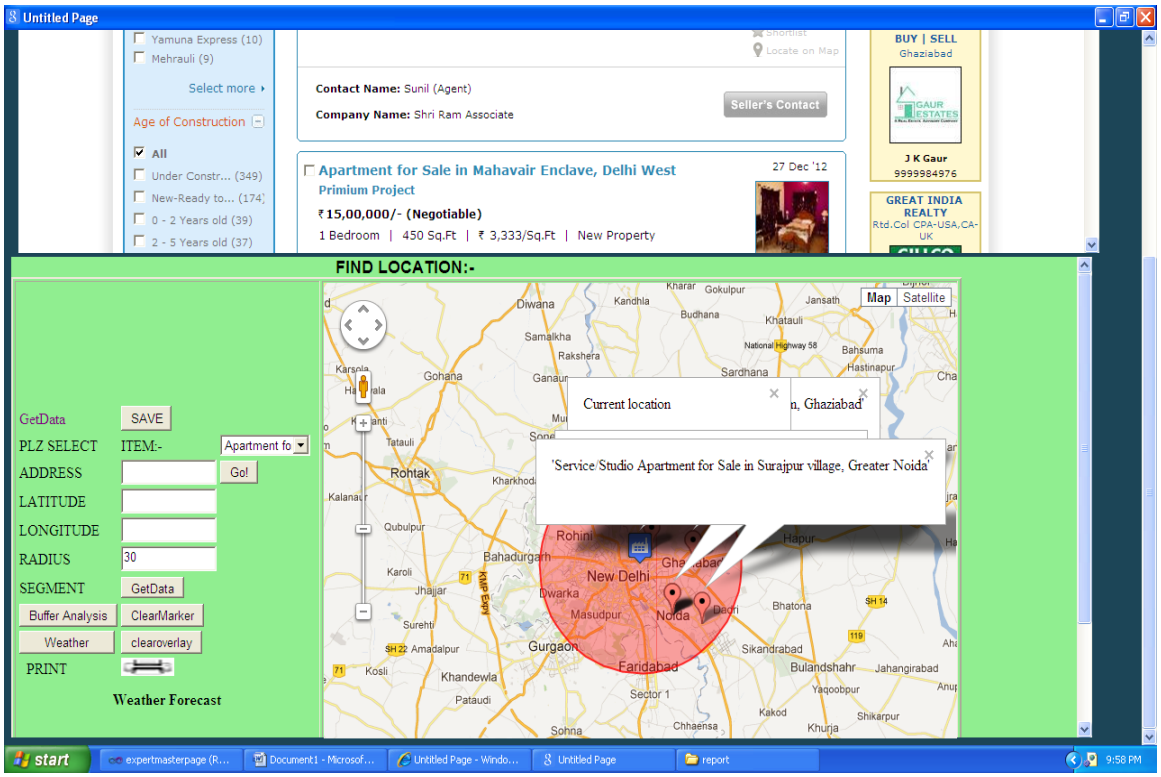

Figure 6.8: Application page showing locations on the buffer created on a Google Map

6.2.2.3 Local Weather forecasting

Weather forecasting is a very important application in meteorology, EGPS provides this facility by calling freely available weather service of wunderground.com by passing spatial attributes (Latitude and Longitude) to get the weather forecast for the whole buffer zone as shown in Figure 6.9.

For providing weather forecast information, EGPS uses non spatial data provided by makaan.com web application by recurrsively converting them into spatial data (latitude and longitude) with the help of Geocoding function present on Google Map APIs and then passing them repeately into the web service provided by wunderground.com.

When user click on the weather button, the weather information which includes latitude, longitude, wind speed, temperature and cloud information is shown in the tabular format in the client application as shown in Figure 6.9.

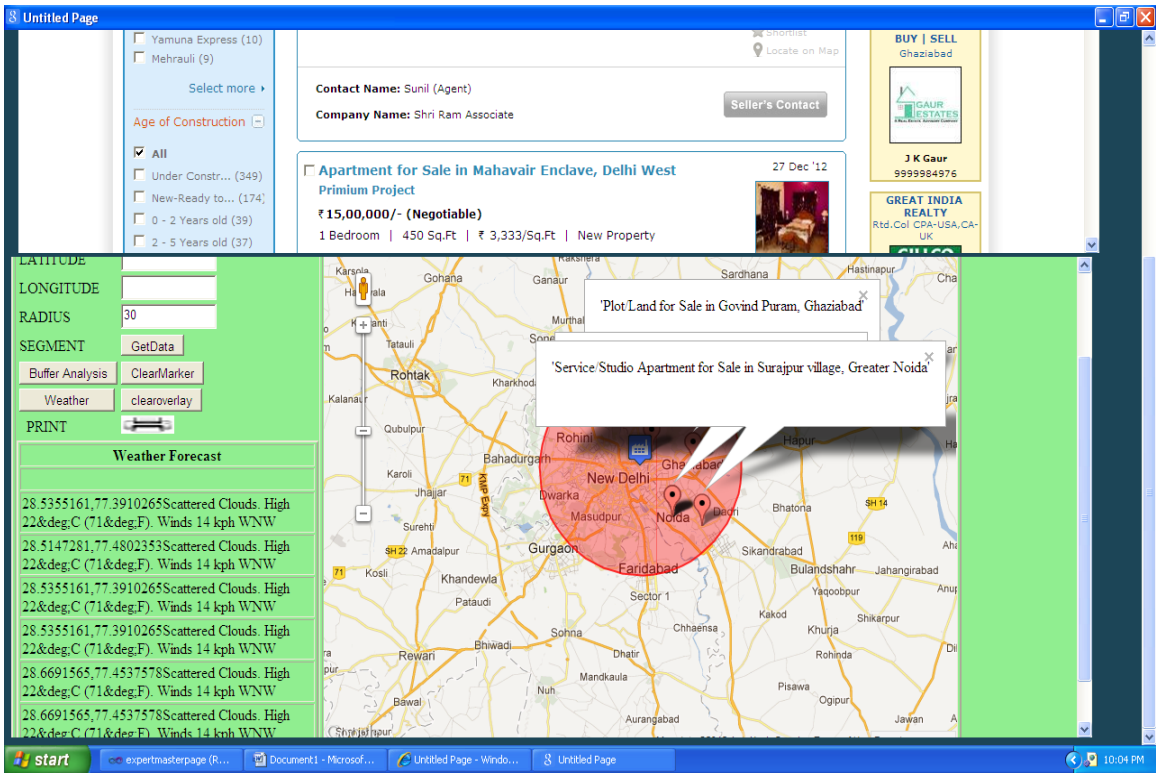

Figure 6.9: Application page showing weather forecast for the buffer created on a Google Map

6.2.2.4 Print

To provide hard copy output, EGPS also provide the printing option on a single click as shown in Figure 6.10 and Figure 6.11**.**

Figure 6.10 shows the print output of a single location selected by user, while Figure 6.11 shows the print output of a full buffer for the user specified radius with locations.

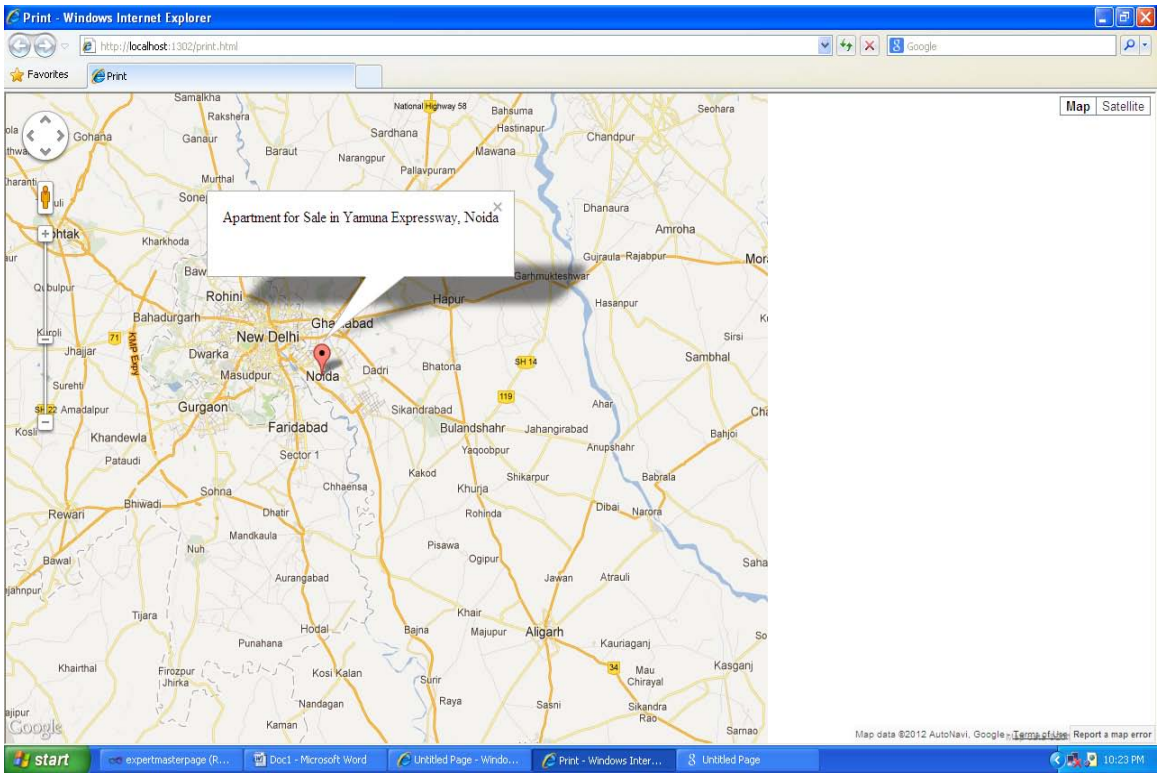

Figure 6.10: Showing print output for a single location

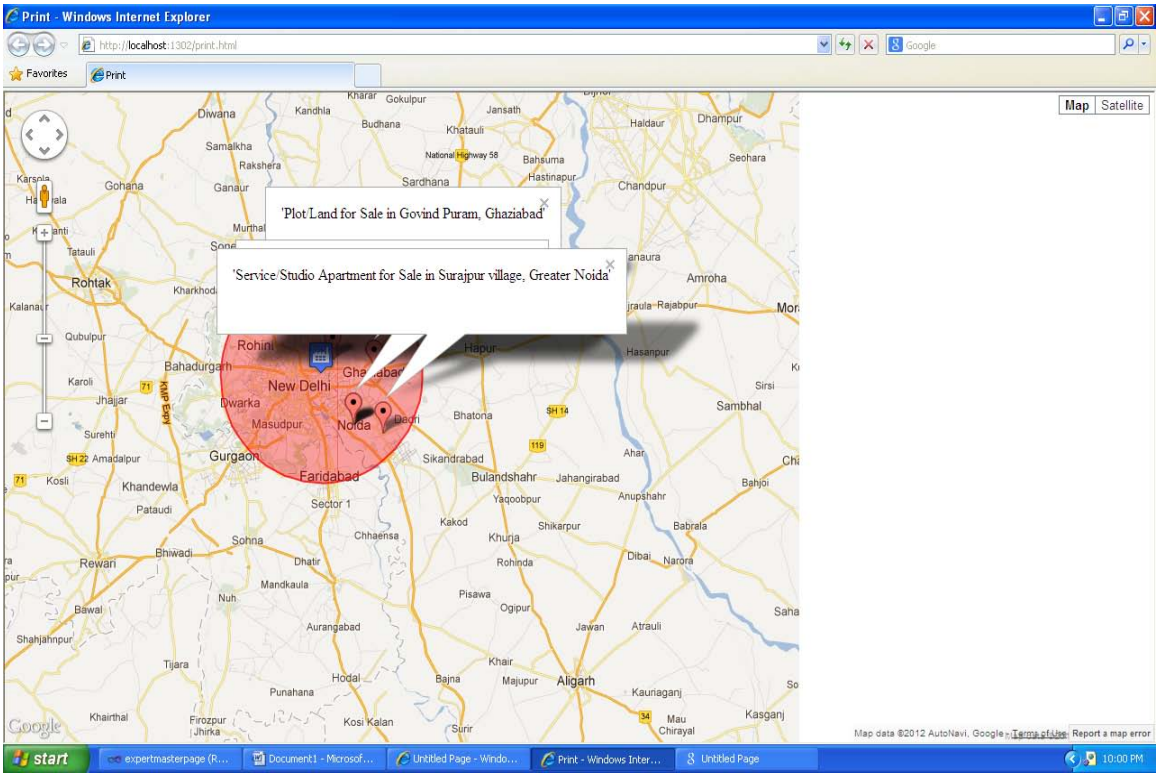

Figure 6.11: Showing print output for a buffer

6.2.3 The result obtained by using data provided by Yahoolocal.in

The results obtained by using front end data provided by yahoolocal.in are shown from Figure 6.12 to Figure 6.18**.**

6.2.3.1 Show Location

It is used to show the exact position of a selected attribute onto the map with its latitude and longitude, so that it is easily recognizable by unknown user, this facility was not available on yahoolocal.in.

Figure 6.12 shows the yahoolocal.in home page which contain options for selection, from giving categories like restaurants, entertainment, health, travel and lodging etc. Users can also change the city by using dropdown option, search from the given search boxes by passing attribute values according to their requirement.

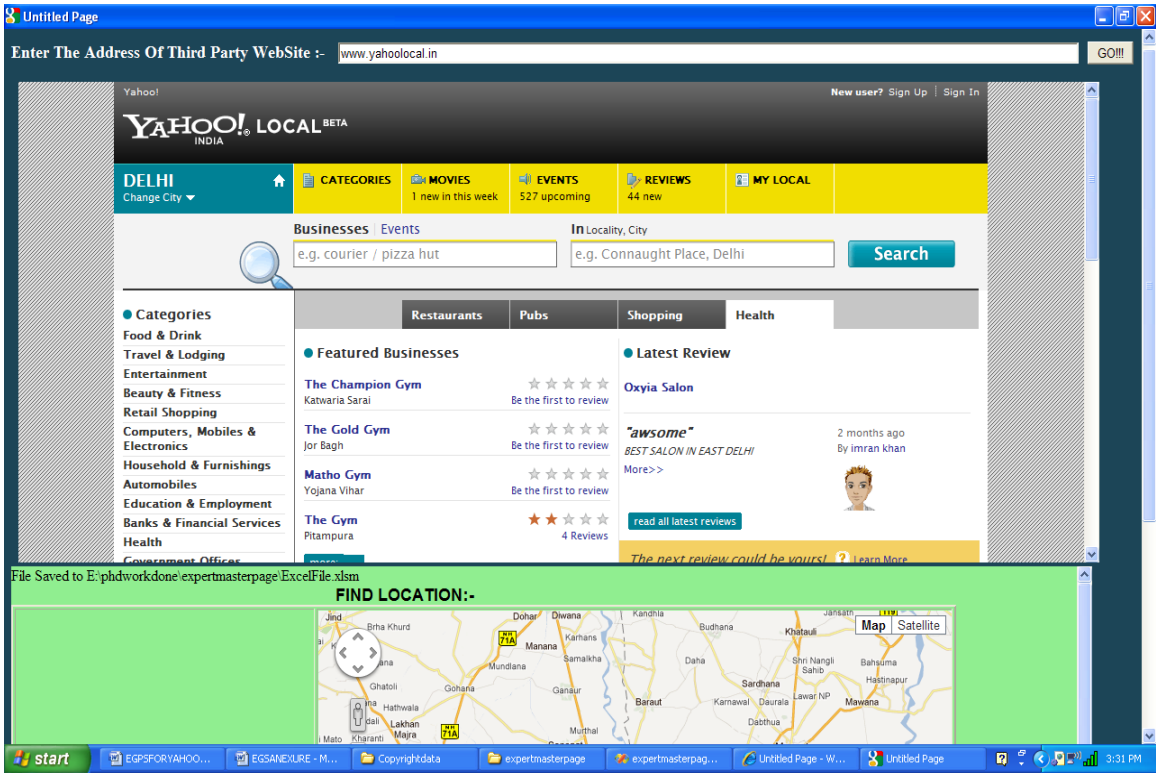

Figure 6.12: Application page showing data on yahoo local.in after passing Url by the user

Figure 6.13 shows the yahoolocal.in web page containing non spatial information (Restaurants) e.g. “Ra Bar”, “Pizzeria And Pasta Bar” provided by yahoolocal.in server for Mumbai city after processing the attribute values (Italian reastaurants, Mumbai) passed by user in the search boxes present on the web page.

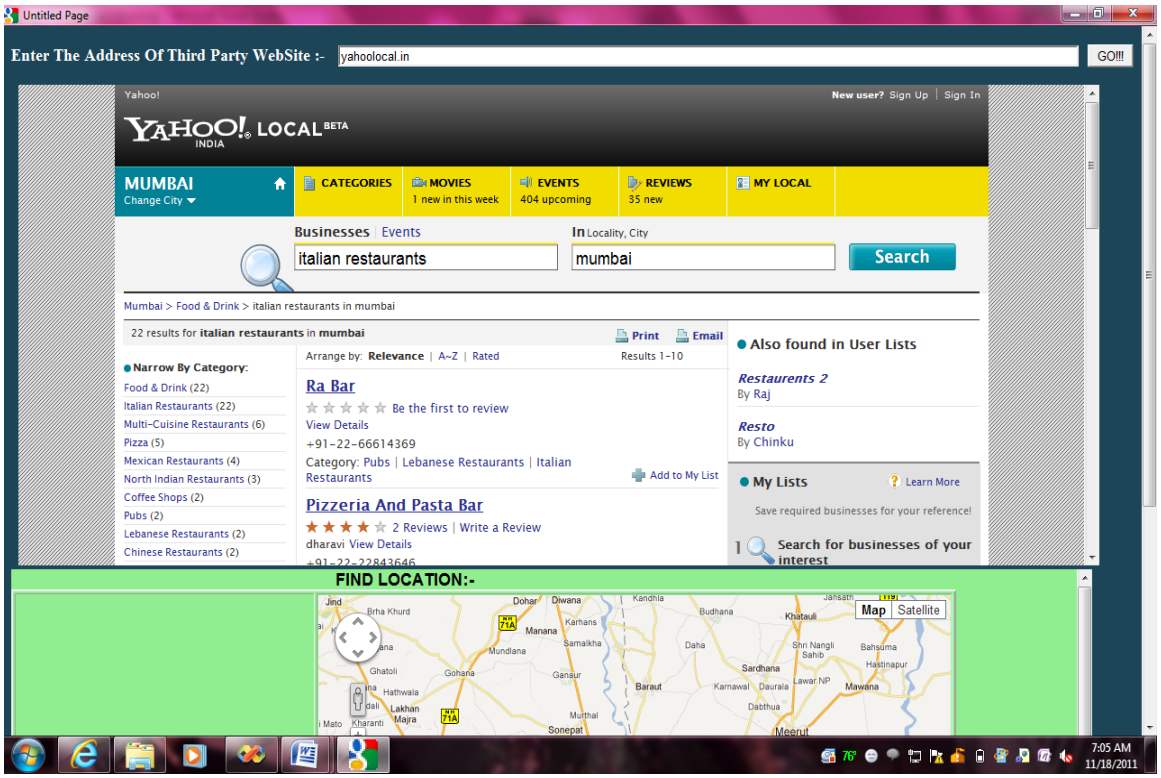

Figure 6.13: Application page showing Restaurants information on yahoo local. in for Mumbai city

When user click on save button of the client application web page as shown in Figure 6.14. The application uses JavaScript, Asp.net and web query for interacting with yahoolocal.in website and get its front end non-spatial data present on web page shown in Figure 6.13 on an Excel sheet (see Appendix II, Figure 4). Further, VBA programming is done for rearranging this Excel data into proper format (see Appendix II, Figure 5), before exporting it into a dropdown list box present on the client application as shown in Figure 6.14.

When user click on the Go button present on the client application as shown in Figure 6.15, after selecting non-spatial value from dropdown list as shown in Figure 6.14 , the geocoding function of the Google map API is executed as a result that non- spatial value is automatically converted into spatial value and the marker corresponding to that value shown on the map, with its latitude and longitude value in the text boxes present on the client application shown in Figure 6.15.

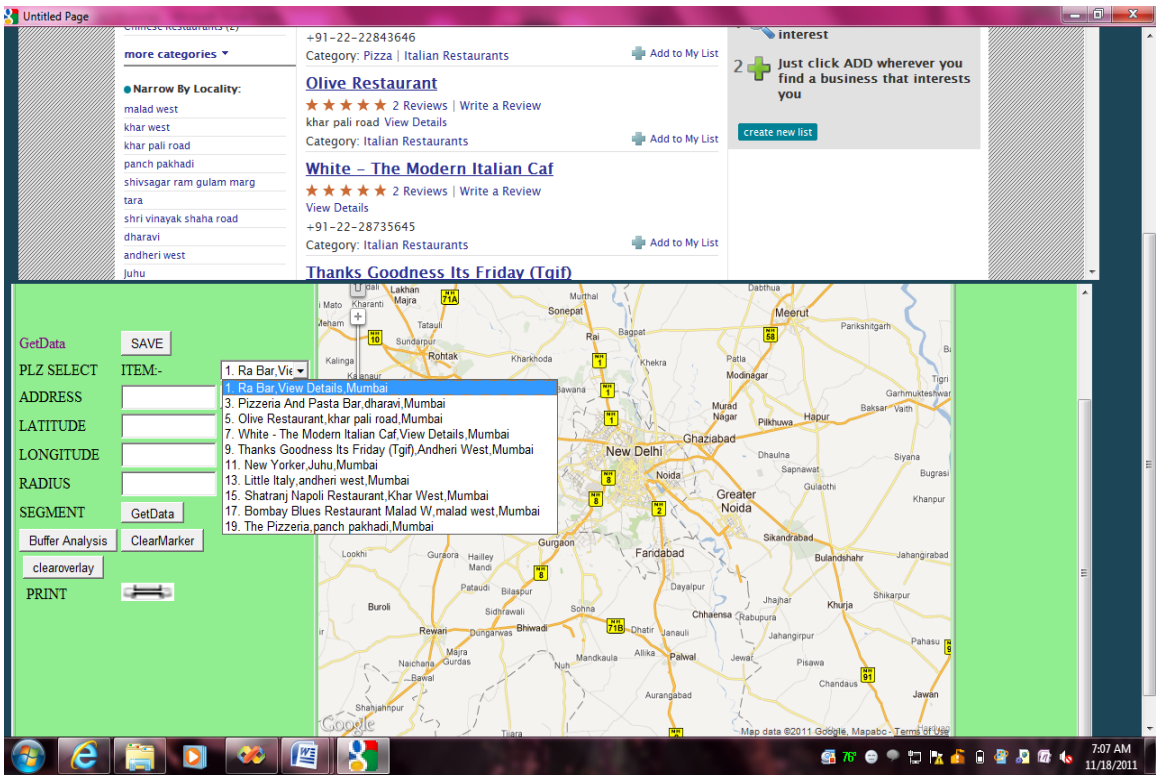

Figure 6.14: Dropdown list showing Restaurants information of Mumbai city provided by Yahoolocal.in

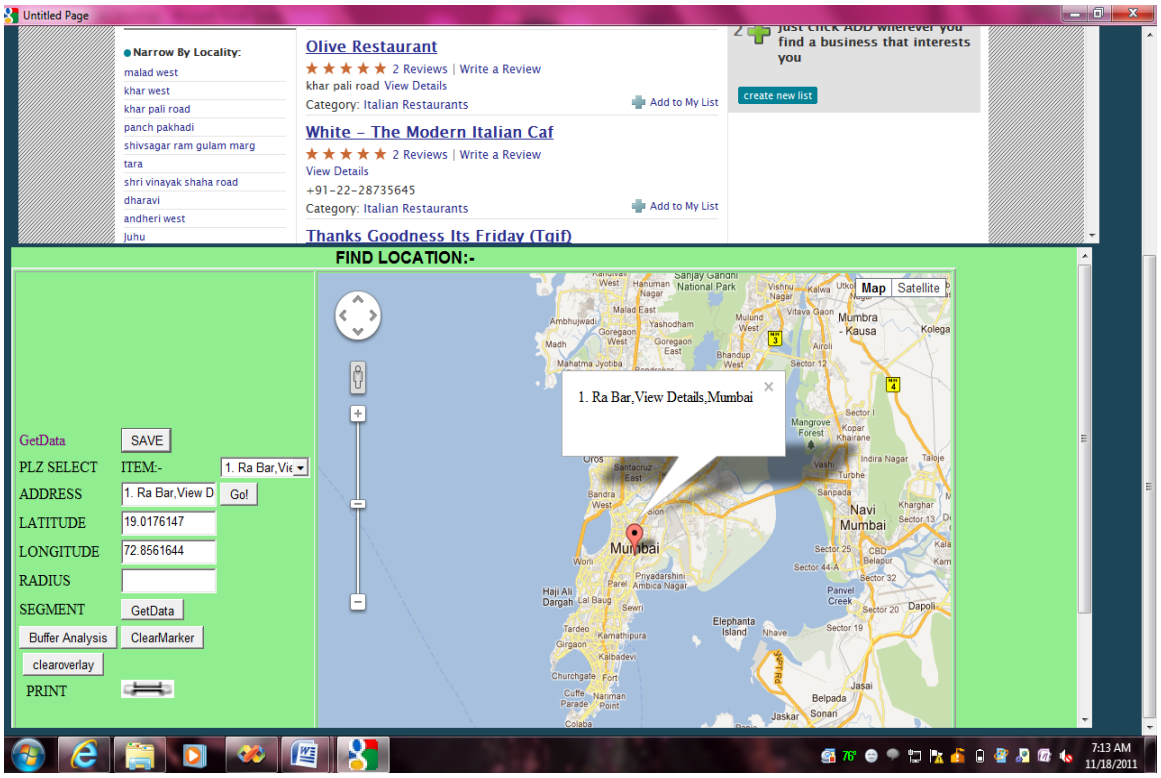

Figure 6.15: Application page showing location of "Ra Bar" restaurant in Mumbai on the Google Map

6.2.3.2 Buffer Analysis

Buffer analysis is used for better decision making. Since this feature was not present on Yahoolocal.in, the Expert Geoportal System provides this facility to its user by which, from the selected position of his/her choice user can specify a buffer zone of any radius in kilometer to find Hotels, Restaurants, Malls etc. and then he/she can make the proper decisions to select one which is most appropriate as shown in Figure 6.16.

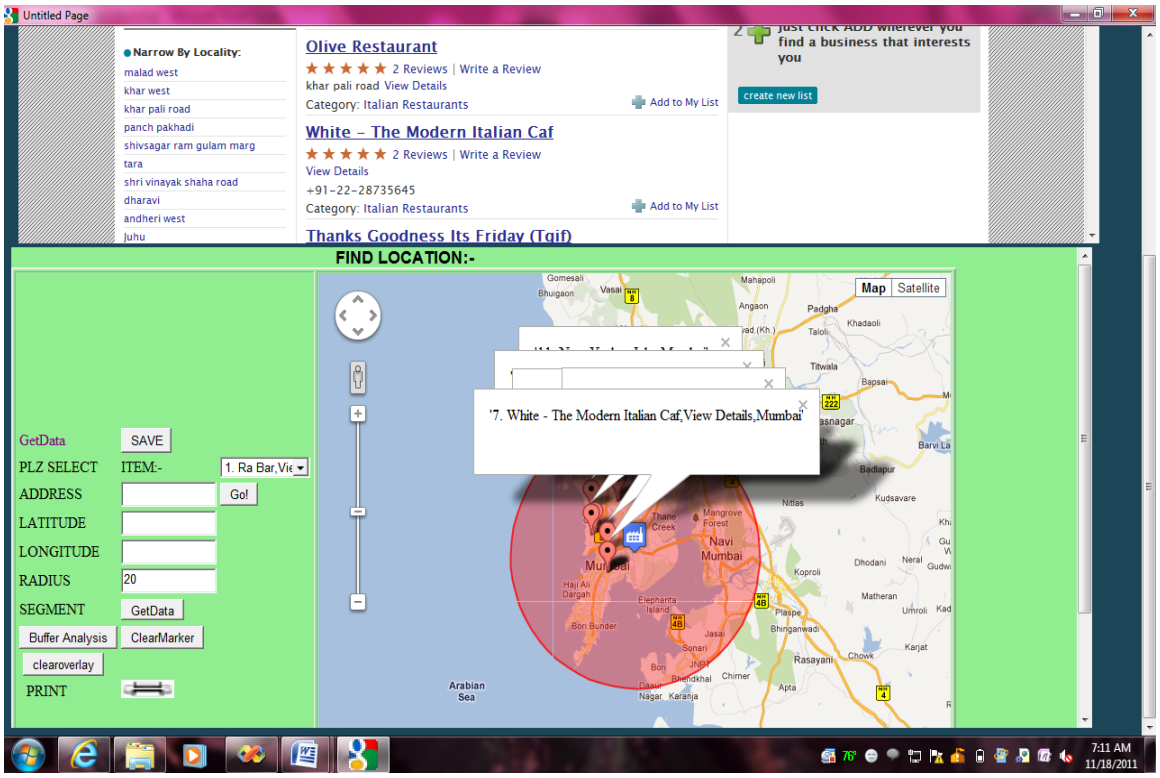

Figure 6.16: Application page showing location of Restaurants in Mumbai on the buffer created on a Google Map

6.3.3 Print

To provide hard copy output, EGPS also provide the printing option as shown in Figure 6.17 and Figure 6.18.

Figure 6.17 shows the print output of a single location selected by user, while Figure 6.18 shows the print output of a full buffer for the user specified radius with locations.

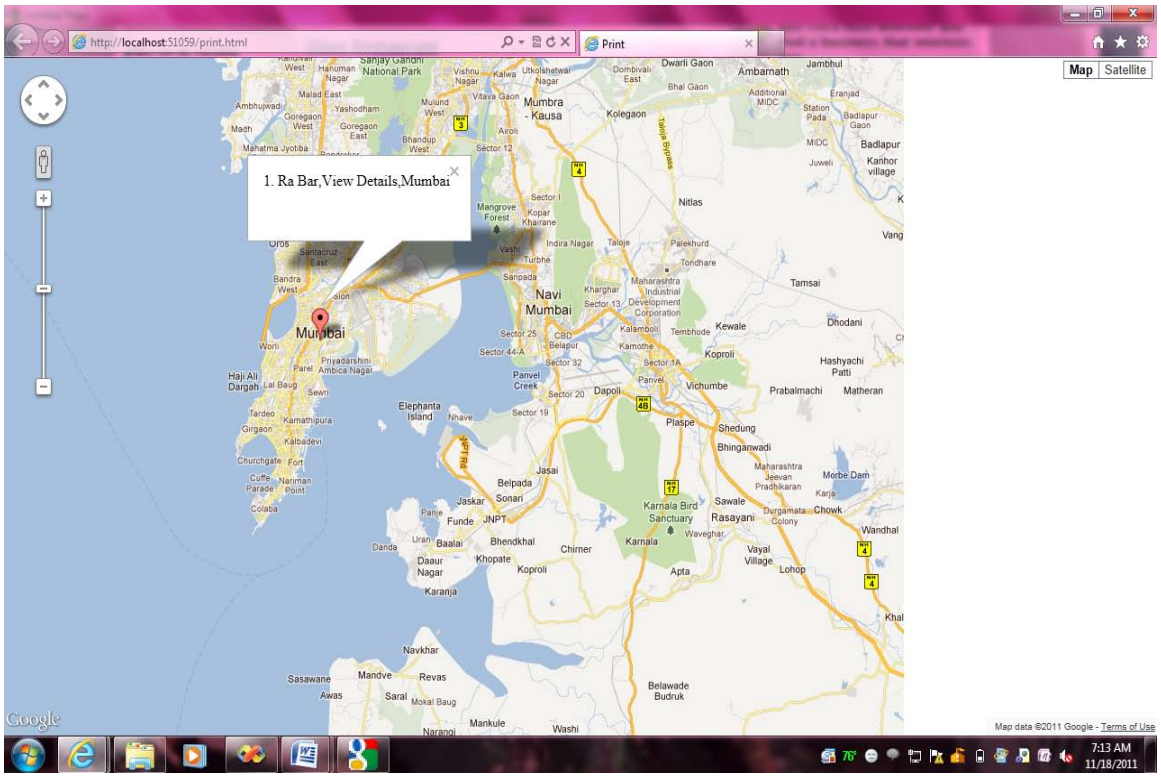

Figure 6.17: Showing print output for "Ra Bar" restaurant in Mumbai

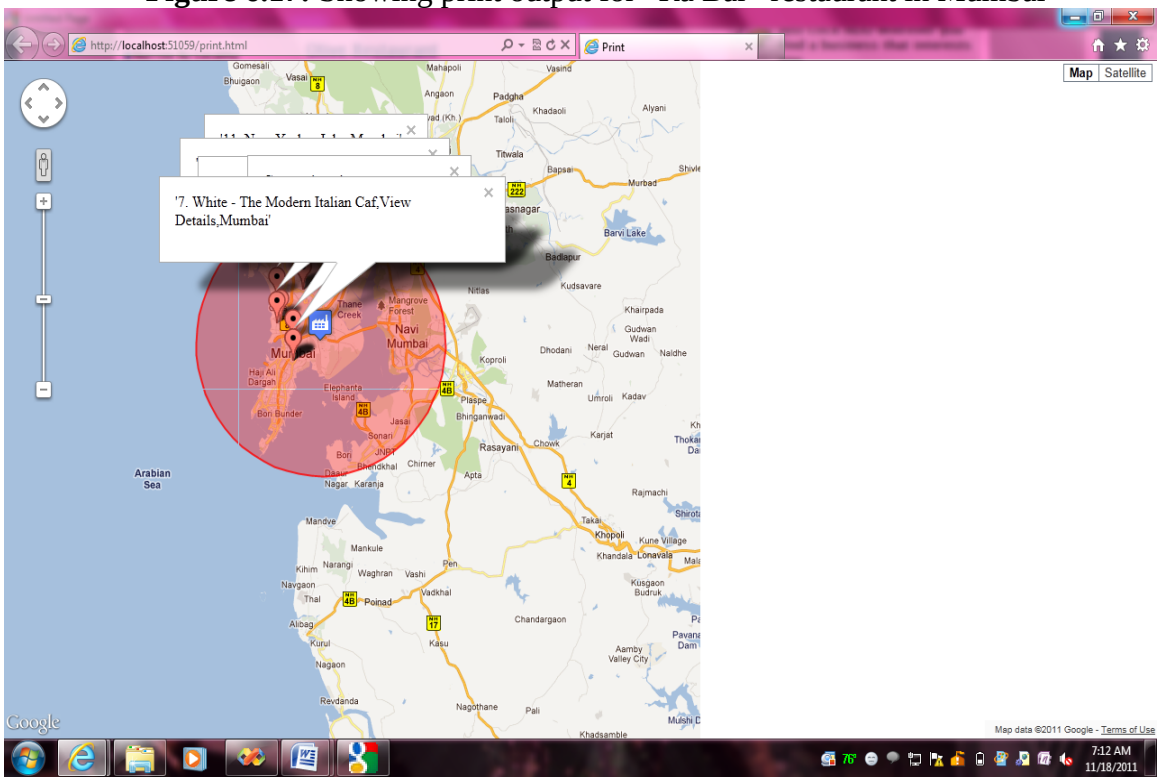

Figure 6.18: Showing print output for Restaurants in Mumbai with 20 km buffer

6.3 VEGETATIVE GROWTH AND CROP PATTERN ANALYSIS

The main objective of this module is to provide the real time information about the vegetation growth of the selected region. This module is divided into two phases**,** in the first phase the change detection image was generated through a digital comparison of the two temporal classified images, using the data provided by the GLAM website by accessing their public database as shown from Figure 6.19 to Figure 6.22. This change detection image (difference image) as shown in Figure 6.22, shows changes in vegetation types occurring throughout the selected region between two time periods.

In the next phase a pie chart is plotted which shows the percentage amount of particular vegetation type change into another. For e.g. dense vegetation changes into sparse or bare land etc. as shown from Figure 6.23 to Figure 6.25.

6.3.1 Vegetative Growth Analysis

Figure 6.19 shows the GLAM project website web page containing regional image of 2.5 km resolution which contains options for selecting temporal attribute and can also specify a region by clicking on the image.

Figure 6.20 shows the GLAM project web page containing detailed image of 250 meter resolution, after processing the attribute values passed by user and selecting the specific region on the web page shown in Figure 6.19.

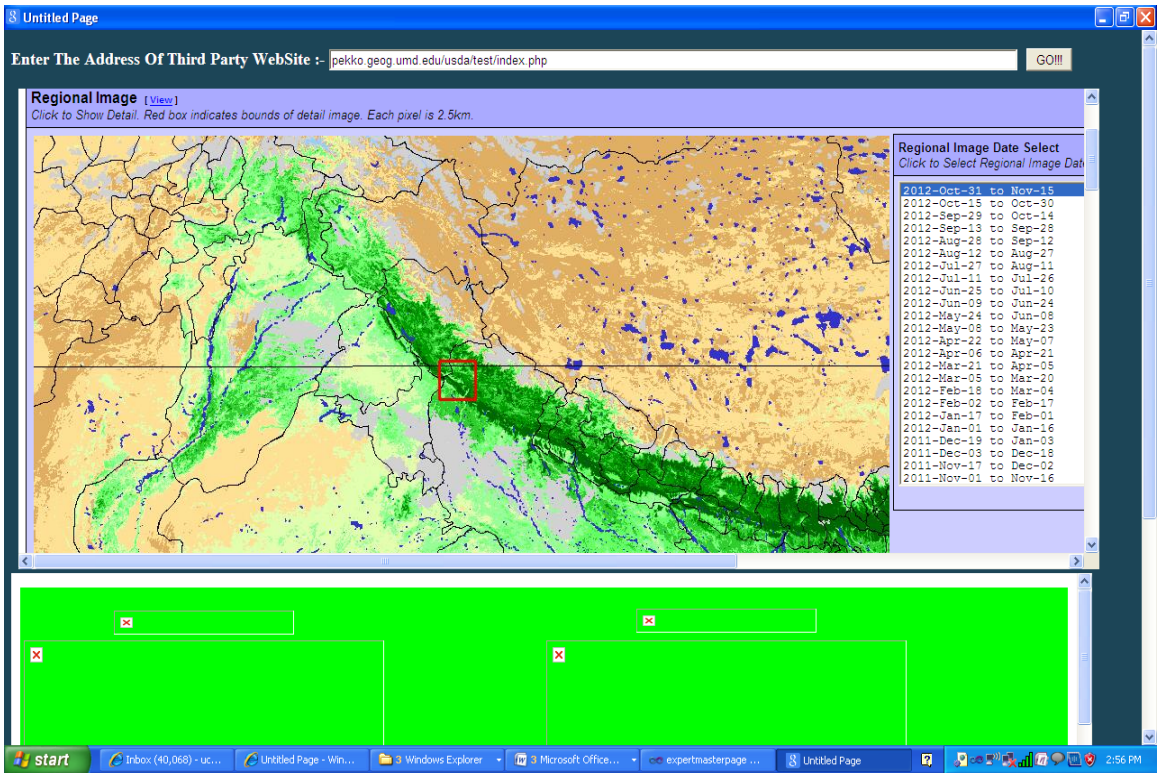

Figure 6.19: Application page showing regional image (2.5 kilometre/pixel) of the GLAM website after passing Url by the user

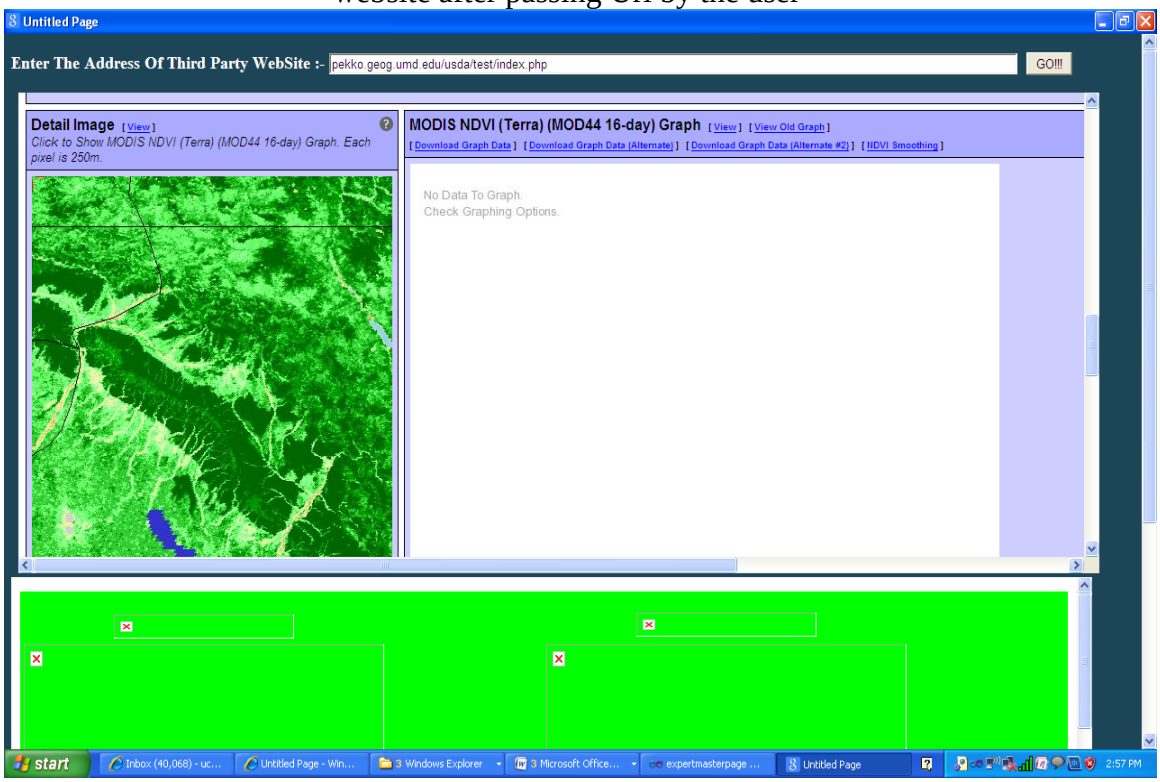

Figure 6.20: Application page showing a detail image (250 meter/pixel) provided by GLAM website

When user click on the GetImage1 button present on the client application, application use JavaScript and Asp.net for interacting with GLAM website and save the whole web page in the form of image (see Appendix II, Figure 6), further detail image1 (see Appendix II, Figure 7) is clliped and restored (see Appendix II, Figure 8) before exporting it into the imagecontrol1 present on the client application. Similarly, after clicking on GetImage2 button the detail image2 of another time appears in imagecontrol2 as shown in Figure 6.21.

When user click on the GetDifference button present on the client application as shown in Figure 6.22, the difference image (see Appendix II, Figure 9) is generated in which if there is a change in the vegetation of image1 and image2, then in the difference image pixel position the RGB value calculated by taking average of RGB value of the pixel present in first image with the (RGB)/2 value of the corresponding pixel of the second image is filled, else pixel (color (RGB value)) remains same.

When the user selects sparse vegetation from the dropdown list present on the client application as shown in Figure 6.23. The pie chart is generated which shows 3.76% of sparse vegetation type converted into dense vegetation, 19.89% of the sparse vegetation remain same etc.

Similarly, after selecting dense vegetation and water bodies, percentage amount of converted vegetation will reflect in the Figure 6.24 and Figure 6.25.

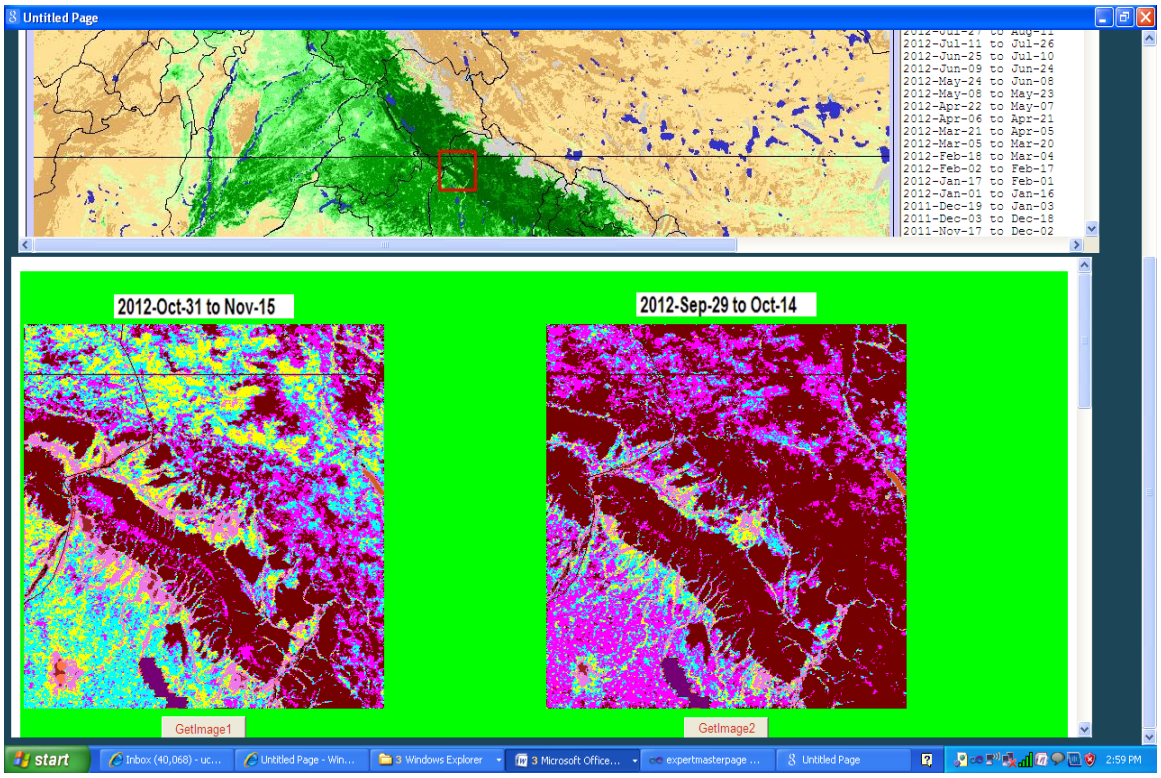

Figure 6.21: Client application shows temporal images of GLAM website

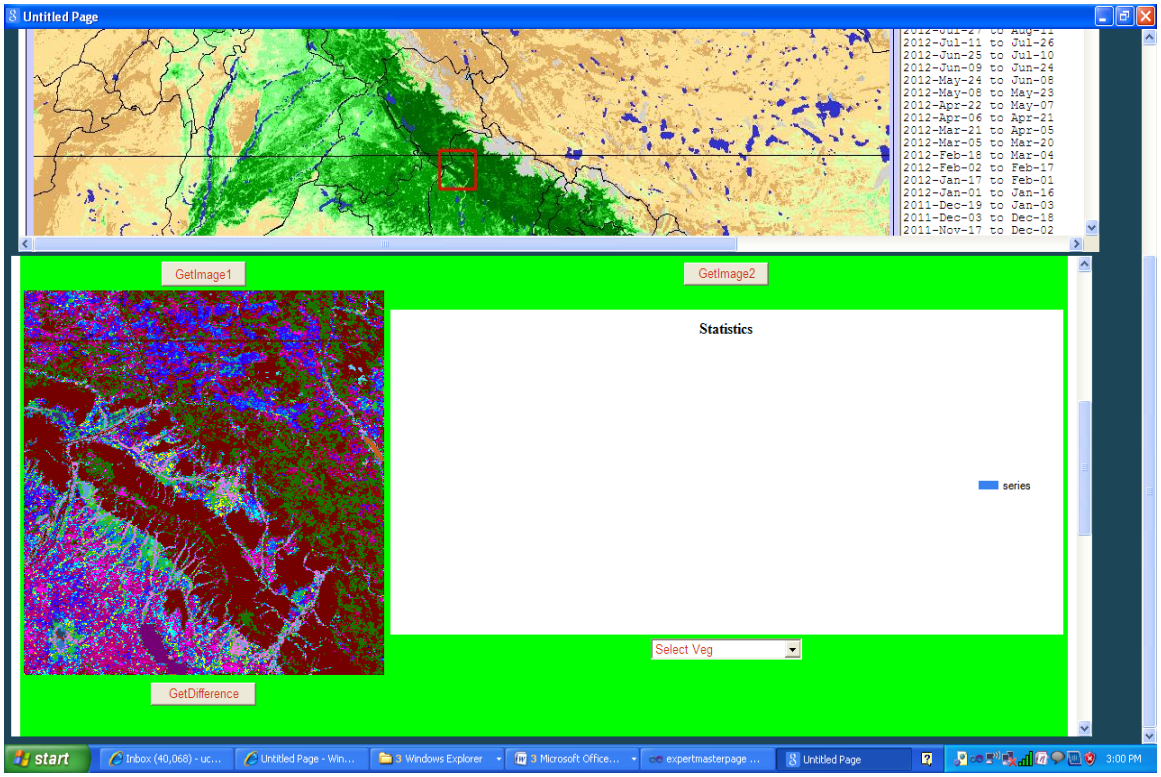

Figure 6.22: Client application shows the difference image

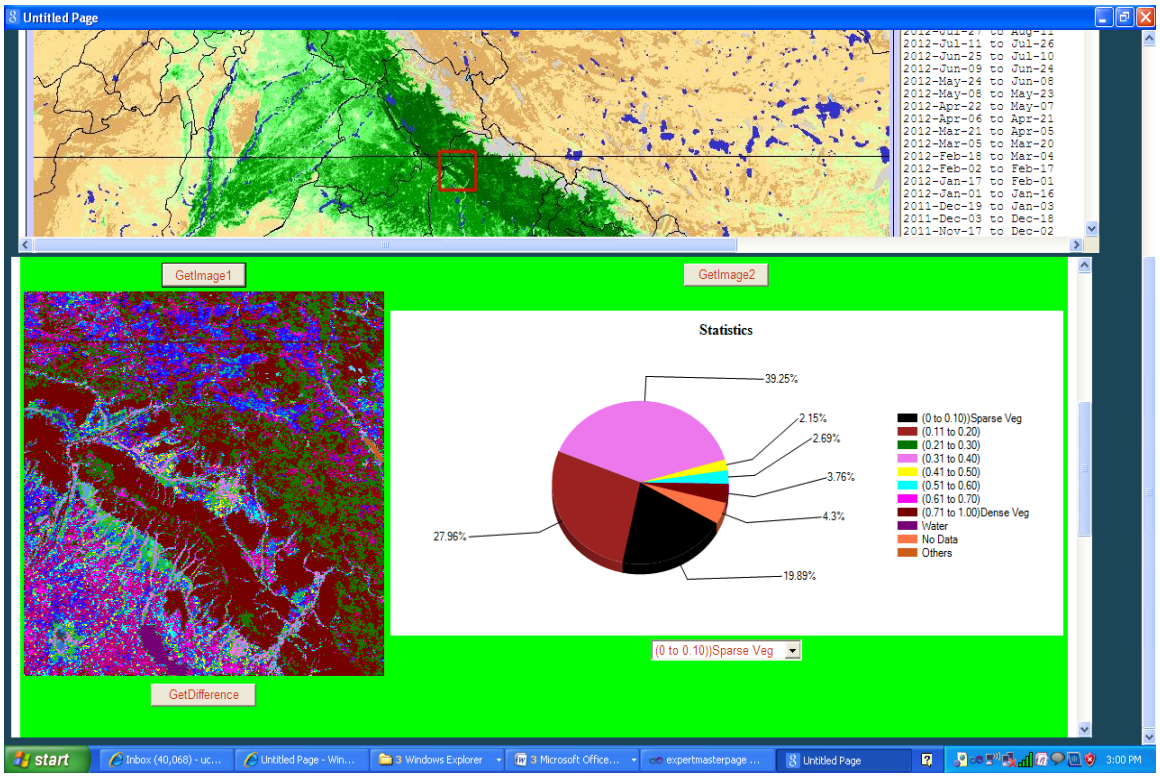

Figure 6.23: Client application shows the percentage amount of change of sparse vegetation to another type

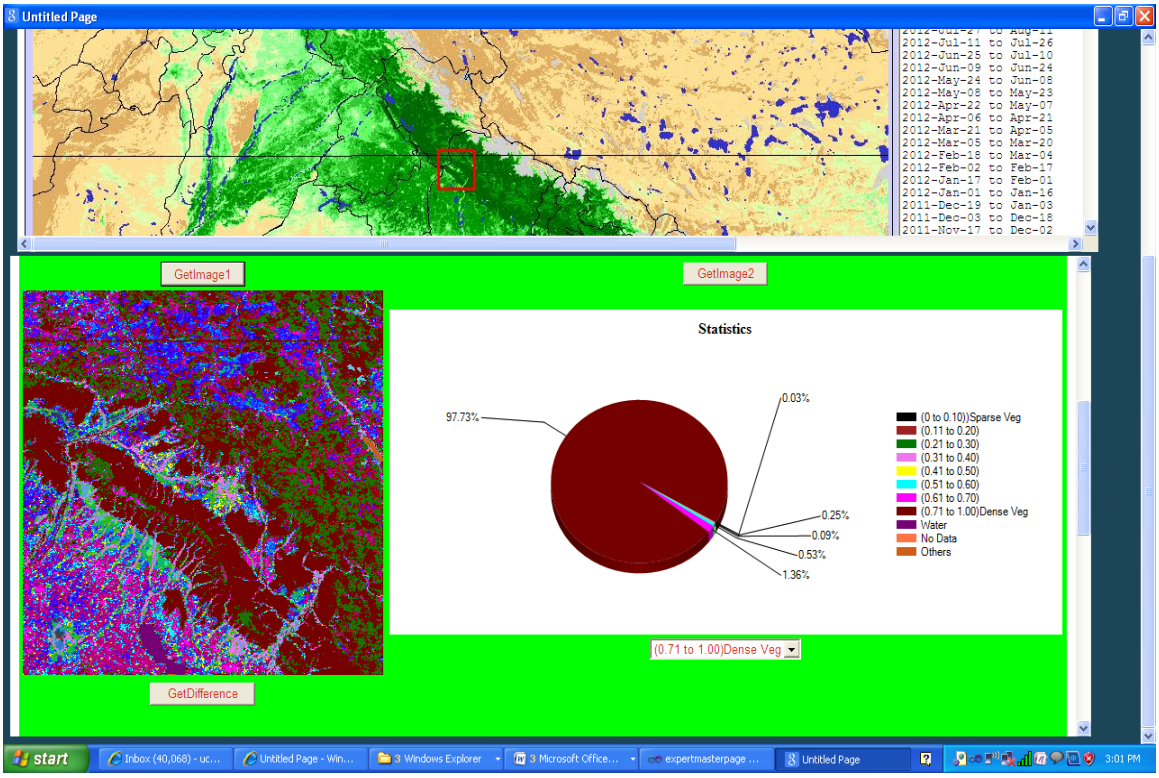

Figure 6.24: Client application showing the percentage amount of change of Dense vegetation to another type (97.73% remain same i.e. no change)

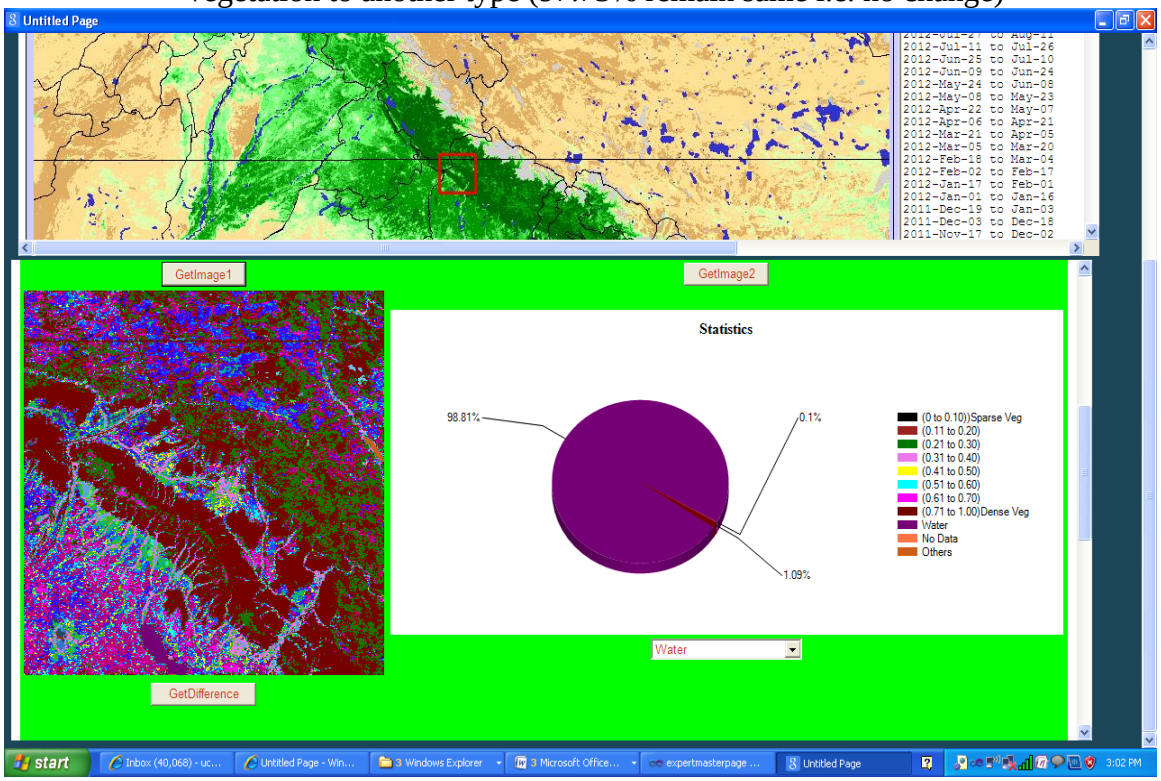

Figure 6.25: Client application shows that approximately there is no change in water bodies

6.3.2 Crop Pattern Analysis

For an effective implementation of precision agriculture, users requires spatial and temporal information of the soil and crop status of their parcel. In this module historic multi-temporal remote sensing data provided by GLAM website is analyzed to plot a pattern recognition graph at run time .

As depicted in the Pattern Graph of Roorkee (as already discuss in the previous chapter, section 5.2.5.1) for the time period of 5 years (July 2007 to June 2012) growth period for Rice varies from July to October and harvesting time is in the end of October and for the wheat, growth period varies December to March and harvesting time is in the end of March as shown in Figure 6.26 and Figure 6.27, where peaks present in the graph shows the shift of growing periods of the vegetation and the sudden falls shows the harvesting time accordingly. It is also clearly visible in Figure 6.28 that water bodies of Roorkee region remain same.

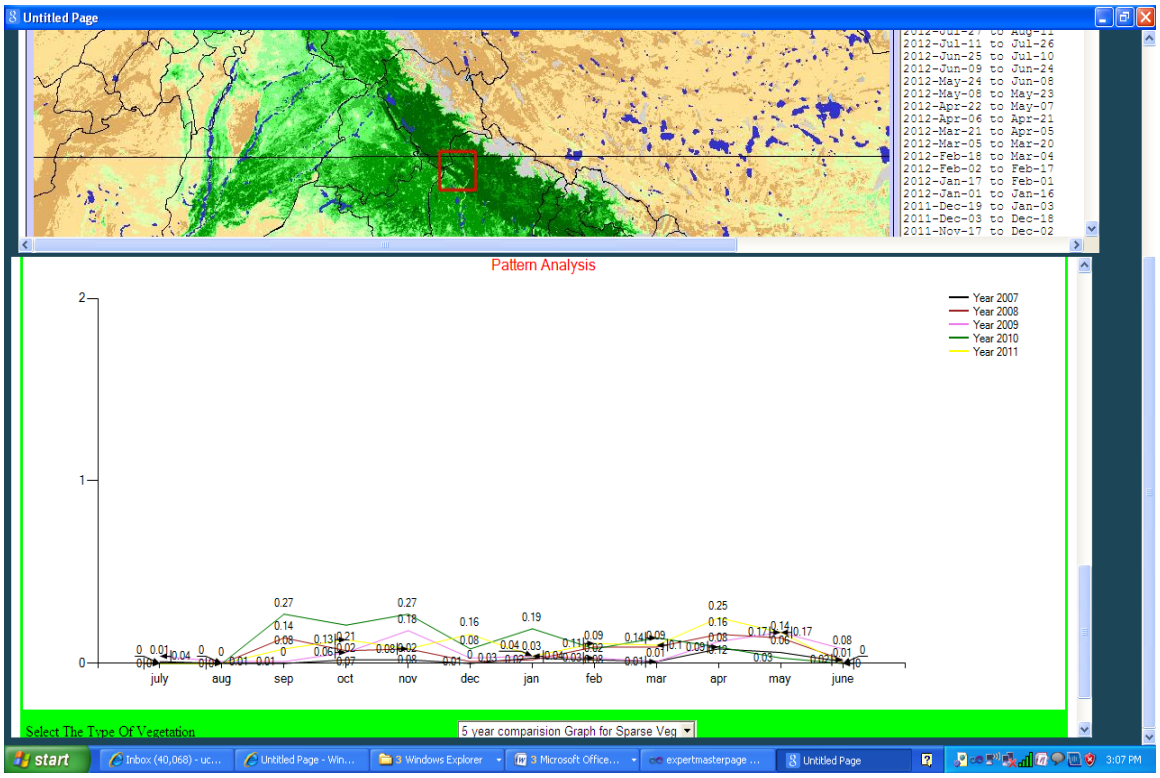

Figure 6.26: Client application showing pattern graph of Sparse Vegetation of Roorkee area for 5 years

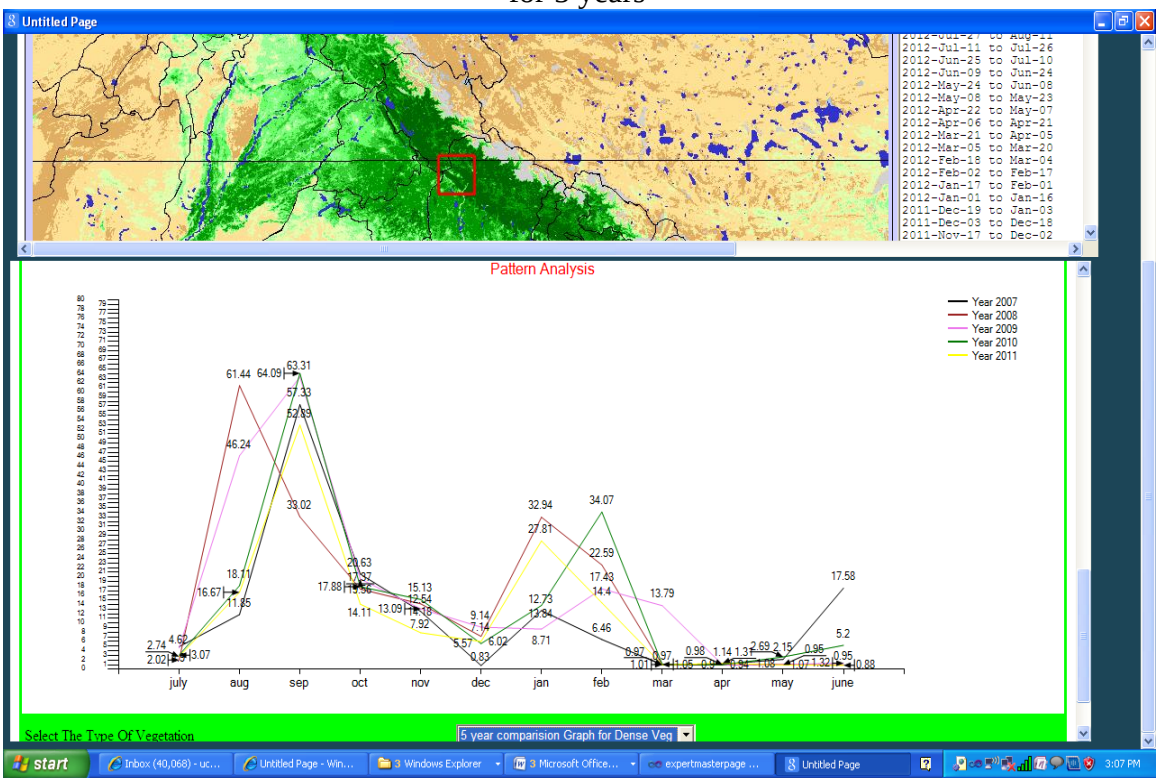

Figure 6.27: Client application showing pattern graph of Dense Vegetation of Roorkee area for 5 years

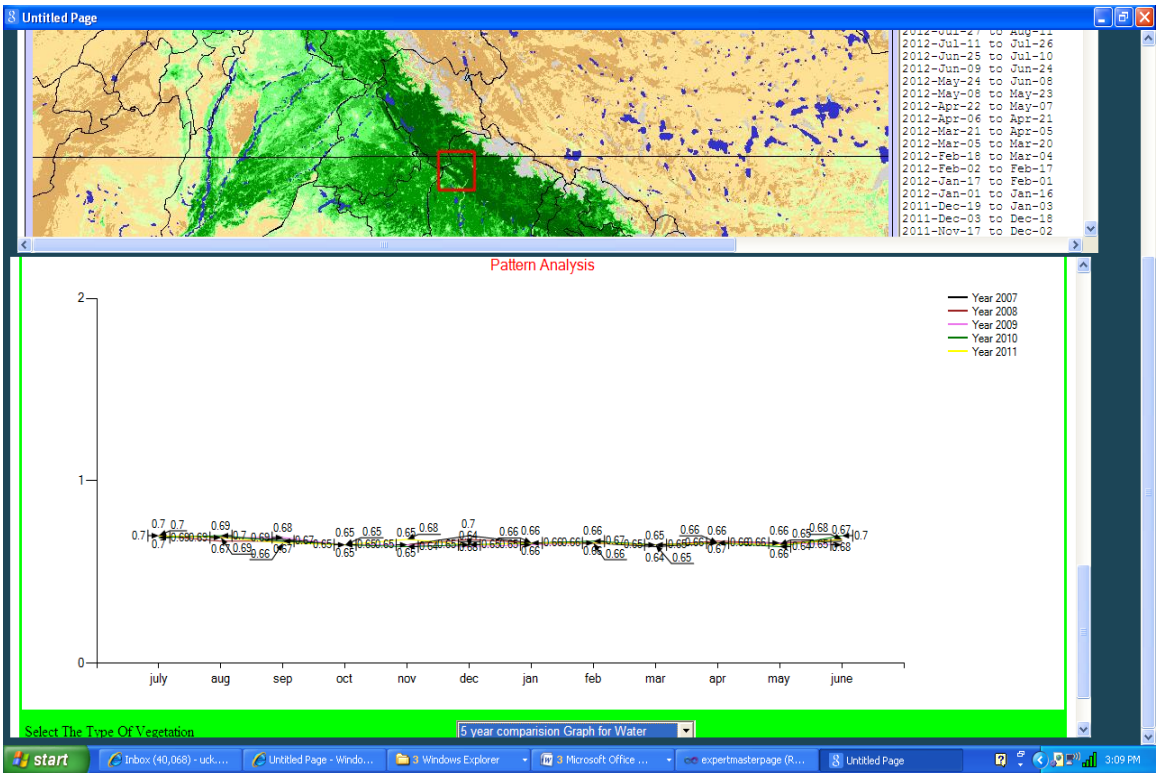

Figure 6.28: Client application shows a pattern graph of Water bodies of the Roorkee area for 5 years (approx. no change)

6.4 IMAGE GOREFERENCING

Expert Geoportal System (EGPS) deployed a new referencing system that is used to generate a georeferenced raster data collected by capturing Google Earth image at run time for different GIS application, (e.g. for change detection, assess damages after a natural disaster etc.).

6.4.1 Geotiff Application Page

When a user browses a Geotiff page, the system opens with a screen which contains Google Earth plug-in, option for selecting location, Buttons to capture georeferenced images etc. as shown in Figure 6.29.

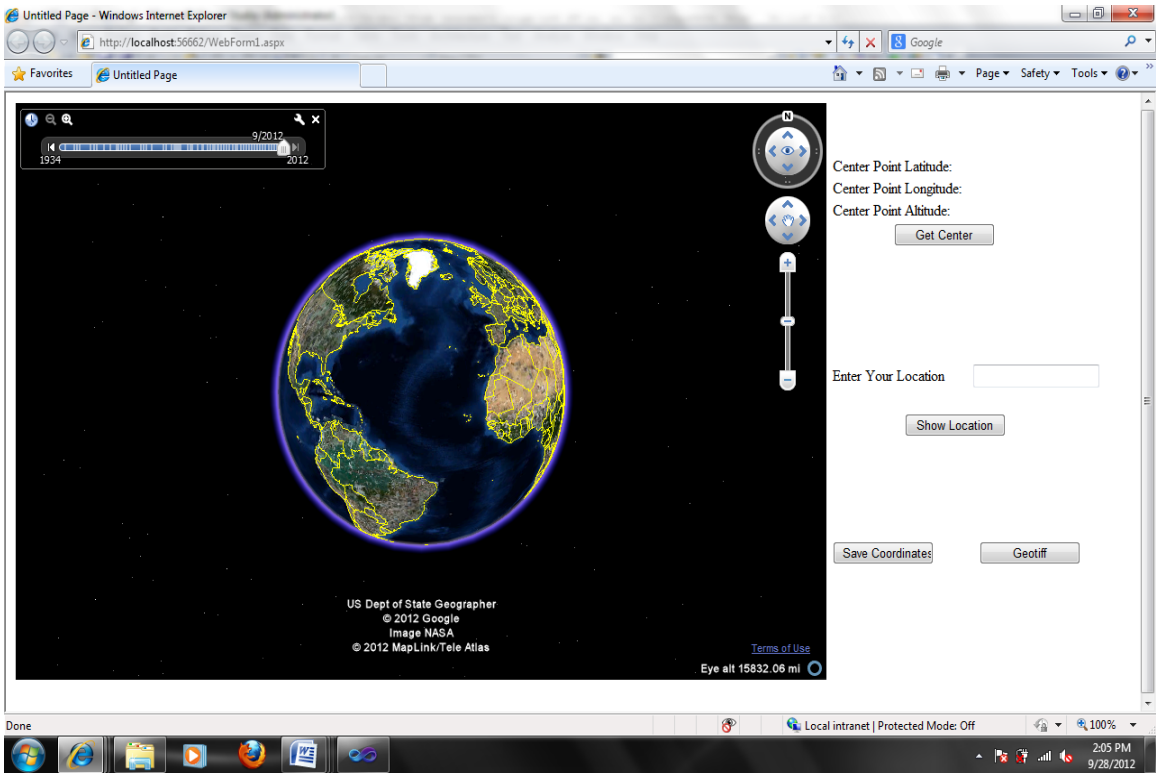

Figure 6.29: Geotiff application page

6.4.2 Georeferenced Image Capturing

User only specifies the required location, the georeferenced image is automatically captured on the clicking of button (as already discuss in the previous chapter, section 5.2.4.1), which contains spatial information as shown from Figure 6.30 to Figure 6.35.

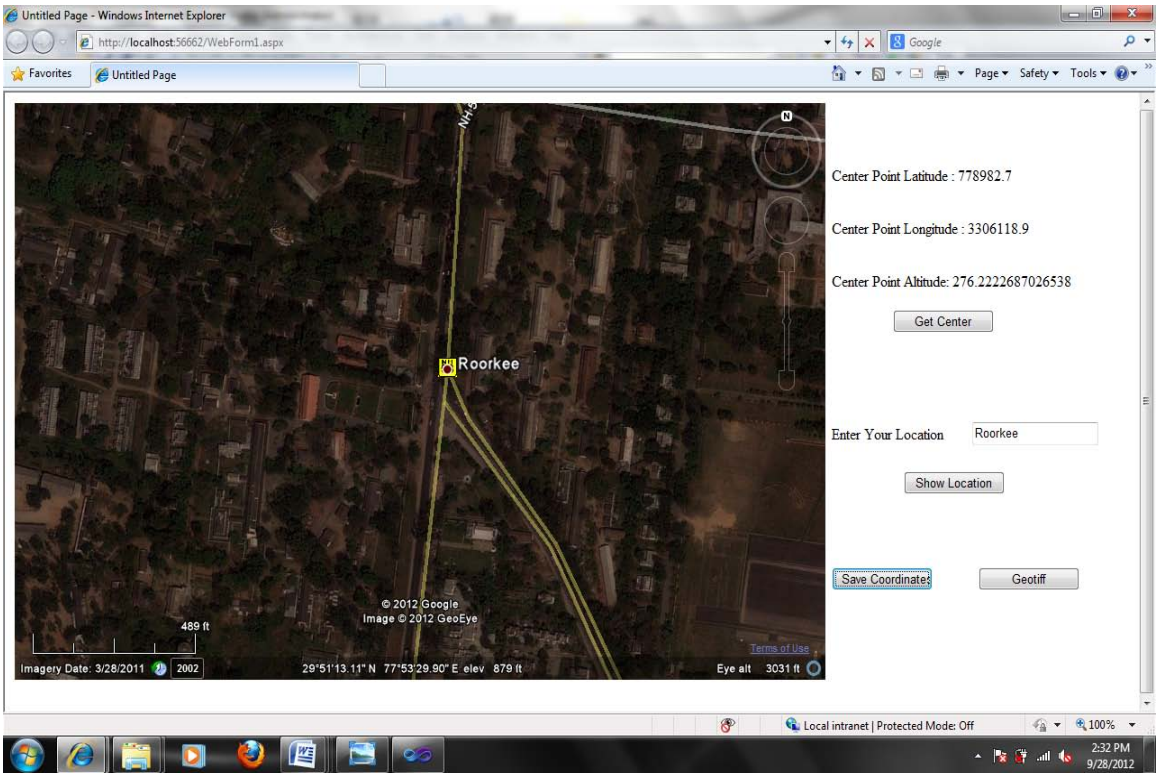

Figure 6.30: Google image of Roorkee area selected by user

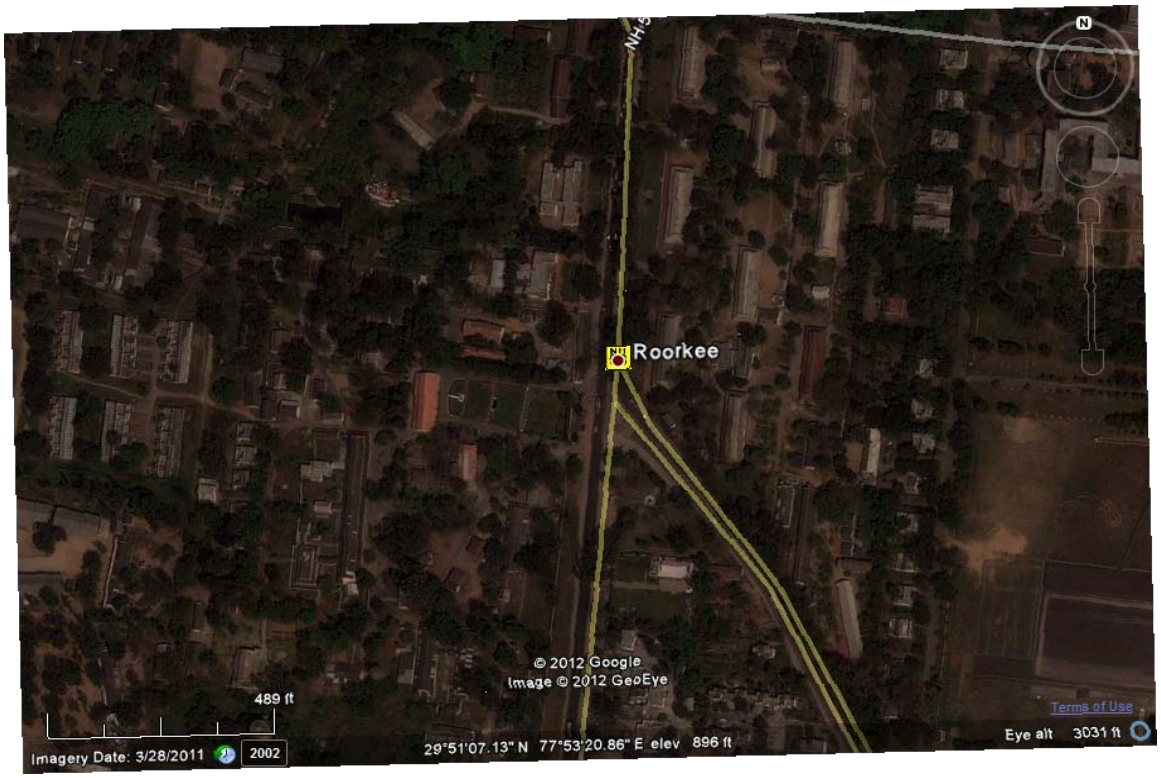

Figure 6.31: Georeferenced image of Roorkee area captured by EGPS

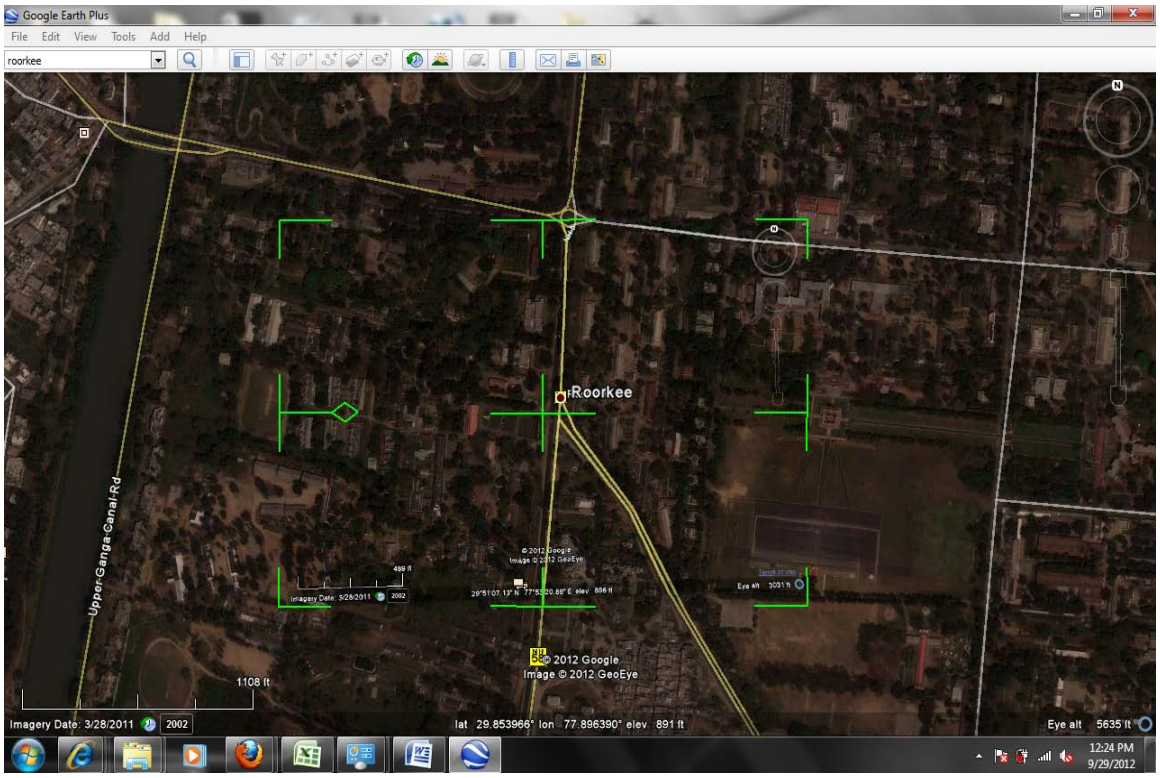

Figure 6.32: Georeferenced image of Roorkee area shown in Google Earth Plus

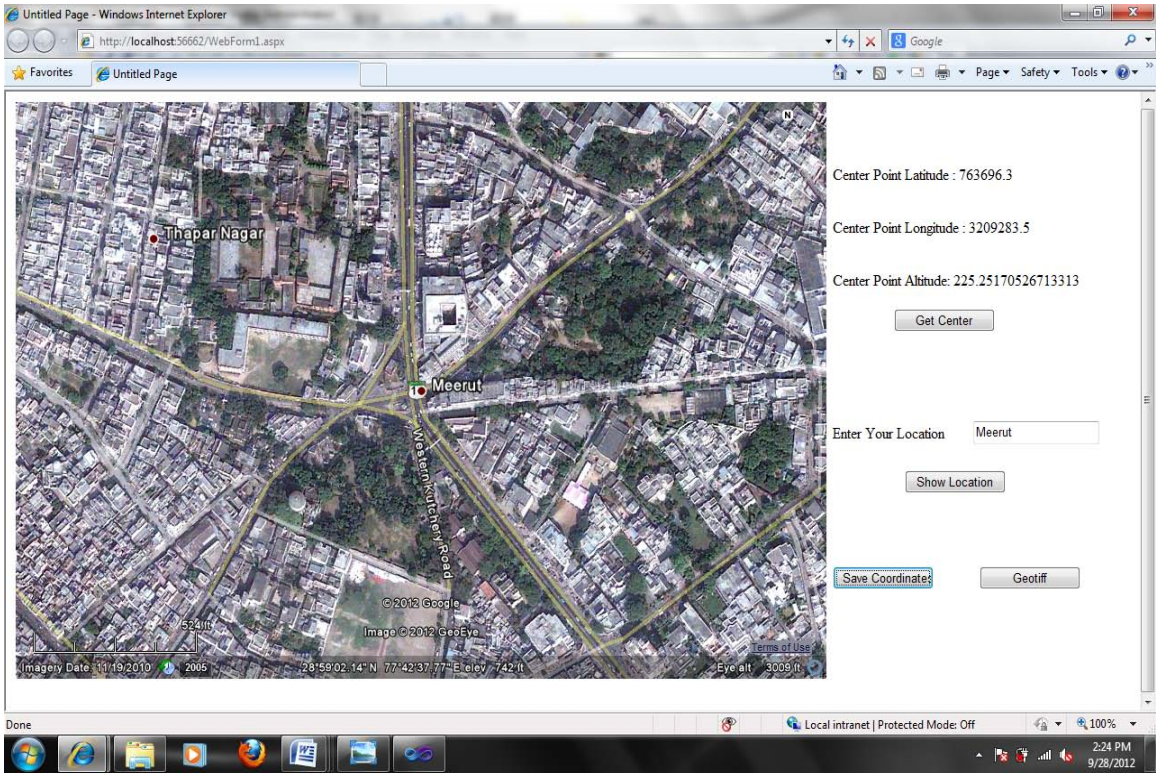

Figure 6.33: Google image of Meerut area selected by the user

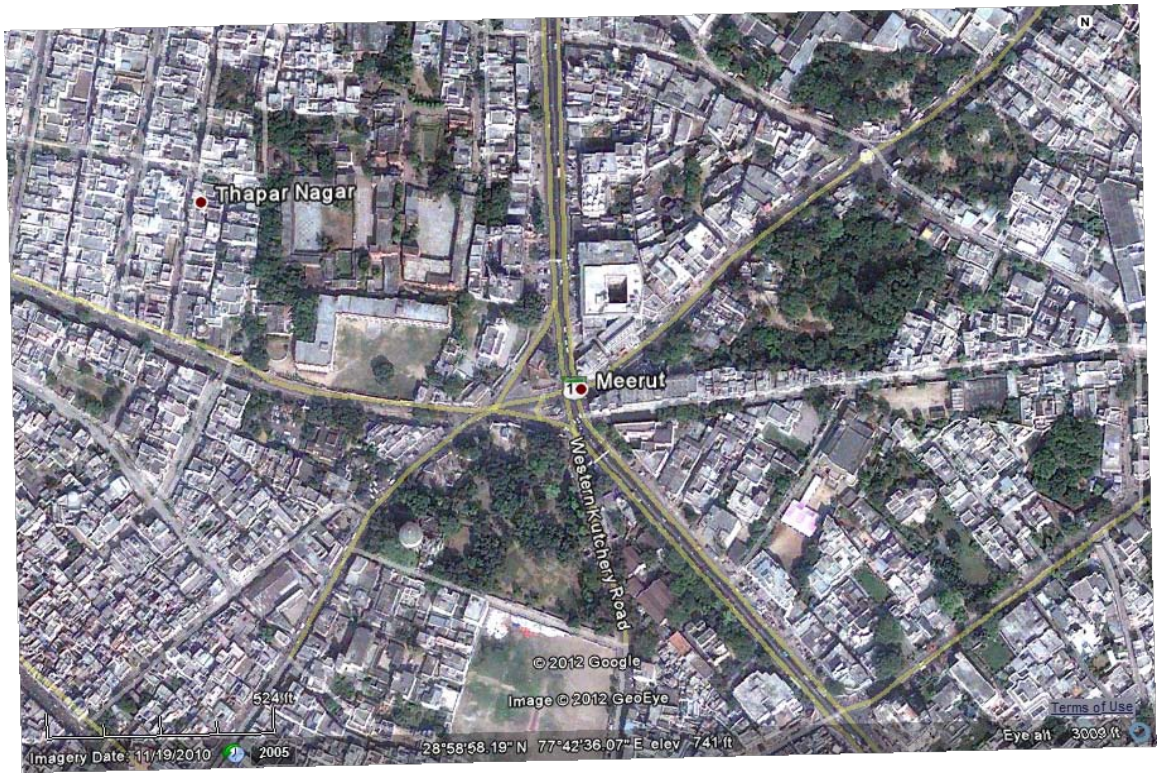

Figure 6.34: Georeferenced image of Meerut area captured by EGPS

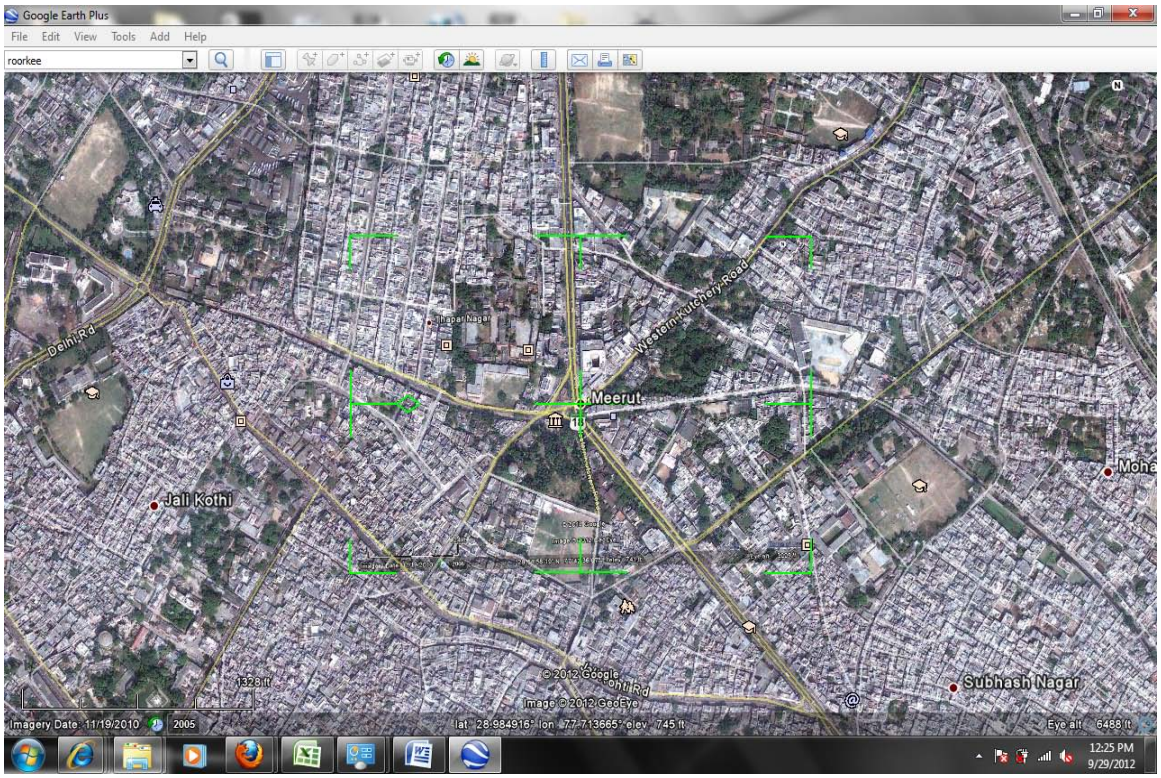

Figure 6.35: Georeferenced image of Meerut area shown in Google Earth Plus

6.5 DEM FILE

Expert Geoportal System (EGPS) deployed a new system, where users can specify the grid interval according to their requirement and the output file is automatically saved in text (.txt) format, which contains elevation values of a grid point with its latitude and longitude.

6.5.1 DEM Application Page

When a user browses an application page, the system opens with a screen which contains Google Earth plug-in, options for selecting horizontal and vertical pixel value, text box for entering a DEM file name to save etc. as shown in Figure 6.36.

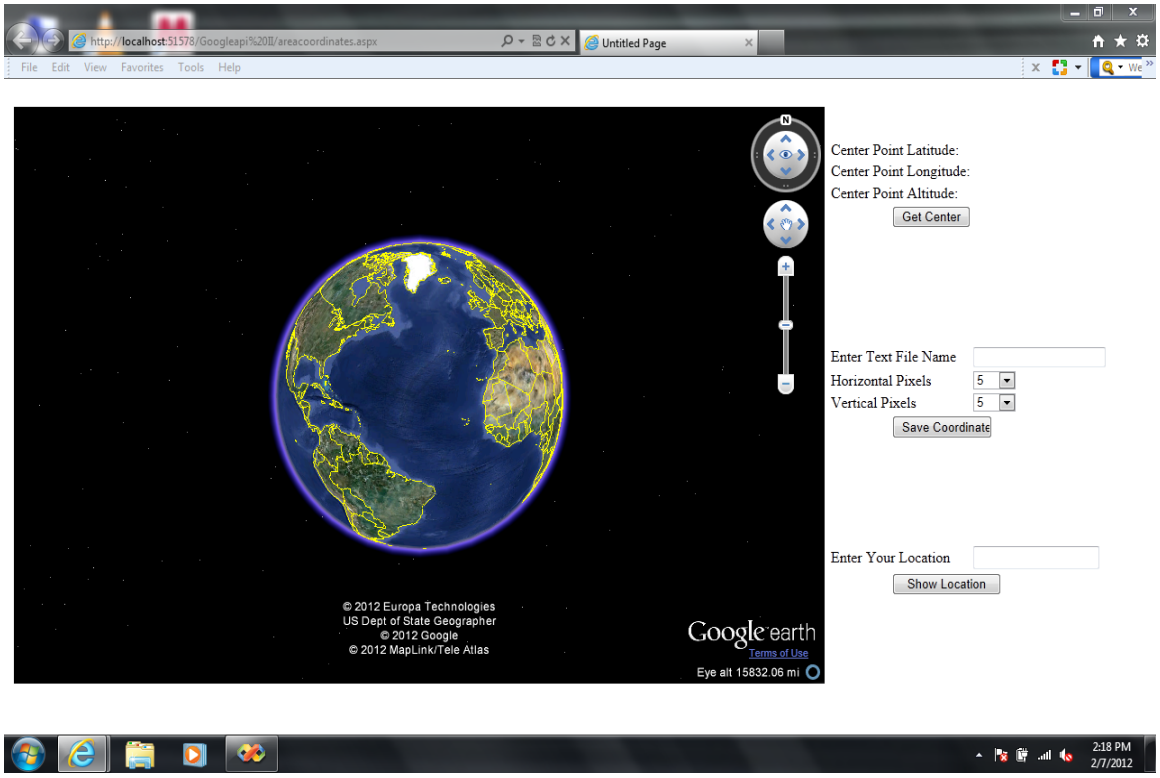

Figure 6.36: DEM application page

6.5.2 DEM File Generation

User specified location, file name, horizontal and vertical pixel value for which DEM file is generated as shown from Figure 6.37 to Figure 6.40.

When user click on the Save Coordinates button present on the client application as shown in Figure 6.37, after passing attributes like horizontal and vertical pixel value, text file and location name, a text file is generated as shown in Figure 6.38 and Figure 6.40 which contains altitude, latitude and longitude value for the specified grid interval (as already discuss in the previous chapter, section 5.2.3.1)..

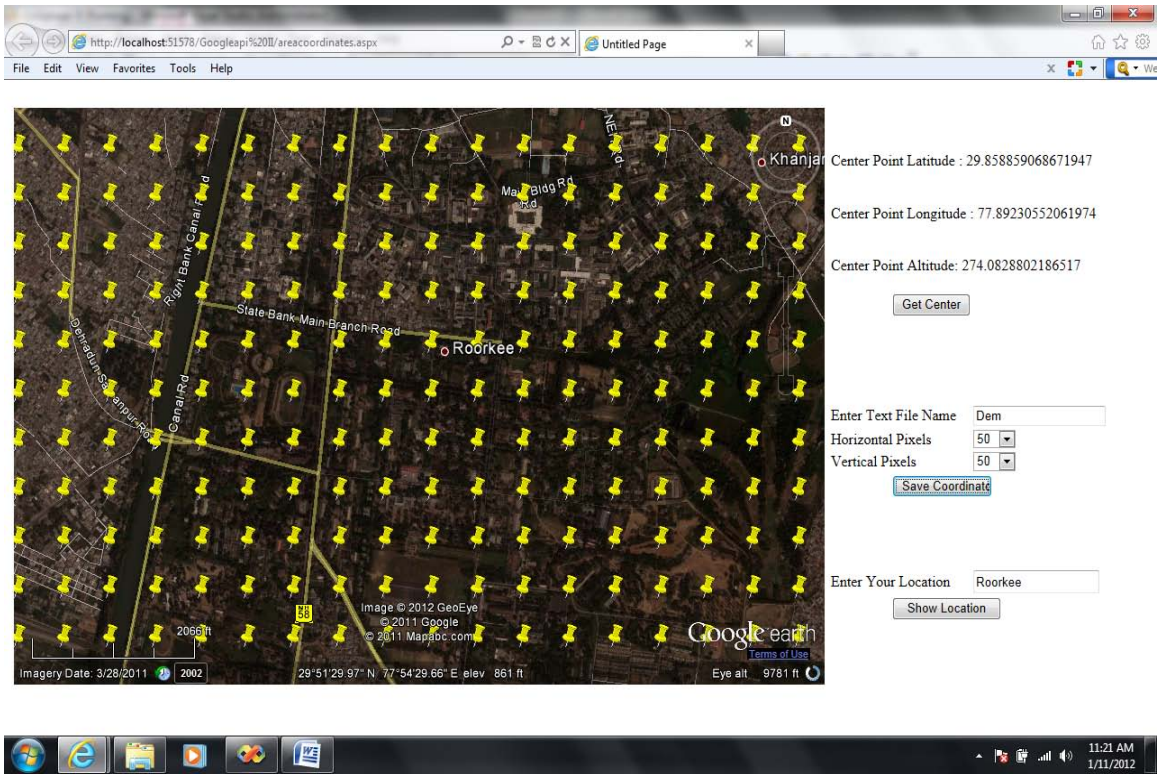

Figure 6.37: Roorkee DEM (50 Pixel)

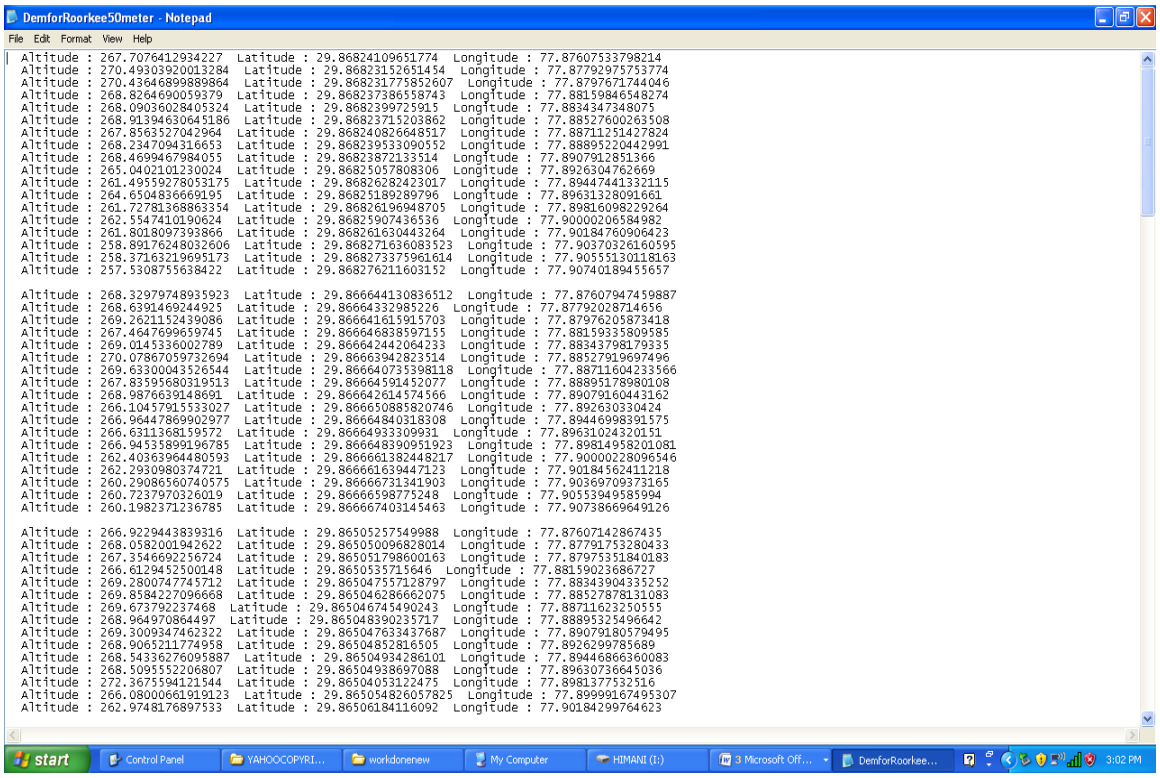

Figure 6.38: DEM file showing Altitude, Latitude and Longitude values for the Roorkee area at a grid interval of 50 Pixel

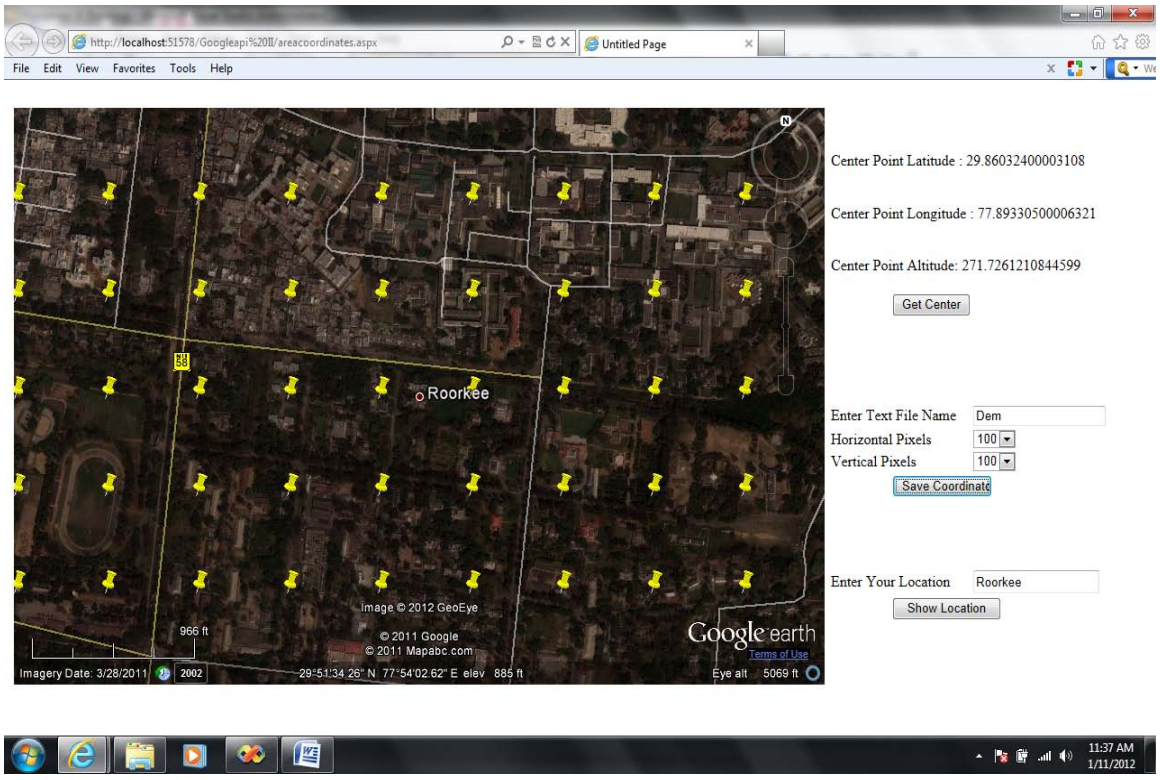

Figure 6.39: Roorkee DEM (100 Pixel)

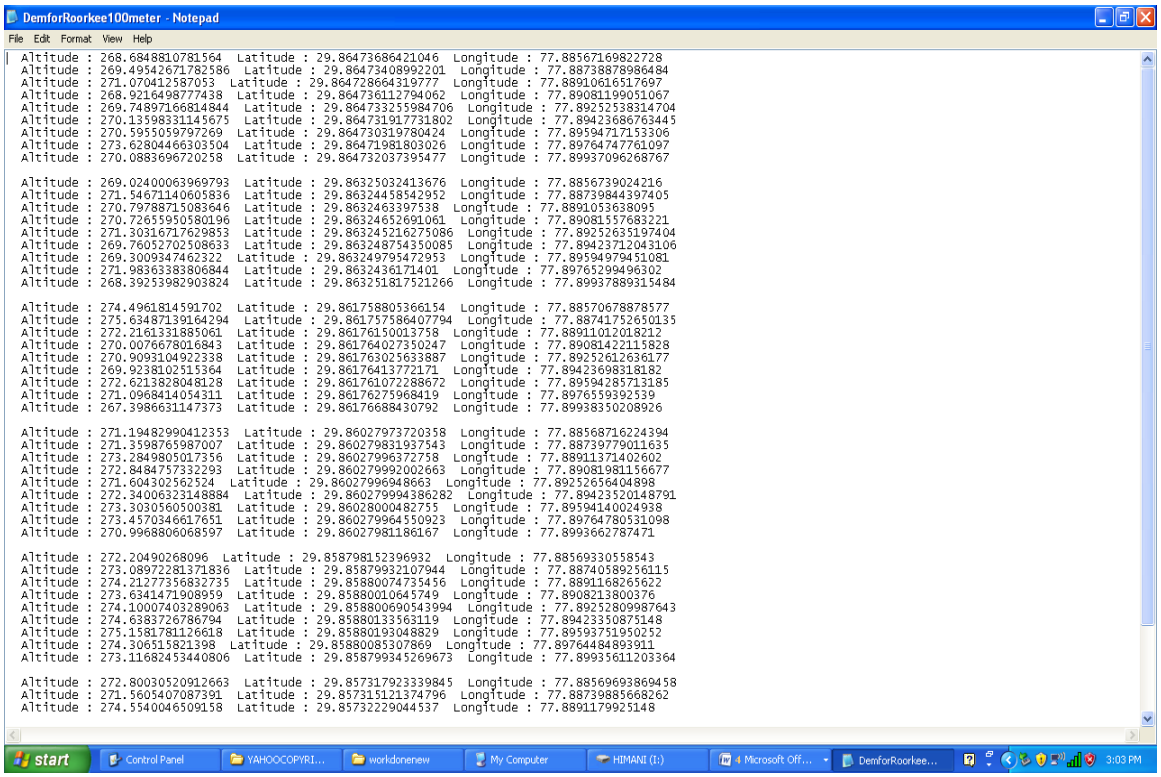

Figure 6.40: DEM file showing Altitude, Latitude and Longitude for Roorkee area at a grid interval of 100 Pixel

Chapter 7

CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter present a summarizes finding of each objective highlighting how these are addressed from the research point of view. The chapter concludes with suggestions for some potential research areas preceded by the research contributions in the present work.

7.2 CONCLUSION

The following conclusions are drawn from the present research work:

- This study fulfil its objective of proposing a methodology for using third party authorized non spatial web data into spatial form without unauthorized access.
- The present study approach a methodology of creating a Geoportal system without the burden of managing database which need not only a huge amount of humanitarian efforts as well as financial aid.
- The Developed EGPS system in the study provides the facility of developing queries by using real time data of the third party website.
- The developed system in the study is able to provide different GIS functionality like Georeferencing, DEM file etc. which is very important for data modelling etc.
- The EGPS system is successfully tested on to the local web server so that in future it is freely used by the needed user without purchasing it.
- The result of the proposed methodology is tested for two website www.makaan.com and www.yahoolocal.in for providing location based services , both of them give an identical result.

7.3 MAJOR CONTRIBUTIONS OF THIS RESEARCH

Through the study following points immerged:

- Define a methodology for using diverse Spatial Data already present on the web in a single platform.
- Given a Cost Effective Mashup based solution for providing different GIS functionalities.
- Reduce the burden of creating and managing the Spatial Database.
- Reduce the lengthy procedure of Georeferencing of an image, which also need specific domain knowledge.
- Develop a full flash running web based application known as Expert Geoportal System (EGPS) by using the diverse freely available spatial data already present on the web, for providing different Geospatial services.
- The present study also specifies the associated problems arising in developing a web mashup based applications.

7.4 FUTURE SCOPE AND RECOMMENDATIONS

- **Needs of more and more web resources** which follow the same type of front end data support and provide their services free of charges.
- **Resolve Cross domain issue** the data security and http proxy standards for cross domain data access are two important considerations while implementing any web mashup solution.
- **Some Alternative for wrapping technology** as Excel is not made for server side automation and wrapping is essential because writing programs for different front end styles is not easy.
- **Improve Processing speedand computational time.**
- **Copyrights and Patent issues** to resolve illegal accessing of third party web data or copyrights or patent issues etc.. It is necessary to understand the terms and conditions of third parties before using their data or images.

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APPENDIX I

LIST OF COPYRIGHTS FROM THIS THESIS

- “Expert Geoportal System for makaan.com”(Copyright Diary number 14104/2011- cosw Date 5-12-2011)
- “Expert Geoportal System supplement yahoolocal.in”(Copyright Diary number 14105/2011 - cosw Date 7-12-2011)
- “Expert Geoportal System For Google Earth Image Capturing”(Copyright Diary number 13893/2012 -cosw Date 17-10-2012)
- “Expert Geoportal System For Real Time Digital Elevation Model Creation” (Copyright Diary number 13894/2012 - cosw Date 17-10-2012)
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LIST OF PUBLICATIONS FROM THIS THESIS

- Umesh Chandra, Kamal Jain and S.K Jain (2013), “Mashup as a future of Geo-Portal”, International Journal of Advanced Research in Engineering and Technology (IJARET), Volume 4, Issue 4, May- June 2013, pp. 22-26, ISSN: 0976 – 6499.
- Umesh Chandra, Kamal Jain and S.K Jain (2013) “Real Time Vegetation Analysis Through Data Provided By GLAM Website”, International Journal of Civil Engineering and Technology (IJCIET), Volume 4, Issue 1, January-February 2013, ISSN: 0976 – 6316.
- Umesh Chandra and Kamal Jain (2013), “Web Based Ambient Air Quality Monitoring System for Delhi”**,** International Journal of Science, Engineering and Technology Research (IJSETR), Volume 2, Issue 1, January 2013, ISSN: 2278 – 7798.

APPENDIX II

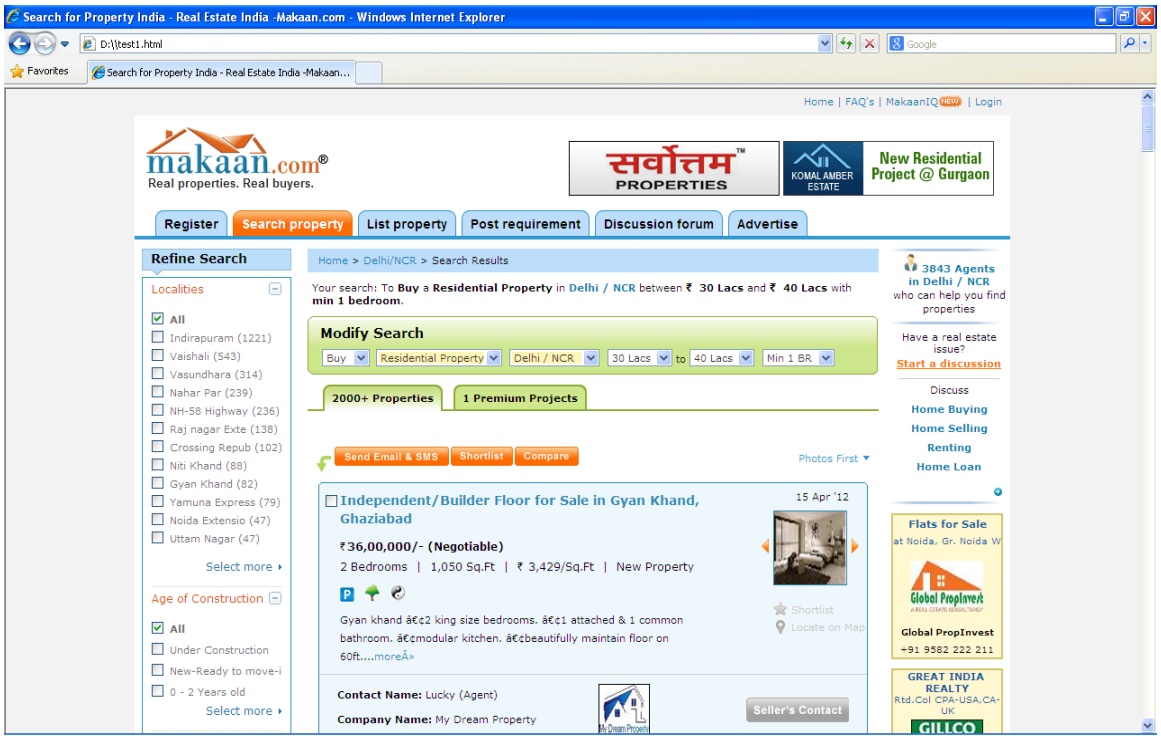


Figure 1: Makaan.com web page saved as an HTML page by the client application

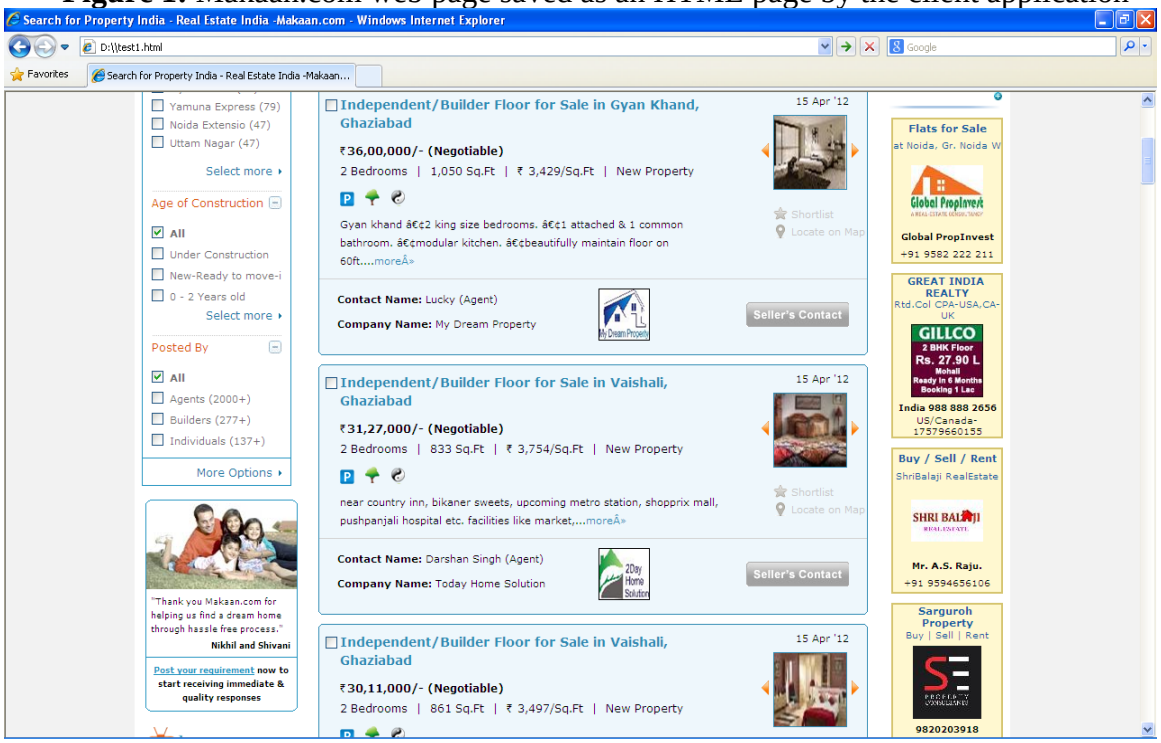
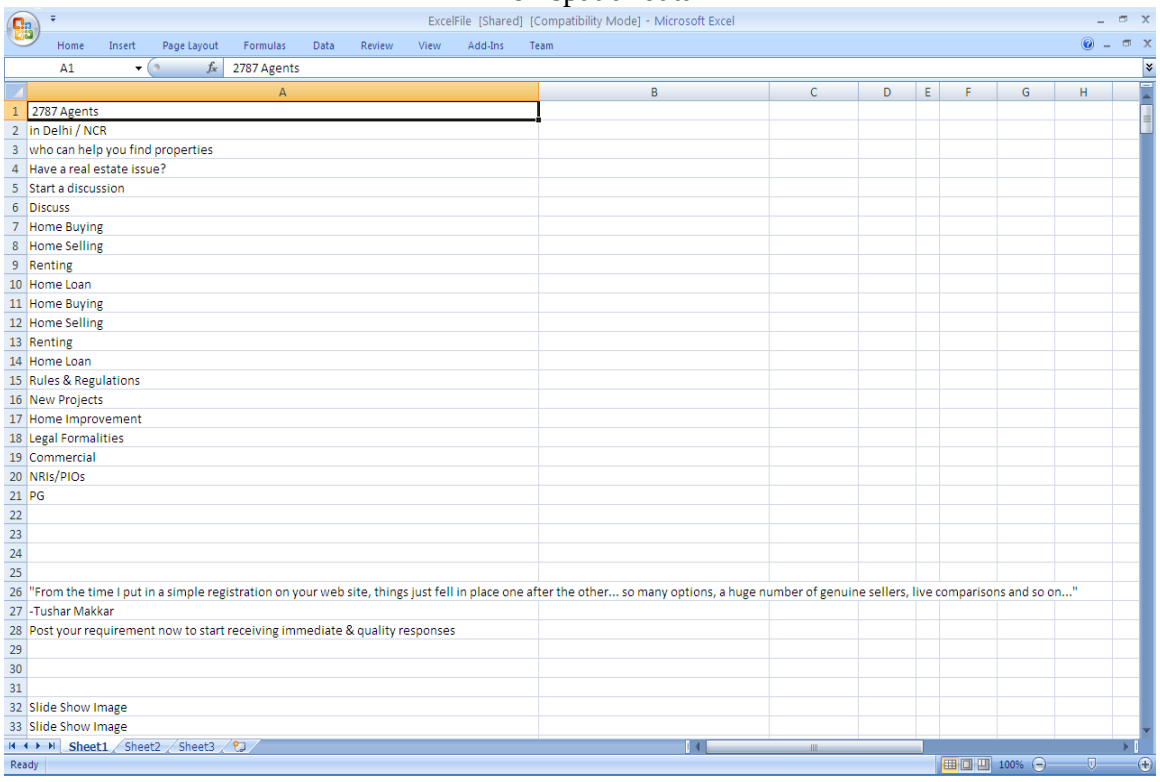


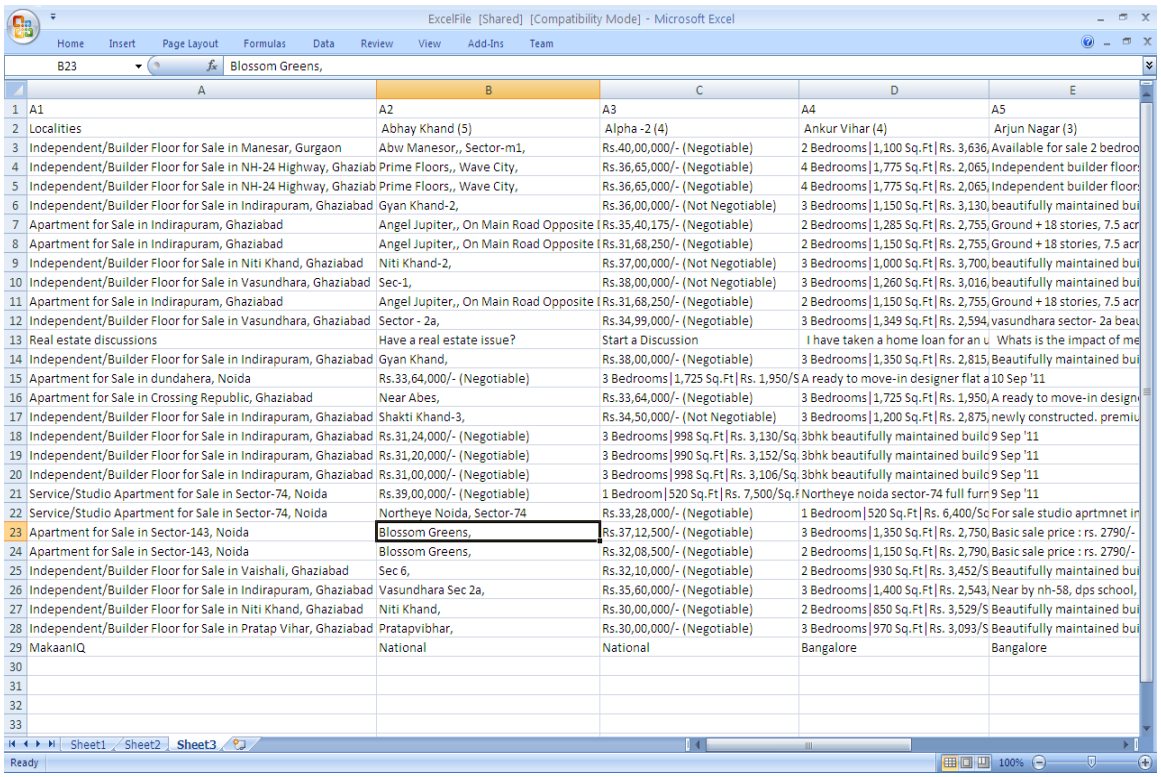
Figure 2: Makaan.com web page saved as an HTML page by the client application showing non spatial data

Figure 3: Makaan.com web page saved as a text format by the client application showing non spatial data



	A
1	2787 Agents
2	in Delhi / NCR
3	who can help you find properties
4	Have a real estate issue?
5	Start a discussion
6	Discuss
7	Home Buying
8	Home Selling
9	Renting
10	Home Loan
11	Home Buying
12	Home Selling
13	Renting
14	Home Loan
15	Rules & Regulations
16	New Projects
17	Home Improvement
18	Legal Formalities
19	Commercial
20	NRIs/PIOs
21	PG
22	
23	
24	
25	
26	"From the time I put in a simple registration on your web site, things just fell in place one after the other... so many options, a huge number of genuine sellers, live comparisons and so on..."
27	-Tushar Makkar
28	Post your requirement now to start receiving immediate & quality responses
29	
30	
31	
32	Slide Show Image
33	Slide Show Image

Figure 4: Makaan.com web data (randomly distributed) shown on the Excel sheet



	A	B	C	D	E
1	A1	A2	A3	A4	A5
2	Localities	Abhay Khand (5)	Alpha -2 (4)	Ankur Vihar (4)	Arjun Nagar (3)
3	Independent/Builder Floor for Sale in Manesar, Gurgaon	Abw Manesor,, Sector-m1,	Rs.40,00,000/- (Negotiable)	2 Bedrooms | 1,100 Sq.Ft | Rs. 3,636,	Available for sale 2 bedroo
4	Independent/Builder Floor for Sale in NH-24 Highway, Ghaziab	Prime Floors,, Wave City,	Rs.36,65,000/- (Negotiable)	4 Bedrooms | 1,775 Sq.Ft | Rs. 2,065,	Independent builder floors
5	Independent/Builder Floor for Sale in NH-24 Highway, Ghaziab	Prime Floors,, Wave City,	Rs.36,65,000/- (Negotiable)	4 Bedrooms | 1,775 Sq.Ft | Rs. 2,065,	Independent builder floors
6	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Gyan Khand-2,	Rs.36,00,000/- (Not Negotiable)	3 Bedrooms | 1,150 Sq.Ft | Rs. 3,130,	beautifully maintained bui
7	Apartment for Sale in Indirapuram, Ghaziabad	Angel Jupiter,, On Main Road Opposite I	Rs.35,40,175/- (Negotiable)	2 Bedrooms | 1,285 Sq.Ft | Rs. 2,755,	Ground + 18 stories, 7.5 acr
8	Apartment for Sale in Indirapuram, Ghaziabad	Angel Jupiter,, On Main Road Opposite I	Rs.31,68,250/- (Negotiable)	2 Bedrooms | 1,150 Sq.Ft | Rs. 2,755,	Ground + 18 stories, 7.5 acr
9	Independent/Builder Floor for Sale in Niti Khand, Ghaziabad	Niti Khand-2,	Rs.37,00,000/- (Not Negotiable)	3 Bedrooms | 1,000 Sq.Ft | Rs. 3,700,	beautifully maintained bui
10	Independent/Builder Floor for Sale in Vasundhara, Ghaziabad	Sec-1,	Rs.38,00,000/- (Not Negotiable)	3 Bedrooms | 1,260 Sq.Ft | Rs. 3,016,	beautifully maintained bui
11	Apartment for Sale in Indirapuram, Ghaziabad	Angel Jupiter,, On Main Road Opposite I	Rs.31,68,250/- (Negotiable)	2 Bedrooms | 1,150 Sq.Ft | Rs. 2,755,	Ground + 18 stories, 7.5 acr
12	Independent/Builder Floor for Sale in Vasundhara, Ghaziabad	Sector - 2a,	Rs.34,99,000/- (Negotiable)	3 Bedrooms | 1,349 Sq.Ft | Rs. 2,594,	vasundhara sector- 2a beau
13	Real estate discussions	Have a real estate issue?	Start a Discussion	I have taken a home loan for an u	Whats is the impact of me
14	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Gyan Khand,	Rs.38,00,000/- (Negotiable)	3 Bedrooms | 1,350 Sq.Ft | Rs. 2,815,	Beautifully maintained bui
15	Apartment for Sale in dundahera, Noida	Rs.33,64,000/- (Negotiable)	3 Bedrooms | 1,725 Sq.Ft | Rs. 1,950/S	A ready to move-in designer flat a	10 Sep '11
16	Apartment for Sale in Crossing Republic, Ghaziabad	Near Abes,	Rs.33,64,000/- (Negotiable)	3 Bedrooms | 1,725 Sq.Ft | Rs. 1,950,	A ready to move-in design
17	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Shakti Khand-3,	Rs.34,50,000/- (Not Negotiable)	3 Bedrooms | 1,200 Sq.Ft | Rs. 2,875,	newly constructed. premiu
18	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Rs.31,24,000/- (Negotiable)	3 Bedrooms | 998 Sq.Ft | Rs. 3,130/Sq.	3bhk beautifully maintained builc	9 Sep '11
19	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Rs.31,20,000/- (Negotiable)	3 Bedrooms | 990 Sq.Ft | Rs. 3,152/Sq.	3bhk beautifully maintained builc	9 Sep '11
20	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Rs.31,00,000/- (Negotiable)	3 Bedrooms | 998 Sq.Ft | Rs. 3,106/Sq.	3bhk beautifully maintained builc	9 Sep '11
21	Service/Studio Apartment for Sale in Sector-74, Noida	Rs.39,00,000/- (Negotiable)	1 Bedroom | 520 Sq.Ft | Rs. 7,500/Sq.F	Northeye noida sector-74 full furn	9 Sep '11
22	Service/Studio Apartment for Sale in Sector-74, Noida	Northeye Noida, Sector-74	Rs.33,28,000/- (Negotiable)	1 Bedroom | 520 Sq.Ft | Rs. 6,400/Sc	For sale studio aprtmnet in
23	Apartment for Sale in Sector-143, Noida	Blossom Greens,	Rs.37,12,500/- (Negotiable)	3 Bedrooms | 1,350 Sq.Ft | Rs. 2,750,	Basic sale price : rs. 2790/-
24	Apartment for Sale in Sector-143, Noida	Blossom Greens,	Rs.32,08,500/- (Negotiable)	2 Bedrooms | 1,150 Sq.Ft | Rs. 2,790,	Basic sale price : rs. 2790/-
25	Independent/Builder Floor for Sale in Vaishali, Ghaziabad	Sec 6,	Rs.32,10,000/- (Negotiable)	2 Bedrooms | 930 Sq.Ft | Rs. 3,452/S	Beautifully maintained bui
26	Independent/Builder Floor for Sale in Indirapuram, Ghaziabad	Vasundhara Sec 2a,	Rs.35,60,000/- (Negotiable)	3 Bedrooms | 1,400 Sq.Ft | Rs. 2,543,	Near by nh-58, dps school,
27	Independent/Builder Floor for Sale in Niti Khand, Ghaziabad	Niti Khand,	Rs.30,00,000/- (Negotiable)	2 Bedrooms | 850 Sq.Ft | Rs. 3,529/S	Beautifully maintained bui
28	Independent/Builder Floor for Sale in Pratap Vihar, Ghaziabad	Pratapvibhar,	Rs.30,00,000/- (Negotiable)	3 Bedrooms | 970 Sq.Ft | Rs. 3,093/S	Beautifully maintained bui
29	MakaanIQ	National	National	Bangalore	Bangalore
30					
31					
32					
33					

Figure 5: Makaan.com web data (arranged in proper format by EGPS through VBA programming) shown on the Excel sheet

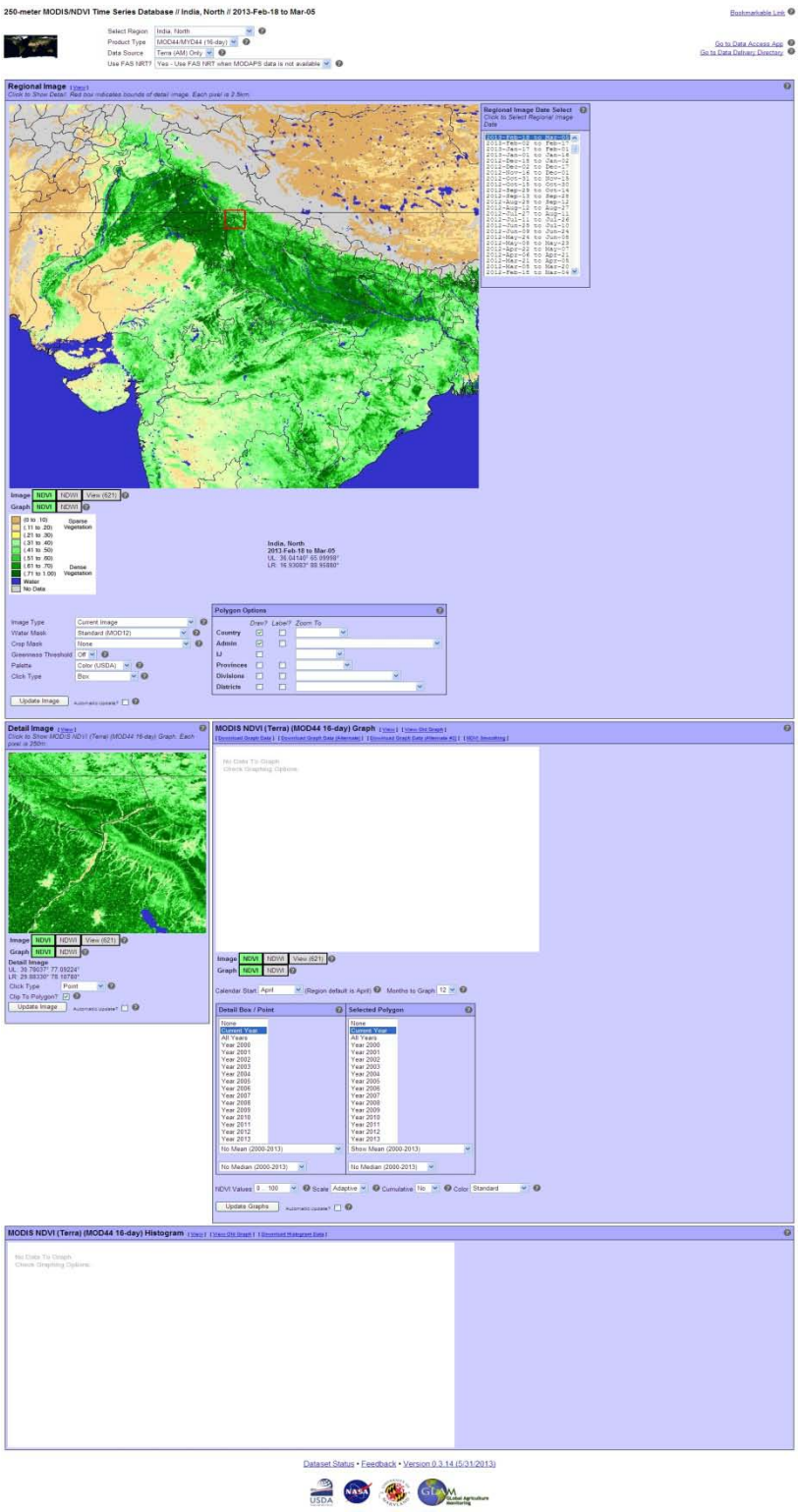


Figure 6: GLAM whole web page saved as an image

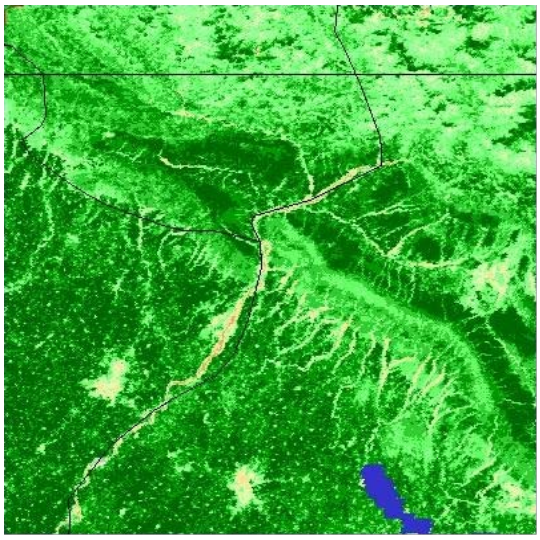


Figure 7: GLAM Detail image (250 meter/resolution) cuts from the original image

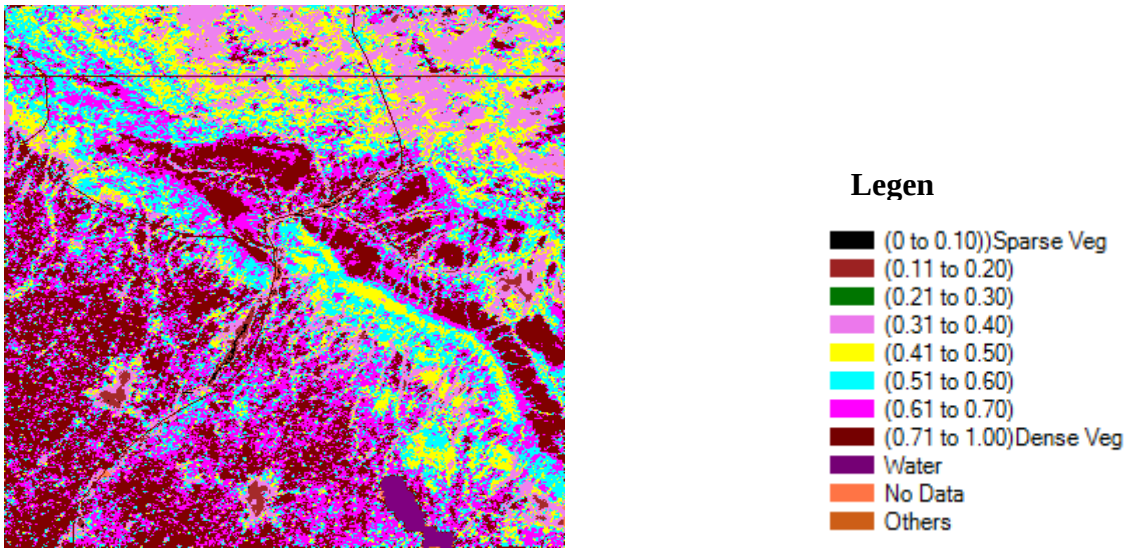


Figure 8: GLAM classified Detail image

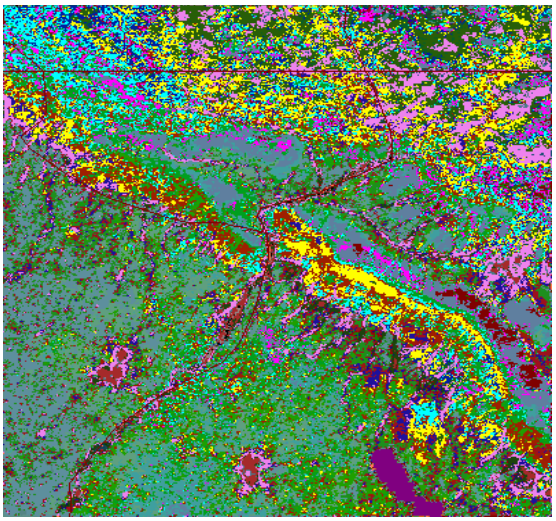
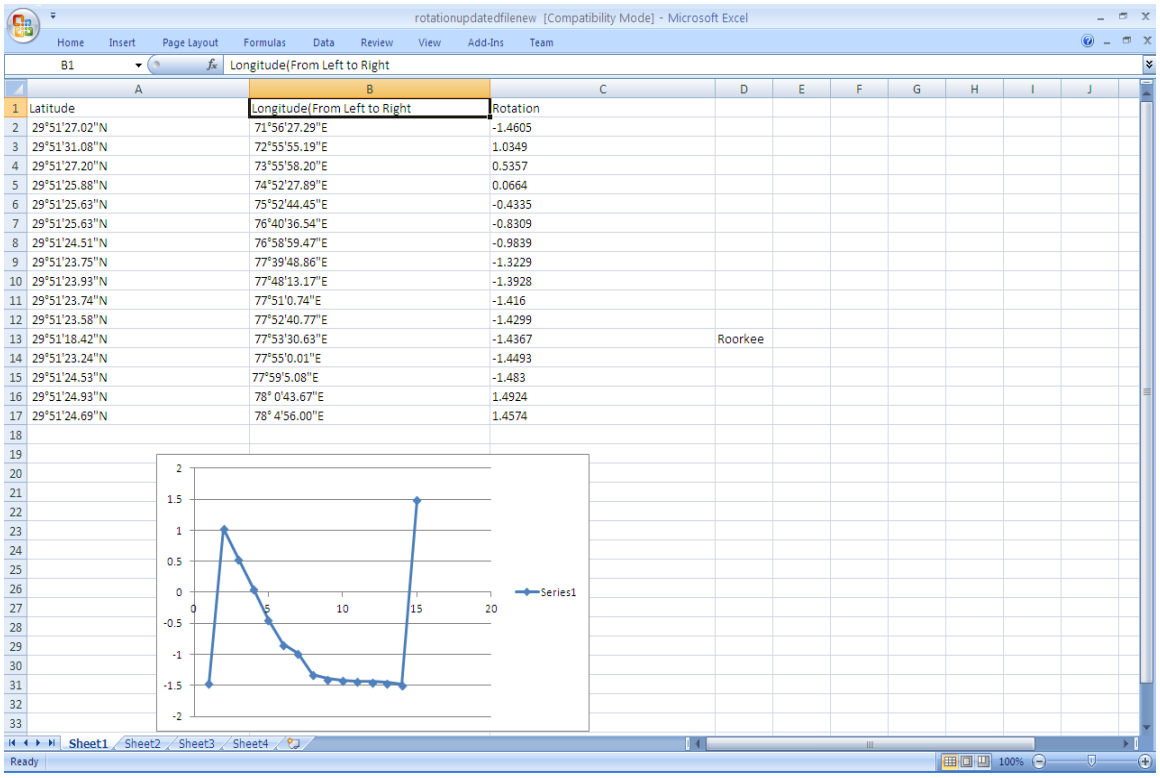


Figure 9: Difference image generated by using two temporal images from GLAM website



rotationupdatedfilenew [Compatibility Mode] - Microsoft Excel

Home Insert Page Layout Formulas Data Review View Add-Ins Team

B1 Longitude(From Left to Right

	A	B	C	D
1	Latitude	Longitude(From Left to Right	Rotation	
2	29°51'27.02"N	71°56'27.29"E	-1.4605	
3	29°51'31.08"N	72°55'55.19"E	1.0349	
4	29°51'27.20"N	73°55'58.20"E	0.5357	
5	29°51'25.88"N	74°52'27.89"E	0.0664	
6	29°51'25.63"N	75°52'44.45"E	-0.4335	
7	29°51'25.63"N	76°40'36.54"E	-0.8309	
8	29°51'24.51"N	76°58'59.47"E	-0.9839	
9	29°51'23.75"N	77°39'48.86"E	-1.3229	
10	29°51'23.93"N	77°48'13.17"E	-1.3928	
11	29°51'23.74"N	77°51'0.74"E	-1.416	
12	29°51'23.58"N	77°52'40.77"E	-1.4299	
13	29°51'18.42"N	77°53'30.63"E	-1.4367	Roorkee
14	29°51'23.24"N	77°55'0.01"E	-1.4493	
15	29°51'24.53"N	77°59'5.08"E	-1.483	
16	29°51'24.93"N	78° 0'43.67"E	1.4924	
17	29°51'24.69"N	78° 4'56.00"E	1.4574	

Sheet1 Sheet2 Sheet3 Sheet4

Ready 100%

Figure 10: Rotation file used for generating Georeferenced image for Roorkee area

APPENDIX-III

EXISTING GEOPORTALS

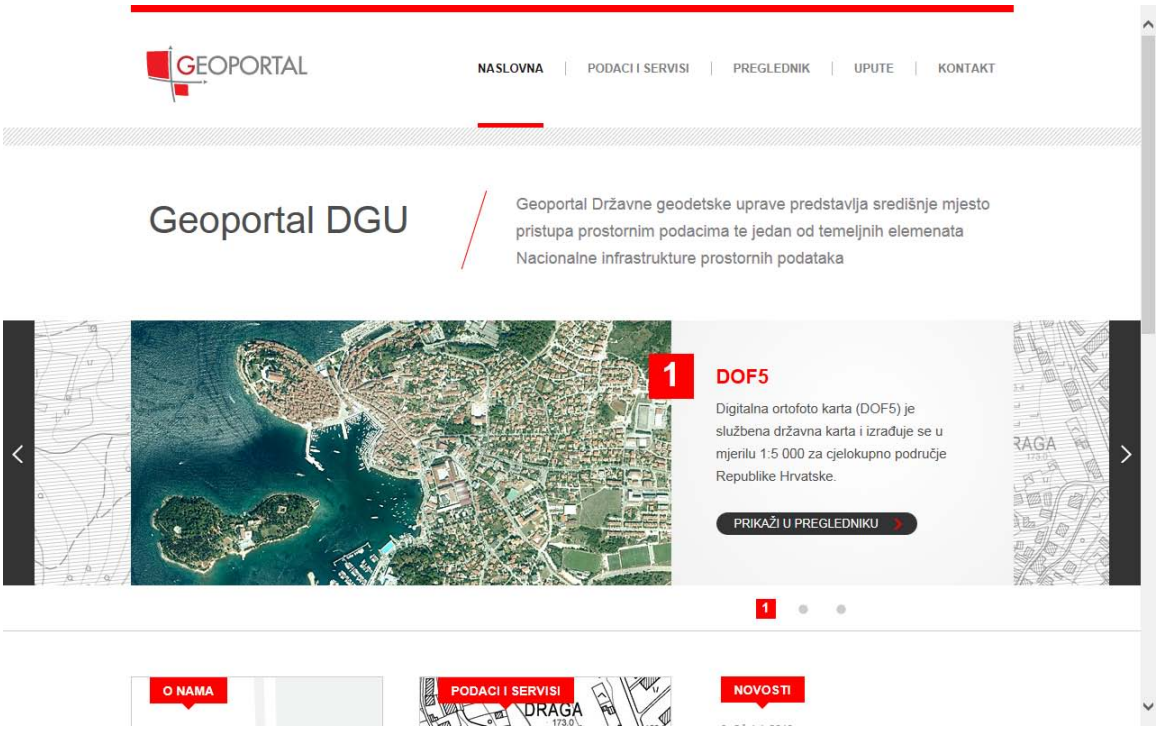


Figure 1: Home page of Croatia Geoportal

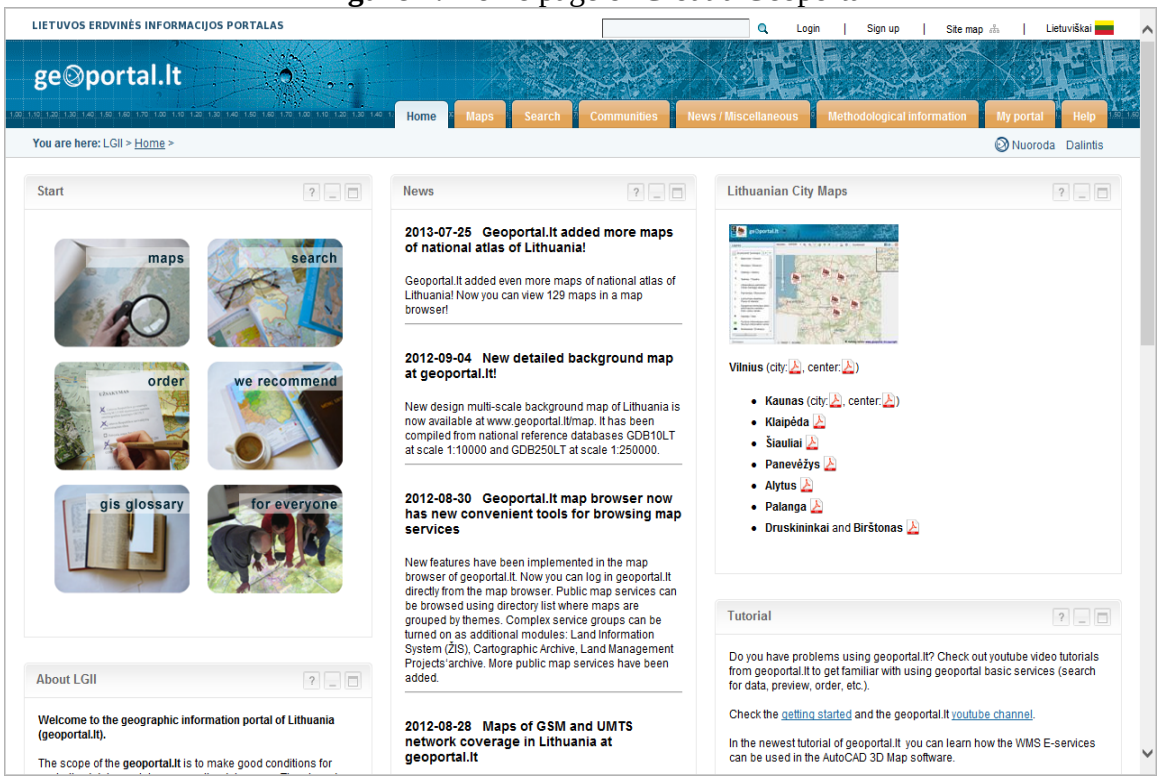


Figure 2: Home page of Lithuanian Geoportal

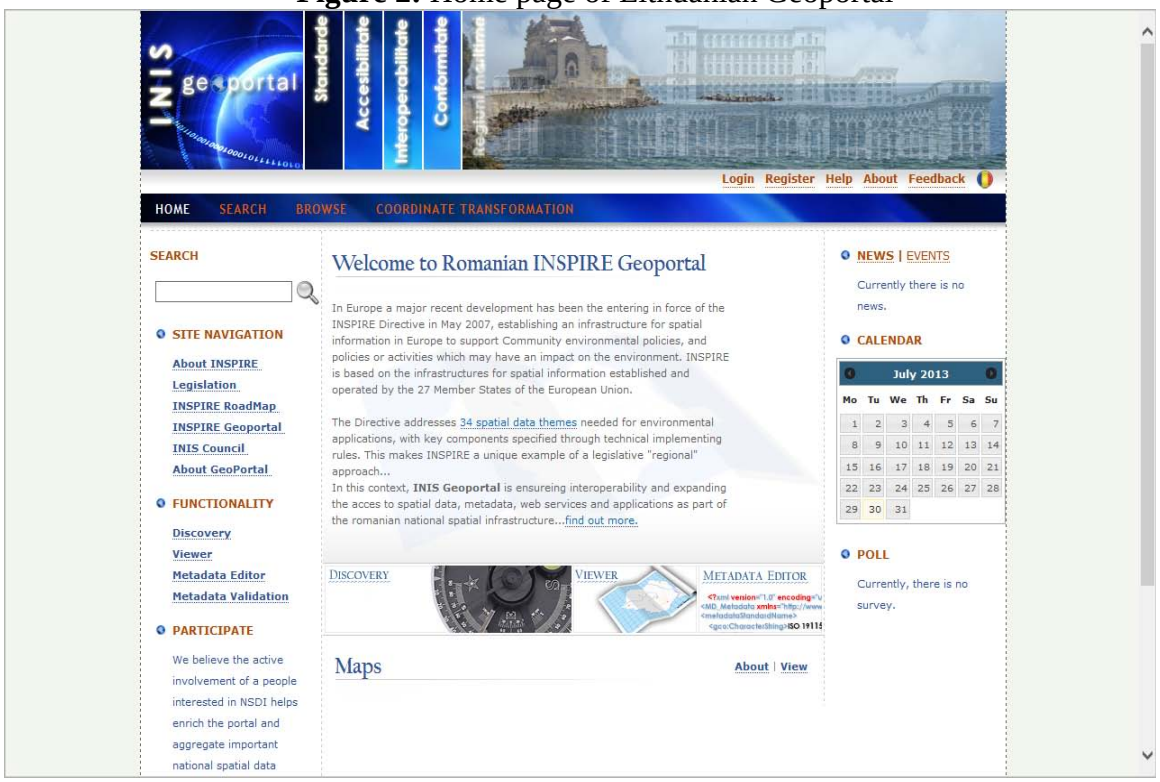


Figure 3: Home page of Romanian INSPIRE Geoportal

Figure 4: Home page of Kosmosnimki Geoportal

Figure 5: Home page of Bhuvan Geoportal

Figure 6: Home page of Karnataka Geoportal