UNIT 7 DATA ANALYSIS TOOLS

Structure

7.1 INTRODUCTION

You have been introduced to geospatial data types, its sources, data products and formats in previous units. You have learnt that geospatial data has both spatial and non-spatial information. Handling of any geospatial data requires special tools because of their spatial and non-spatial information contents. Besides the analysis functionalities, the geospatial data handling tools should have the capabilities to create and store data, locate them with geographic location, create outputs and visualise them. In this unit, you will study in detail about the geospatial data analysis tools, their types and comparison. You will also learn about the pointers which would guide you to choose a tool for your study.

Objectives

After studying this unit, you should be able to:

- define geospatial tools and explain their importance;
- describe types of geospatial data handling tools outlining their usage and advantages;
- differentiate between COTS and FOSS; and
- select a geospatial tool for your project.

7.2 GEOSPATIAL TOOLS

Geospatial tools (or geoinformatics software) are increasingly being used as the principal tools for digital exploration of variation in landscapes, as they provide the necessary functions for spatial data collection, management, analysis and representation. Any geospatial data analysis tool should be capable of generating thematic maps, and allowing overlay of different layers of information. It should carry out specific calculations, databases linking and also processing satellite images as well as aerial photographs. The recent advances in remote sensing have made it possible to have latest information about the Earth at different spatial resolutions, rather than extracting the same information from maps which have been prepared using various symbols and colours.

Geospatial data handling tools (i.e. software packages/ systems) provide a unified approach to working with geographic information.

Geospatial data handling tools form the basis of the processing engine, and comprise a vital component of operational software. Geospatial tools (/ software) comprise an integrated collection of computer programs that implement geographic storage, processing and display functions. Geospatial tools' functionality includes the following aspects:

Geospatial tools deal with user interfaces, tools and data management.

- allow studying of data, methods and algorithm implementation
- developed models and algorithms need not be reimplemented by others in order to continue research or validate previous results
- ensure worldwide development, advancement and applications.

Apart from these, researchers should have access to libraries of the original models for analysis, validation, development and implementation for further improvement and customisation, depending on the local requirement.

7.2.1 Historical Development

All the available tools, which perform geographic analyses, are packed into a bundle of application, is known as geospatial tools. Geospatial tools have evolved through multiple parallel but separate applications across numerous disciplines. You will study about the historical development of geoinformatics tool in this section.

The development of the geospatial tools started in 1960s by the U.S. Census Bureau which marked the beginning of the adoption of digital mapping by the government. This system led to the production of the Census TIGER files; one of the most important socio-economic spatial data sets in use today. Important geographic work was also being done at universities throughout the 1950s and

1960s. A grid-based mapping program called SYMAP, developed at the Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design in 1966, was widely distributed which served as a model for later system. These early geoinformatics software packages were often written for specific applications and required the mainframe computing systems, usually found in government or university settings.

SYMAP is a programme for mapping on a line printer.

In the 1970s, private vendors began offering off-the-shelf software packages. M&S Computing (later Intergraph) and Environmental Systems Research Institute (ESRI) emerged as the leading vendors of GIS software. In 1981, ESRI released Arc/Info, a standard GIS package, which assisted in GIS becoming a viable technology for state and municipal planning. In 1992, ESRI released ArcView, a desktop mapping system with a graphical user interface that marked a major improvement in usability over Arc/Info's command-line interface. This enabled distributed mapping and spatial analysis over the Internet and marked major developments in the history of Commercial Off-The-Shelf (COTS) geoinformatics software.

The development of open source tools is marked by the development of Map Overlay and Statistical System (MOSS) in 1978 - a pioneer vector-based geospatial tool developed by the U.S. Department of Interior. Later, during 1982, GRASS (Geographic Resources Analysis Support System) was developed by US Army Construction Engineering Research Laboratories (USA-CERL), and was published as public domain software. This was followed by PROJ4 library (1983) and a number of other software. In 1992, Open GRASS Foundation (OGF) was established. In 2006, Open Source Geospatial Foundation was established whose mission was to support and promote the collaborative development of open geospatial technologies, data and educational material.

7.2.2 Classification

A modern geospatial tool, particularly, the GIS comprises an integrated suite of software components of three basic types:

- data management system for controlling access to data
- mapping system for display
- interaction with maps and other geographic visualisation, and a spatial analysis and modelling system.

Widely used GIS are built and released by GIS software development and product teams that may operate according to commercial or open-source models. Mature software products are carefully planned versioned release cycles that incrementally enhance and extend the pool of capabilities. The key parts of GIS are:

Core GIS software systems are usually written in a modern programming language, like Visual C++/C# or Java.

- architecture - the user interface
- business logic (tools)
- data manager
- data model and
- customisation environment.

GIS product teams start with a formal design of a software system followed by building each part or component separately before assembling the whole system. Mostly the development will be repetitive with creation of an initial prototype framework containing a small number of partially functioning parts, followed by increasing refinement of the system.

A key choice that is faced by all software developers is whether to design a software system by buying in components, or to build it from scratch. Both options have their own advantages; building components give greater control over system capabilities and enable specific-purpose optimisation, whereas buying components can save time and money.

Even though, you may have geoinformatics software with expected functionality, yet you cannot access it if you do not have necessary license to use it. A ***license*** is a process of allowing an individual or group to use a piece of software. Most of the applications are licensed rather than sold in geoinformatics market. There are a variety of different types of software licenses. Some are based on the number machines on which the licensed program can run, whereas others are based on the number of users that can use the program. Most personal computer software licenses allow you to run the program on only one machine and to make copies of the software only for backup purposes. Some licenses also allow you to run the program on different computers as long as you don't use the copies simultaneously. This is one type of license which a user must purchase to run or upgrade the software. Software coming under this category are grouped as ***COTS*** *(Commercial Off-The – Shelf)* Software. There is another type of licensing system known as GPL (General Public License) whereby the recipients are granted the rights to use modify and circulate a computer program for free of cost. This kind of software is known as ***FOSS (Free and Open Source Software). Open source software*** is defined as software that has the source code freely available, and is licensed so that it can be freely distributed and modified as long as appropriate credit is provided to the developers. (www.whrc.org /education/rwand/pdf/ Horning_OpenSource_software.pdf).

7.2.3 Advantages

You have read about the advantages of using a GIS in Unit 1 of this Course. One of the main attractions is the convenience at which information can be presented. This provides much of the basis for the support of the technology. The advantages of geoinformation technologies are encountered through the tasks that the various packages can perform. Specific advantages of geospatial tools are the followings:

- it allows you to map the location of objects, like natural, cultural and human resources. Terrain models can be generated to aid with 3-D visualisation. Densities and quantities of a specific item in a given area can be calculated and displayed, as can population changes over time
- it helps you to know specific street address and coordinate data (i.e. longitudes and latitudes) which can be accurately computed from a map using geocoding methods. The software provides a very effective means for graphically conveying the complex information

- it can help you organise and centralise your data. A GIS database can link all of your organisation's digital data together based on locations, such as addresses. This could enable all departments of an organisation to have access to, and share the same data, and ensure all departments and individuals are using the most up-to-date information
- websites can be developed with geoinformatics software for either the internet or company intranet applications which can help your company or organisation to effectively convey information to members of a private group, or public at large. Maps can be created dynamically and uploaded over the web
- field based GPS data can be analysed, displayed and plotted, and subsequently imported into your organisation's database using geospatial tools.

7.3 COMMERCIAL OFF-THE-SHELF SOFTWARE (COTS)

Commercial Off-The-Shelf (COTS) software is considered an economically viable method of integrating various software components to produce a new product. Many commercial and government organisations are now relying on COTS software rather than developing and maintaining their own programs. COTS products seem to be less expensive than the proprietary software to integrate into the infrastructure of an organisation, whilst decreasing the development time for new products. COTS software products have been defined as "commercial items that have been sold, leased, or licensed in a quantity of at least 10 copies in the commercial marketplace, at an advertised price" (National Research Council, 1997). COTS software products include a description or definition of the functions the software performs, documented to good commercial standards, and a definition of the resources needed to run the software. Four issues need to be considered when considering COTS software:

- functionality and performance,
- interoperability,
- product evolution, and
- vendor behaviour.

7.3.1 Definition

COTS is an abbreviation used for ***Commercial Off-The-Shelf,*** an adjective that describes software or hardware products which are readily available for sale to the general public. For example, Microsoft Office is a COTS product that is a packaged software solution for business. COTS products are designed to be implemented easily into existing systems without the need for customisation. 'The New York Times' everyday dictionary, 1982 says that commercial means either "oriented to profit-making" or more generally "of, pertaining to, or suitable for commerce", where commerce means "intercourse, dealings, the buying and selling of commodities, or trade". So, we are talking about something which is oriented towards profit or at least something pertaining to public trade or dealings.

7.3.2 Usage and Functionality

Functionality of COTS software determines the outcome of the system, whereas its performance depends on various factors, including vendor's specifications. Many variables affect COTS programs' interoperability with each other and with proprietary software, including the source of COTS software, presence or absences of standards, and the extent of use of open architecture. Vendors' commitment to upgrade COTS products and the software evolution cycle is usually independent of users' system requirements. Ultimately, vendor's ability, willingness, resources, and attitude determine their behaviour and conduct towards their customers and the kind of support that they provide. Developing a new system based on COTS products involves acquiring different components, customising various software packages to suit local requirements.

It is important to understand that the use of COTS is not simply a technical or cost issue; it has total system life cycle implications. The use of COTS software reduces programmatic, technical, schedule, and cost risk. Reduced risk means immediate increased value when compared to any alternative commercial or government-owned software. A 'best value' determination includes both cost and non-cost factors, when an agency assesses the near and long-term benefits that it will realise in selecting a particular software solution. An organisation may weigh past performance and technical expertise against cost considerations to determine the most beneficial solution. It may be in the best interest of the organisation to consider factors other than the lowest price. Important non-cost factors for any customer include the following:

- compliance with technical requirements,
- robust software functionality,
- demonstrated commitment to industry standards
- market presence and stability, and
- domain knowledge and experience

Many COTS software use an open modular architecture based on Microsoft's Component Object Model (COM). COM is the industry standard, and the leading technology used in building component-based software. This technology has been chosen because it enabled the development of geo-processing objects using a 'fine-grained' object framework, which enables the customers to develop, customise, and extend geo-processing software systems at the detailed core level (www.esri.com/library/whitepapers/pdfs/cots-gis.pdf).

7.3.3 Advantages

The advantages of COTS software include predictable license costs, shorter development time, broad and immediate availability, comprehensive functionality and potentially frequent upgrades. The following are the key benefits or advantages of using COTS:

- **Company stability:** It is an important non-cost factor that adds value by ensuring longevity to support and advance any program now and into the future. Many of the COTS providers are technically, administratively, and fiscally healthy corporations recognised as the technical and market leaders in the GIS field. For example, Environmental Systems Research Institute (ESRI), founded in 1969, is a privately held, financially growing company. ESRI's average annual growth of 23 percent and high customer revenues (more than $427 million in 2001) indicate its success. ESRI is the world's largest COTS mapping and GIS Software Company (www.esri.com/ library/whitepapers/pdfs/cots-gis.pdf).

- **Research and Development Investments:** They are high in the development of COTS. For example, ESRI, after six years of engineering and development and more than $260 million invested, offers one of the largest COM based commercial component ware toolkits. ESRI has re-invested more than $228 million, ~30 percent of its revenue into research initiatives in the past few years alone (www.esri.com/library/whitepapers/ pdfs/cots-gis.pdf).

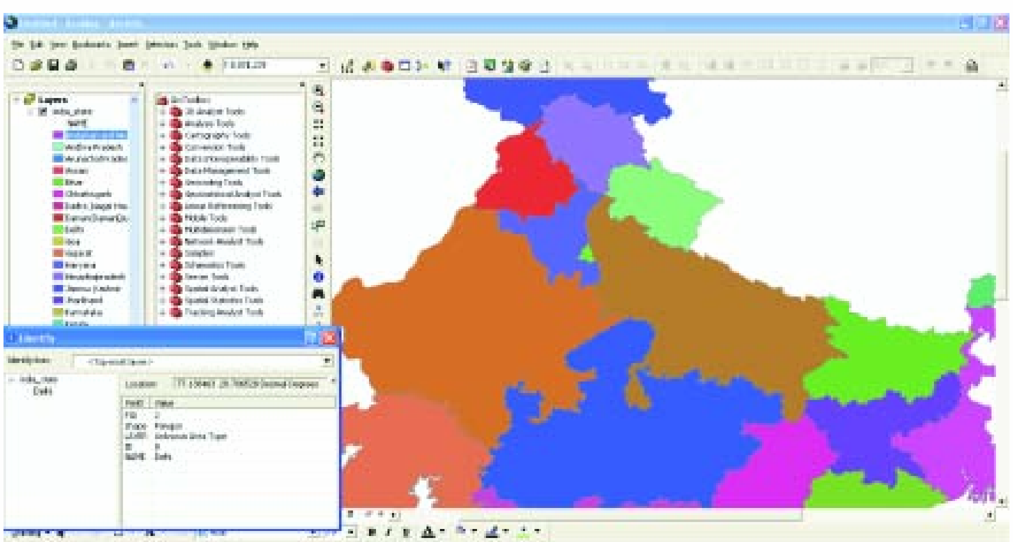
- **Customer Support Infrastructure:** The successful implementation of any new product depends on responsive, effective, reliable support, sustainable over the long term. COTS provides a large and responsive support infrastructure that adds value by reducing the risk of inadequate support of software throughout the life cycle.

7.3.4 Examples

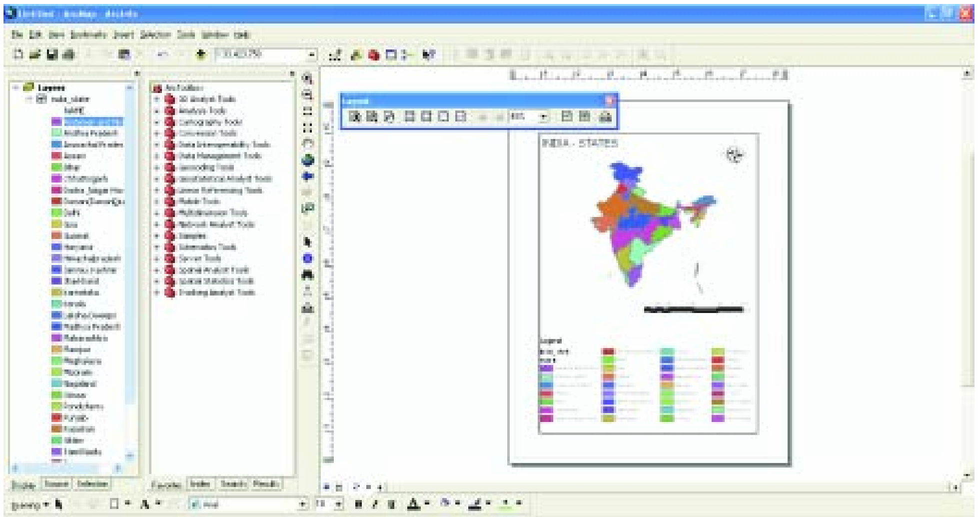
There are gamuts of COTS software available in the market, which include PCI Geomatica, ERDAS Imagine, ENVI, ArcGIS, MapInfo, IDRISI, etc. We take *ESRI- Arc GIS* and *ERDAS Imagine*, as two examples of COTS.

a) ArcGIS

ArcMap is the main component of ESRI's ArcGIS (Fig. 7.1a) suite of geospatial processing programs, and is used primarily to view, edit, create, and analyse geospatial data. ArcMap allows the user to explore data within a data set, symbolise features accordingly, and create maps (Fig. 7.1b).



(a)



(b)

Fig. 7.1: (a) A snapshot of the ArcGIS software with attribute table of Delhi; (b) A snapshot of the layout view of the ArcMap software

ArcMap users can create and manipulate data sets to include a variety of information. For example, the maps produced in ArcMap generally include features, such as north arrows, scale bars, titles, legends, etc. The software package includes a style-set of these features.

The ArcGIS suite is available at three license levels: ArcEditor, ArcView, and ArcInfo. Each step up in the license provides the user with more extensions that allow a variety of querying to be performed on a data set. Maps created and saved within ArcMap will create a file on the hard drive with an *.mxd* extension. Once an *.mxd* file is opened in ArcMap, the user can display a variety of information, as long as it exists within the data set. At this time, the user will create an entirely new map output and use the customisation and design features to create a unique product. Upon completion of the map, ArcMap has the ability to save, print, and export files to *.pdf*.

b) ERDAS IMAGINE

ERDAS IMAGINE is a geoinformatics application tool with raster graphics editor capabilities designed by ERDAS, Inc., for geospatial applications (Fig. 7.2). It is aimed primarily at geospatial raster data processing and allows the user to prepare, display and enhance digital images for mapping use in GIS or in CADD software. It is a toolbox allowing the user to perform numerous operations on an image and generates an answer to specific geographical questions. By manipulating imagery data values and positions, it is possible to see features that would not normally be visible and to locate geo-positions of features that would otherwise be graphical. The level of brightness or reflectance of light from the surfaces in the image can be helpful for vegetation analysis, prospecting minerals, etc. Other usage examples include linear feature extraction, generation of processing work flows (‘spatial models’ in ERDAS IMAGINE), import/export of data for a wide variety of formats, ortho-rectification, mosaicking of imagery, stereo and automatic feature extraction of thematic map data from imagery.

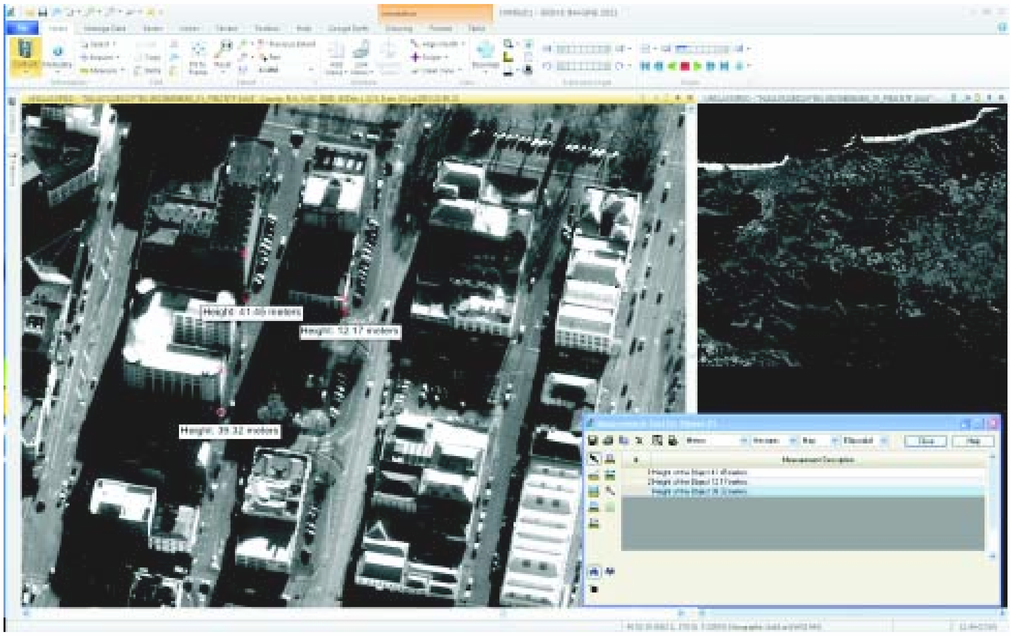


Fig. 7.2: A snapshot of the ERDAS Imagine software showing measurement of height of image features (source: www.erdas.com/products/ERDASIMAGINE/ERDASIMAGINE/Details.aspx)

c) ENVI

ENVI, which is an acronym for 'Environment for Visualising Images', is a software application used to process and analyse geospatial imagery (Fig. 7.3). It is marketed by ITT Visual Information Solutions, and is commonly used by remote sensing professionals, scientists, researchers, and image analysts. ENVI software provides scientifically advanced image processing and analysis capabilities accessible to all levels of geospatial imagery users. The software uses an automated, wizard-based approach that walks users through complex tasks. ENVI was originally developed by adapting the U. S. Geological Survey's REMAPP-PC public domain, and was subsequently sold to Kodak.

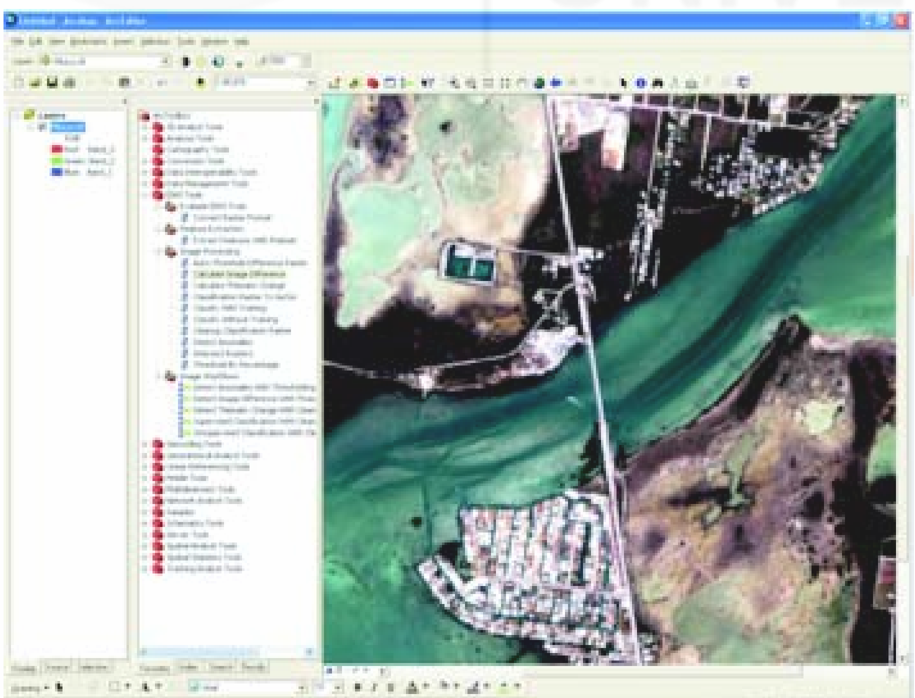


Fig. 7.3: A snapshot of the ENVI software (source: www.imagingnotes.com/enews/2010-12)

Check Your Progress I

Spend 5 mins

1) Expand the ENVI.

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2) What is the latest version of ESRI's Arc GIS available in the market?

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3) What is COM?

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4) The main purpose of ENVI is ....
   a) Digitisation of the contours
   b) Analysing the shortest distance
   c) Analysis of geospatial images.

7.4 FREE AND OPEN SOURCE SOFTWARE (FOSS)

You will find it interesting to read and understand about the open source software – FLOSS. This kind of software is generally distributed along with its source code. This is usually done free with the purpose of allowing the improvement of the software by the general user and developer base. This way, the software can definitely apply to user needs and interests as well as draw closer to perfection in the most efficient way possible. Many organisations have adopted the open source philosophy in order to produce the premier software of their markets, and many non-profit organisations have coalesced in support of open source software. Even governments have heralded their support of open source software, and some have even gone as far as to initiate mandates that render the distribution of open source software all but compulsory.

7.4.1 Definition

Free and Open Source Software (FLOSS, FOSS) or Free Library Open-Source Software is liberally licensed to grant the right of users to use, study, change, and improve its design through the availability of its source code. This approach has gained both momentum and acceptance as the potential benefits have been increasingly recognised by both individuals and corporations. Free and open source software is an inclusive term which covers both free software and open source software that, despite describing similar development models, have differing cultures and philosophies.

Free software focuses on the philosophical freedom it gives to users while open source focuses on the perceived strengths of its peer-to-peer development model. FOSS is a term that can be used without particular bias towards either political approach. Free software licences and open source licenses are used by many software packages.

7.4.2 Usage and Functionality

The uses of FOSS are many besides being cheap. Some of the uses of FOSS are listed below:

- **Marketable skills:** In this ever-changing job market, it is a huge benefit to be able to bring a total software package to the table.
- **Supported by huge development and support community:** FOSS community is very passionate about helping each other and continually improving software.
- **Low start-up costs:** It is now possible to install a complete GIS stack without paying any thing legally.
- **Security:** Arguably more secure than proprietary software backed by a large development community. Increasingly, now-a-days, bugs are found and fixed quickly.
- **Workability:** It works on all major platforms, like Mac, Linux, Windows.
- **Works with existing GIS data:** Import *.shp* files, most major formats, and export to most major formats. ArcSDE now connects to PostGIS (OS database)þ, and above all there is no file format lock-in.

Most of the FOSS geoinformatics software are enabled with the following functionalities:

- **View and overlay:** Vector and raster data in different formats and projections without conversion to an internal or common format.
- **Create maps:** Interactively explore spatial data with a friendly graphical user interface. The many helpful tools are available in the GUI.
- **Edit and export:** Spatial data.
- **Spatial analysis:** It is performed using many of the freely available plug-ins.

7.4.3 Advantages

Motivations for using and developing open source software are mixed, ranging from philosophical and ethical reasons to pure practical issues. Usually, the first perceived advantage of open source models is the fact that open source software is made available without or at a low cost. Some of the benefits of using open source software are listed below:

- the availability of the source code and the right to modify is very important. It enables the unlimited tuning and improvement of a software product

- the right to redistribute modifications and improvements to the code, and to reuse other open source code. This is usually the point that differentiates open source software licenses from 'nearly free' ones
- the right to use the software in any way helps to improve the quality of the product, and to improve its functionality. This combined with redistribution rights ensures (if the software is useful enough), a large population of users, which helps in turn to build up a market for support and customisation of the software, that can only attract more and more developers to work in the project.

Vendor lock-in is avoided in the case of FOSS software. In economics, vendor lock-in, also known as proprietary lock-in, is a situation in which a customer is so dependent on a vendor for product and services that he or she cannot move to another vendor without substantial switching costs, real and/or perceived. Because FOSS software can be modified and distributed by anyone, the availability of functionality cannot tie a user to one distributor.

7.4.4 Examples

Like COTS, FOSS also has a gamut of software having different functionalities, which includes ILWIS, GRASS - GIS, Q-GIS, SAGA, gvSIG, etc. You can get information about all the above mentioned software packages and download them from internet. We will discuss here about two software.

GRASS - GIS

Geographic Resources Analysis Support System, commonly referred to as GRASS, is a free GIS software used for geospatial data management and analysis, image processing, graphics/maps production, spatial modelling and visualisation (Fig. 7.4). GRASS is used in many academic and commercial settings around the world, as well as by many government agencies, including NASA, NOAA, USDA, DLR, CSIRO, the National Park Service, the U.S. Census Bureau, USGS, and many environmental consulting companies. GRASS is an official project of the Open Source Geospatial Foundation.

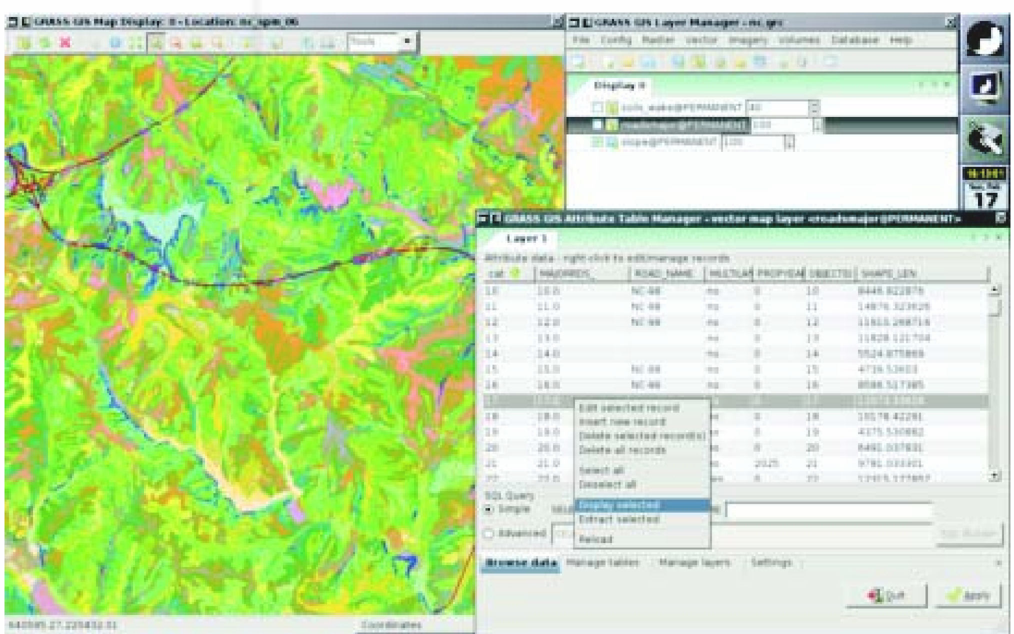

Fig. 7.4: A snapshot of the GRASS software (source: http://en.wikipedia.org/wiki/GRASS_GIS)

Originally developed by the U.S. Army Construction Engineering Research Laboratories (USA-CERL, 1982-1995) as a tool for land management and environmental planning by the military, GRASS has evolved into a powerful utility with a wide range of applications in many different areas of scientific research.

The new version of GRASS 6 introduces a new topological 2D/3D vector engine and supports for vector network analysis. Attributes are now managed in a SQL-based DBMS. A new display manager has been implemented. The GRASS Development Team has grown into a multi-national team consisting of developers at numerous locations.

a) Quantum GIS

Quantum GIS (QGIS) is a user friendly Open Source GIS licensed under the GNU (General Public License). QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It is a multi-platform application and runs on different operating systems such as Linux, Unix, Mac OSX and Windows and supports numerous vector, raster, and database formats and functionalities. Quantum GIS provides a continuously growing number of capabilities provided by core functions and plug-ins. You can visualise, manage, edit, analyse data, and compose printable maps. You will get a first impression of the software with the screenshot in Fig.7.5. QGIS is a cross-platform (Linux, Windows, Mac) open source application with many common GIS features and functions.

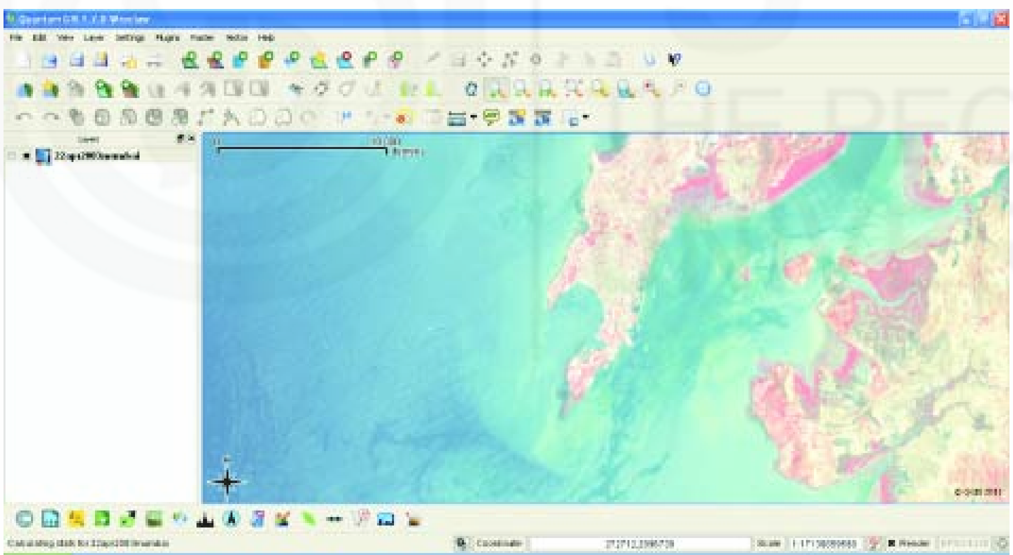

Fig. 7.5: A snapshot of the QGIS software

Check Your Progress II

Spend 5 mins

1) Expand FOSS.

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2) List any three open source geoinformatics software.

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3) Expand GRASS.

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4) What is OSGeo?

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7.5 COMPARISON BETWEEN COTS AND FOSS

During the past two decades, the software market has been dominated by COTS products that offer numerous functionalities at reasonable prices. However, the inherent limitations of COTS software have emerged over time (i.e. closed source code, expensive upgrades, lock-in effect, security weaknesses, etc.). This led to the development of a parallel ‘economy’ based FOSS. After a slow beginning in the late 1990s, FOSS has been constantly growing in importance and expanding in many software architectures all over the world. This impressive growth has been supported by the numerous successes, the high quality reputation of FOSS based systems and, of course, by the expectation of cost savings. In order to evaluate these two sets of software, a SWOT (Strength/Weakness/Opportunities/Threats) analysis has been done. The results of which are provided here.

SWOT analysis of COTS is as follows (Fig. 7.6):

- **Strength:** research and development investments/customer support infrastructure
- **Weakness:** closed source code/expensive upgrades/controlled by a profit-driven enterprise
- **Opportunities:** research and development initiatives/innovative new products/recent and up-to-date.
- **Threats:** lock-in effect/security weaknesses

The three commonly identified benefits of FOSS are:

- inexpensive and so demonstrates that a government agency is being fiscally responsible
- it avoids a government agency getting 'locked in' to a commercial supplier, and
- it can be inspected by adequately 'informed' citizens because the source code is not hidden and hence consistent with open and transparent government.

Fig. 7.6: SWOT analysis of COTS

SWOT analysis of FOSS is shown in Fig. 7.7. The usefulness of any software depends on the type of demand and functionality required. If you wish to have geoinformatics software for the purpose of learning, any open source platform is good to begin. When there is a need for more specialised analysis and customisation, COTS are the best choice. So, the one who is going to choose the software need to evaluate the software based on its strength and weaknesses, and if possible may perform a SWOT analysis before finalising the choice.

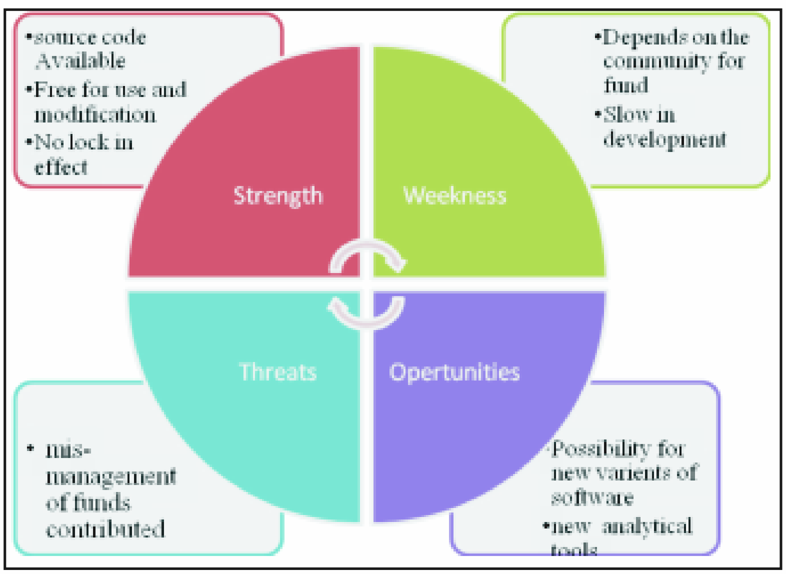

Fig. 7.7: SWOT analysis of FOSS

7.6 INDIGENOUSLY DEVELOPED GEOSPATIAL TOOLS

Indigenous GIS software is developed by many institutions to address their own specific needs as well as for the targeted customers. Such software has much functionality which would not otherwise be addressed by either COTS or FOSS. In India, Centre of Studies in Resources Engineering, IIT Bombay has indigenously developed a GIS software package, named *GRAM++*. Similar such software like *IGIS*, *GISNIC*, *GEOSPACE*, and *THEMAPS* are developed and available in GIS software arena. Indigenous software is developed for the following main reasons:

- **To lower total cost of ownership:** Reduces the cost of ownership as working on a single platform across the organisation helps circumvent the licensing, learning, integration and time costs. The cost of upgrading will also be low, and can be done as and when required.
- **To have extensive features:** There would be a gamut of features addressing the local needs which generally would not be available with the COTS/ FOSS.
- **To customise easily:** User defined features and automation tools can be incorporated flexibly.
- **To offer easy training and support:** It is made locally to address the local needs. So, this indigenous software has the possibility to be developed in vernacular versions, making them more flexible to work with even less trained staff.

Two of the indigenously developed software is briefly discussed below:

- **GRAM++**

It is developed by IIT Bombay. The software is organised as a number of modules, including Import/Export of different format data, Map Editing, Raster Analysis, Vector Analysis, Network Analysis, Terrain Modelling and Watershed Delineation, Digital Image Processing, and Map Layout (Fig. 7.8). Support for Survey of India's Digital Vector Data (DVD) format is added to the package to enhance the functionality in the Indian environment. This development was supported by the UNDP assisted project on 'GIS Based Technologies for Local Level Development Planning' and the Department of Science and Technology, Government of India.

Fig. 7.8: A view of the GRAM++ software (source: http://nrdms.gov.in/GRAM++Suite .ppt)

- **IGIS**

IGIS has been developed in partnership with prestigious Space Applications Centre, Indian Space Research Organisation (ISRO), Ahmedabad. It is a seamless geoinformatics application with both single user/multi-user platform and includes GIS, image processing and its integration with the real time information using GPS (www.scanpointgeomatics.com/igis.html). This software is a complete enterprise solution and meets all geoinformatics needs of an organisation through GIS, Image Processing, Analysis, Terrain Analysis, 3D Modelling and Neural Network Analysis. It has multi-users capability and networking capability support. It has enhanced data security through authorised user access by a field level and backup/restore.

7.7 HARDWARE REQUIREMENTS AND CONSTRAINTS

There are certain basic requirements for installing the geoinformatics software. The ever-growing development and innovation in the field of computer hardware and software industry generally require continuous updation and upgradation of both software and hardware. It is neither possible nor desirable to recommend a generalised requirement in terms of hardware and software for a GIS program. It is obvious that hardware and software requirements vary considerably depending on the tasks undertaken. The following minimum configuration (Table 7.1) allows installation of most modern GIS applications for work with small components:

Table 7.1: Hardware Requirements for a Geoinformatics System

CPU Speed	2.2 GHz dual core or higher
Processor	Intel Core Duo, Pentium 4 or Xeon Processors
Memory/RAM	1 GB or higher
Display Properties	24Â bit colour depth
Screen Resolution	1024 x 768 recommended or higher at Normal size (96dpi)
Swap Space	Determined by the operating system, 500 MB minimum.
Disk Space	2.4 GB In addition, up to 50 MB of disk space maybe needed in the Windows System directory (typically C:\Windows\System32).
Video/Graphics Adapter	24-bit capable graphics accelerator. An OpenGL 2.0 or higher compliant video card is required, with at least 128 MB of video memory, however 512 MB of video memory or higher is recommended.
Networking Hardware	Simple TCP/IP, Network Card or Microsoft Loopback Adapter is required for the License Manager.

For very large tasks, such as intensive web server applications using IMS, investing in a dual socket, quad processor machine may be considered. Various processes within modern GIS applications can use multiple processors.

7.8 SELECTING APPROPRIATE TOOL

The type of software to be acquired usually depends on:

- budget,
- experience, and
- tasks that need to be performed.

It is often helpful to ask for guidance from others who have made a similar decision. The experience with *Photoshop* or a similar package is a good to start if you are interested in working with visual images. However, a GIS package would be better suited for your needs, if you are interested in using remote sensing images with other data, such as vector GIS layers, or if you want to have geospatial capabilities, such as locating a feature using geographic coordinates, such as latitude and longitude. The software links page lists some free and inexpensive software options with additional links for commercial software.

A lot also depends on your current situation. If you work for an organisation with propriety software, you might consider open source software to 'fill in the workability holes' of the propriety software or you may just find that the open source version does some tasks better than what you have already. If you are new to the world of remote sensing or GIS, open source software is a great place to start since it is free. If the software meets your needs than you are all set to use it. If your need functionality is not available from open source packages then you can consider the alternative of purchasing propriety software.

Being a computer programmer, your contribution is fairly straight forward but what if you are an end user who would like to contribute. Simply using the software and providing input to the development team about the interface, additional functionality, and bug reports are appreciated. Writing or commenting on existing documentation is another area where users can help. Most of these software projects have discussion lists and some of these are focused specifically on users. The best advice is to download the software, play around with it and share your thoughts. If you like it, pass on the good news to your friends and colleagues.

7.9 ACTIVITY

1) Prepare an assignment on the various uses and functionality of COTS, such as Mapinfo and IDRISI.
2) Prepare an assignment on the various uses and functionality of FOSS, such as ILWIS, SAGA and gvSIG.
3) Prepare a list of Open Sources Software; find out the URL for downloading the software.
4) Find out the training schedule of the indigenous software in GIS of your choice and enrol for a training session.
5) Go to the websites of the main GIS software vendors and compare their product strategies with open source GIS products. Find out in what ways are they different?

Autodesk: www. Autodesk.com

Bentley: www.bentley.com

Esri: www.esri.com

Intergraph: www.intergraph.com

Openjump: www.Openjump.org

7.10 SUMMARY

Let us now summarise what we studied in this unit:

- Geospatial data analysis tools (software) are a fundamental and critical part of any operational work related to geospatial data. The software employed in a geoinformatics related project has a controlling impact on the type of studies that can be undertaken and the results that can be obtained. There are also far-reaching implications for user productivity and project costs.
- Today, there are many types of GIS software product to choose from and a number of ways to configure implementations. One of the exciting characteristics of GIS software is its very rapid rate of development, not least in the areas of web and open-source GIS. This trend seems set to continue as software development push ahead with significant research and development efforts.
- There are two categories of geoinformatics software, viz., COTS and FOSS software. The geoinformatics software is classified based on the license being used. COTS (Commercially Off-The-Shelf) software is costly but user-friendly. They have specific tools and upgraded frequently but vulnerable to computer viruses. FOSS software are free to use and modify but have certain limitations for use in large data intensive projects.
- The usefulness of any software depends on the type of demand and functionality required. It is important to properly understand the purpose for which it is going to be used, and consider the requirements before selecting any geoinformatics software.
- Geoinformatics software has also been indigenously developed in India by some institutions for specific purposes to address a group of targeted audience.
- It is very important to have basic hardware requirement for installing the geoinformatics software. The ever-growing development and innovation in the field of computer hardware and software industry generally require continuous updation and upgradation of both software and hardware.

7.11 UNIT END QUESTIONS

Spend 30 mins

1) Define COTS and FOSS.
2) Differentiate between COTS from FOSS.
3) What are indigenous software and why they are developed?
4) Enumerate the advantages of using FOSS.

7.12 REFERENCES

- National Research Council, (1997). Ada and beyond: software policies for the department of defense, Washington, D.C.: National Academic Press. (www.nap.edu/catalog.php?record_id=5463).
- The New York Times' everyday dictionary, 1982.
- http://en.wikipedia.org/wiki/GRASS_GIS.
- http://nrdms.gov.in/GRAM++Suite.ppt.
- www.erdas.com/products/ERDASIMAGINE/ERDASIMAGINE/Details.aspx.
- www.esri.com/library/whitepapers/pdfs/cots-gis.pdf.
- www.imagingnotes.com/enews/2010-12.
- www.scanpointgeomatics.com/igis.html.
- www.whrc.org/education/rwand/pdf/Horning_OpenSource_software.pdf.

7.13 FURTHER/SUGGESTED READING

- Chang, Kang-tsung. (2010), *Introduction to Geographic Information Systems*. 4th Ed., Tata McGraw-Hill, 449p.
- Longley, P.A., MF. Goodchild, D.J. Maguire and, D.W. Rhind (2011), *Geographic Information Systems and Science*. 3rd Ed., John Wiley & Sons. 539p.

7.14 ANSWERS

Check Your Progress I

1) ENVI - Environment for Visualising Images
2) Arc GIS 10.0
3) COM - Component Object Model
4) Analysis of the geospatial imagery.

Check Your Progress II

1) FOSS – Free and Open Source Software
2) GRASS; QGIS; SAGA
3) GRASS - Geographic Resources Analysis Support System
4) OSGeo - Open Source Geospatial Foundation

Unit End Questions

1) Refer to the sections pertaining to definition in COTS (section 7.3.1) and FOSS (section 7.4.1).
2) Refer to section 7.5.
3) Refer to section 7.6.
4) Refer to section 7.4.3.

GLOSSARY

- **ASTER** (Advanced Spaceborne Thermal Emission and Reflection Radiometer) : It is a Japanese sensor which is one of five remote sensor devices on board the Terra satellite launched into Earth orbit by NASA in 1999.

- **Attribute :** An attribute is a set or collection of data that describes characteristics of real world entities or conditions.

- **Data :** Any collection of related facts arranged in a particular format; often, the basic elements of information that are produced, stored, or processed by a computer.

- **Data entry :** A process of key entering tabular data into a structured file. This is typically accomplished by using a CRT terminal with a formatted screen.

- **Data format :** The way in which data elements are represented and stored in computer records.

- **Data input :** Entering data into a computer; geographic data is generally entered into a GIS database via a digitiser or a scanner.

- **Data set :** A collection of logically related data records arranged in a prescribed manner. The physical set of data of one data type being referred to or being used in the context of a data processing operation.

- **Database :** A collection of interrelated data sets stored together and controlled by a specific schema.

- **Database Management System (DBMS) :** A systematic approach to maintaining, accessing and manipulating database files. A DBMS may consist of a single program or a collection of task-specific programs.

- **Digital data :** Information stored and processed with numerical digits, often in base 2.

- **Digitisation :** Process of converting an analog image or map into a digital format usable by a computer.

- **Discrete data :** Non-interpolatable data comprised of multiple subjects, each subject is clearly distinct from all other subjects on a map.

- **ERDAS** (Earth Resources Data Analysis System) : A first-generation, raster-oriented microcomputer image processing and GIS system marketed by ERDAS, Inc.

- **GTOPO30 :** It is a digital elevation model for the world, developed by USGS. It has a 30-arc second resolution (approximately 1 km), and is split into 33 tiles stored in the USGS DEM file format.

- **HYDRO1k :** It is a geographic database developed to provide comprehensive and consistent global coverage of topographically derived data sets, including streams, drainage basins and ancillary layers derived from the USGS' 30 arc-second digital elevation model of the world (GTOPO30).

- **IKONOS :** It is a commercial earth observation satellite, and was the first to collect publicly available high-resolution imagery at 1 and 4 meter resolution.

- **Topography :** The features of the actual surface of the Earth, considered collectively according to their form (grassland, cultivated, desert, forest, swamp, etc.). A single feature, such a one mountain or one valley, is called a topographic feature.

ABBREVIATIONS

ADRG	**:**	ARC Digitised Raster Graphics
ASCII	**:**	American Standard Code for Information Interchange
AWS	**:**	Automatic Weather Station
BIL	**:**	Band Interleaved by Line
BIP	**:**	Band Interleaved by Pixel
BSQ	**:**	Band Sequential
COM	**:**	Component Object Model
COTS	**:**	Commercial Off-the-Shelf
CSDGM	**:**	Content Standard for Digital Geospatial Metadata
CWC	**:**	Central Water Commission
DCW	**:**	Digital Chart of the World
DEM	**:**	Digital Elevation Model
DMA	**:**	Defense Mapping Agency
DMS	**:**	Disaster Management Support
DXF	**:**	Drawing Exchange Format
EMR	**:**	Electromagnetic Radiation
ENVI	**:**	Environment for Visualizing Images
EROS	**:**	Earth Resources Observation and Science
ESRI	**:**	Environmental Systems Research Institute
ETM	**:**	Enhanced Thematic Mapper
FGDC	**:**	Federal Geographic Data Committee
FOSS	**:**	Free and Open Source Software
FTP	**:**	File Transfer Protocal
GCP	**:**	Ground Control points
GeoTIFF	**:**	Geographic Tagged Image File Format
GLCF	**:**	Global Land Cover Facility
GLOBE	**:**	Global Land One-kilometer Base Elevation
GRASS	**:**	Geographic Resources Analysis Support System
HDF	**:**	Hierarchical Data Format
IMD	**:**	Indian Meteorological Department
IRS	**:**	Indian Remote Sensing
ISRO	**:**	Indian Space Research Organization
JFIF	**:**	JPEG File Interchange Format
JPEG	**:**	Joint Photographic Experts Group
LGSOWG	**:**	Landsat Ground Station Operators Working Group

LIS	:	Land Information System
LPDAAC	:	Land Processes Distributed Active Archive Centre
MODIS	:	Moderate Resolution Imaging Spectroradiometer
MOSS	:	Map Overlay and Statistical System
MSS	:	Multispectral Scanner Scanner
NASA	:	National Aeronautical and Space Administration.
NBSS&LUP	:	National Bureau of Soil Survey and Land Use Planning
NDC	:	National Data Centre
NIMA	:	National Imagery and Mapping Agency
NOAA	:	National Oceanographic and Atmospheric Administration
NRSC	:	National Remote Sensing Centre
PNG	:	Portable Network Graphics
OGF	:	Open GRASS Foundation
ONC	:	Operational Navigation Chart
ORNL	:	Oak Ridge National Laboratory (ORNL)
SASE	:	Snow and Avalanche Study Establishment
SRTM	:	Shuttle Radar Topography Mission
TIFF	:	Tagged Image File Format
USA-CERL	:	US Army Construction Engineering Research Laboratories
VRC	:	Village Resource Centre