

# UNIT 10

## DATA ACQUISITION

### Structure

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- |      |                            |                                 |
|------|----------------------------|---------------------------------|
| 10.1 | Introduction               | Text Data                       |
|      | Expected Learning Outcomes | Digitisation                    |
| 10.2 | Existing Data              | 10.4 Geometric Transformation   |
|      | Raster and Vector Data     | 10.5 Summary                    |
|      | Metadata                   | 10.6 Activity                   |
|      | Conversion                 | 10.7 Terminal Questions         |
| 10.3 | Creating New Data          | 10.8 References                 |
|      | Remote Sensing Data        | 10.9 Further/Suggested Readings |
|      | In Situ Data Collection    | 10.10 Answers                   |

### 10.1 INTRODUCTION

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We need data for map generation, analysis and even for modelling to work in any GIS. The question is where do we get data that is needed to work with GIS? The solution is to get the required data from different sources. Therefore, we can acquire data from various sources like existing data sources and if the data we needed is not available the only solution is to create new data. Thus, finding the solution is by data acquisition.

In the previous unit you have read about the GIS data standards and interoperability, topological models, connectivity, area definition and contiguity. In this unit, we will discuss the existing data that includes raster and vector data, metadata and data conversion. We will also discuss creation of new data that comprises remote sensing data, in situ data collection, text data and digitisation, and geometric transformation.

## Expected Learning Outcomes

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After studying this unit, you will be able to:

- ❖ describe the existing data that includes raster and vector data;
- ❖ illustrate the other elements of existing data such as metadata and data conversion;
- ❖ explain creation of new data that comprises remote sensing data, and in situ data collection;
- ❖ know text data and digitisation, that are important constituents of creation of new data; and
- ❖ describe geometric transformation.

## 10.2 EXISTING DATA

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GIS datasets are produced and distributed in a variety of formats: vector, raster, point, line, polygon, image, etc. and are designed for certain computer systems/software programs (Unix, DOS/Windows, Macintosh, GRASS, QGIS, Idrisi, Arc/Info etc.). Therefore, large numbers of existing important datasets are available with different formats. There are different available methods and tools for converting spatial data to a format which is compatible with the GIS.

Existing data from both primary and secondary source can be retrieved, converted and collected with the help of different methods. Few of the existing GIS data formats that can be collected from different sources are:

- Erdas Imagine
- TIGER - Topologically Integrated Geographic Encoding and Referencing
- Survey of India (SOI) DEMs are available at several scales over most parts of India (coverage is not complete for the finest resolution DEM data)
- AmericaView (website: <http://americaview.usgs.gov/>)
- OhioView (website: <http://www.ohioview.org/>)
- U.S. Census Bureau (website: <http://www.census.gov/>)
- Natural Resources Conservation Service (website: <http://soils.usda.gov/>)
- Montana GIS data clearinghouse (website: <http://www.nris.state.mt.us/>)
- Greater Yellowstone Area Data Clearinghouse (website: <http://sun1.giac.montana.edu/gyadc/gyadchome.html>)
- Federal Geographic Data Committee (website: <http://www.fgdc.gov/>)
- Geospatial One-stop (website: <http://www.geodata.gov/>)
- San Diego Association of Governments (website: <http://www.sandag.cog.ca.us/>)
- Clackamas County, Oregon (website: <http://www.clackamas.us/gis/>)
- U.S. Geological Survey: National Map (website: <http://geography.usgs.gov/>)
- National Land Cover Data 1992 (website: <http://landcover.usgs.gov/>)

- USGS DEMs download sites: LAND INFO International (website:<http://www.atdi-us.com/>)
- National Elevation Data set (NED) (website: <http://ned.usgs.gov/ned/>)
- USGS DEMs download sites: GIS Data Depot (website:<http://data.geocomm.com/>)
- USGS DEMs download sites: Map-Mart (website:<http://www.mapmart.com/>)

### **10.2.1 Raster and Vector Data**

Raster and vector data are the spatial data that fall in the category of existing data. Let us discuss about the raster data and vector data in detail.

#### **A) Raster Data**

Though, raster data can be obtained in a number of ways; the most common ways are by means of aerial photography and satellite remote sensing.

In aerial photography, an aeroplane flies over an area, with a camera mounted underneath it and takes the photographs known as aerial photographs. These photographs in digital format are imported into a computer and used. If the photographs are printed on hardcopy then these are used either as such or converted into digital form (raster form) with the use of a high quality scanner. The scanned digital data are then imported into a computer and used.

Satellite images are recorded when satellites orbiting the Earth capture signals from earth surface features of the area they are passing over. Once the image has been recorded, it is transmitted back to Earth receiving stations, electronically. You know that this process of capturing raster data from an aeroplane or satellite is called remote sensing. Satellite data providers provide satellite images in several data formats with a variety of products created.

Let us discuss about the commonly used raster datasets viz. remote sensing satellite data and digital elevation model data.

#### **a) Remote Sensing Satellite Data**

In India, user can acquire remote sensing data from National Data Centre (NDC) of National Remote Sensing Centre (NRSC), of ISRO, which is located at Hyderabad. Remote sensing data from many satellites are available at the GLCF (Global Land Cover Facility). The Landsat, ASTER, IKONOS, Quickbird, Orbview, MODIS, SRTM data, etc. are available on the GLCF website that can be freely downloadable. The data are associated with locational accuracy of better than 50 m.

The existing remote sensing data could also be obtained from the Google Earth and ISRO Bhuvan. Let us discuss about the Google Earth and ISRO Bhuvan in detail.

#### **i) Google Earth**

You might be using Google Earth, which has a large number of images and other geographic information. The free Google Earth basic program consists of thousands of satellite/aerial photographs that are updated periodically. According to the type of information it provides, we can put the Google Earth

under category of hybrid database provider, because, in addition to image canvas it also provides vector database.

## ii) Bhuvan

It is a geoportal of Indian Space Research Organisation (ISRO) showcasing Indian imaging capabilities in multi-sensor, multi-platform and multi-temporal domain. Bhuvan on its portal provides a range of services enabling visualisation of various thematic data generated from different national missions and projects carried out by NRSC (National Remote Sensing Centre), Hyderabad. Some of the hosted satellite sensor data is freely downloadable.

## b) Digital Elevation Model Data

A Digital Elevation Model (DEM) or digital surface model (DSM) is a representation of the elevation data of a terrain. DEMs are acquired from remote sensing techniques such as photogrammetry, lidar, or InSAR. However, they can also be derived from topographic maps.

Some of the DEM data that can be acquired for the required work by users is given below:

- i) **Shuttle Radar Topographic Mission (SRTM) DEM Data:** The SRTM is a joint project between the National Imagery and Mapping Agency (NIMA) and the National Aeronautics and Space Administration (NASA) to produce digital topographic data for the Earth's surface (between 60°N & 56°S latitudes).
- ii) **ASTER DEM:** Land Processes Distributed Active Archive Centre (LPDAAC) offers ASTER image data DEM products. The 30 m DEM product is available in GeoTiff format via the FTP (File Transfer Protocol) mode.
- iii) **GTOPO30:** It is a global DEM with horizontal grid spacing of 30-arc seconds (approx 1 km). GTOPO30 was derived from several raster and vector sources of topographic information.
- iv) **ETOPO5 5-minute Gridded Elevation Data:** It was generated from a digital database of land and sea floor elevations on a 5' latitude/ longitude grid.
- v) **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 DEM of the world GTOPO30.
- vi) **ETOPO2 2-Minute Gridded Global Relief Data:** Newly created global elevation database gridded at 2-minute (lat-long) resolution.
- vii) **Land Topography:** It is from the GLOBE project, an internationally designed, developed, and independently peer reviewed global digital DEM, at a latitude-longitude grid spacing of 30 arc-seconds.
- viii) **Gridded Global Topography:** The Global Land One-kilometer Base Elevation (GLOBE) project is a 30-arc-second (1-km) gridded, quality-controlled global DEM.

- ix) **Terra Server:** TerraServer.com was founded with the purpose of finding a commercial market for satellite imagery and aerial images.

## **B) Vector Data**

There are many sources of existing vector data from where we can obtain vector data either at some cost or freely. However, you need to be sure and careful while using this data with regard to their appropriateness and accuracy.

The Digital Chart of the World (DCW) is an Environmental Systems Research Institute Inc. (ESRI) product, originally developed for the US Defence Mapping Agency (DMA). It is a vector cartographic dataset based at 1:1,000,000-scale Operational Navigation Chart (ONC) series, which is the largest scale base map source with global coverage.

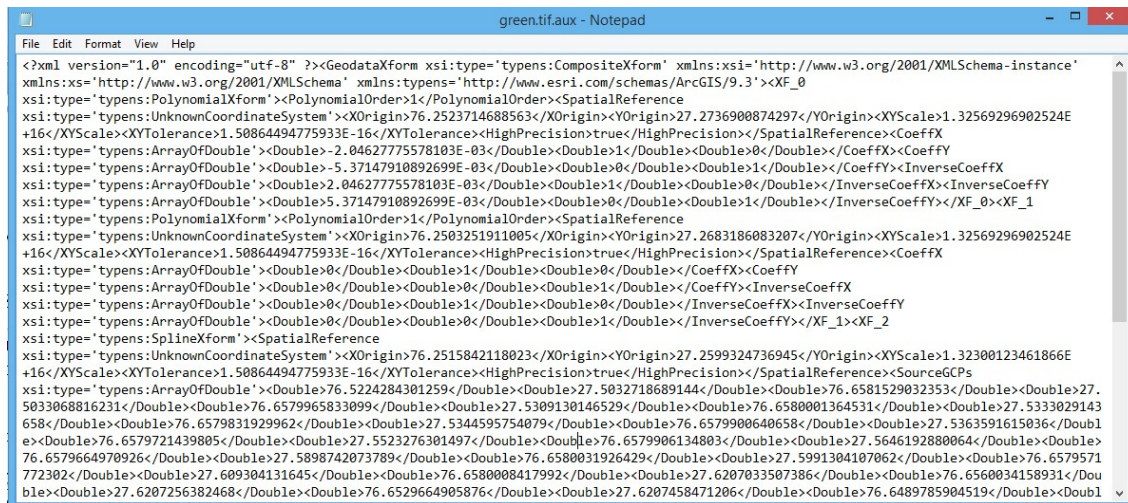
The stock of Omni resources comprising international topographic maps at all scales is one of the largest of any map dealer worldwide. All worldwide topographic maps at 1:250,000 are available. It also stocks most of the topographic maps available worldwide at 1:50,000 scale, especially Europe, Central America and South America. Topographic maps at 1:25,000 scale for selected countries, like U.K, France, Switzerland, Belgium, U.S and other parts of the world are also available. Besides, topographic maps at 1:25,000 scale for many major cities worldwide are available.

In India, there are several data centres located in many states from where one can procure data. The Survey of India (SOI), Dehradun publishes and distributes various types of maps. Some of the topographic products supplied in digital form by SOI to its users are at 1:25,000; 1:50,000 and 1:250,000 scale. National Atlas and Thematic Mapping Organisation (NATMO) is a premier national thematic maps and atlas-making organisation, under the Union Ministry of Science and Technology, which publishes several maps and atlases at small scales.

Geological Survey of India (GSI) is one of the oldest survey organisations in the world and a premier organisation of Earth science studies. In addition to the different products, the GSI publishes different thematic maps and atlases, and geological mapping on 1:50,000 scale for entire India. National Bureau of Soil Survey and Land Use Planning (NBSS&LUP), a national soil survey organisation has published soil and land use maps for districts/village level.

### **10.2.2 Metadata**

Metadata is nothing but data about data. In geoinformatics, it is the information about geospatial data. In other words, metadata is a summary document providing content, type, creation, quality and spatial information about a given data set. Thus, it provides some basic information as to when the data was created, by whom it was created, why it was created, where it was created, etc. Metadata summarises, abstracts, indexes and describes the quality and material of the data. Thus, metadata is an integral part of a GIS project and is usually prepared during the data production process. A metadata is usually presented as an XML (Extensible Markup Language) document (Fig 10.1). XML is a markup language similar to HTML (Hypertext Markup Language). In a metadata XML document, a title may be stored as follows: <title>My Document</title>.



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green.tif.aux - Notepad
File Edit Format View Help
<?xml version="1.0" encoding="utf-8" ?><GeodataXForm xsi:type='typens:CompositeXForm' xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance'
xmlns:xs='http://www.w3.org/2001/XMLSchema' xmlns:typens='http://www.esri.com/schemas/ArcGIS/9.3'><XF_0
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+16</XYScale><XYTolerance>1.50864494775933E-16</XYTolerance><HighPrecision>true</HighPrecision></SpatialReference><CoeffX
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xsi:type='typens:ArrayOfDouble'><Double>-5.37147910892699E-03</Double><Double>0</Double><Double>1</Double></CoeffY><InverseCoeffX
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xsi:type='typens:ArrayOfDouble'><Double>0</Double><Double>1</Double><Double>0</Double></InverseCoeffX><InverseCoeffY
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e><Double>27.6207256382468</Double><Double>76.6529664905876</Double><Double>27.6207458471206</Double><Double>76.6489785904519</Double><Doub1

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Fig. 10.1: A simple metadata record in XML format. (Source: <https://earthexplorer.usgs.gov/>)

### i) Metadata Formats

Metadata under the extracted standard, which come to users interpret differently by each one user. Few common metadata formats are listed below:

- plain text (ASCII) file
- log files/unstructured notes
- HTML file format
- summary formats
- formats are used for the purpose of indexing or searching but not for viewing, few new formats being used specific to GIS software which enables to view, create and manage metadata
- some customisable metadata formats that are becoming popular with XML, etc.

Till 1999, the most common format of metadata used to be **Outline Format**.

Soon **FAQ** (Frequently Asked Question) format was popularised as it was easier to read. This format could be easily understood even by non-technical or non-GIS users.

### ii) Metadata Standards

Now we will discuss the standards of metadata. A metadata standard is a document that contains rules or guidelines for standardising the content of metadata. These standards can be created specifically for use within a particular organisation and also allow developing tools that can be used to create and modify metadata that meets the standard. In fact, it is the way of verifying the content of metadata in compliance with the standard. Metadata standards contain rules or guidelines for the format, content, creation and update policies, and conformance rules.

The following are some of the suitable standards that are followed while representing metadata:

- **International Standards Organisation Technical Committee (ISO/TC 211)** develops standards related to geographic information. Recently ISO has developed an international metadata standard **ISO 19115**. It attempts to satisfy the requirements of all well-known metadata standards.
- **Federal Geographic Data Committee (FGDC)** has developed the content standards for metadata. It lays down specifications for both spatial as well as non-spatial data.
- **Dublin Core Metadata** is specifically intended to support resource discovery which involves searching, locating and retrieving of information resources on computer-based networks in response to user queries.

### iii) Essential Questions for Metadata Creation

We have already discussed that metadata provides information about a number of query/questions related to the data. A general form of metadata has been given in interview approach by U.S. Geological Survey to understand the questions to be answered to create metadata. Some important questions that need to be answered in a metadata are as follows:

- Why was the dataset created?
- Who produced the dataset?
- What was the original source of dataset and techniques of its collection?
- What does the dataset describe?
- What is the reliability of data?
- What is the availability of data?
- What is metadata modification?

### 10.2.3 Conversion

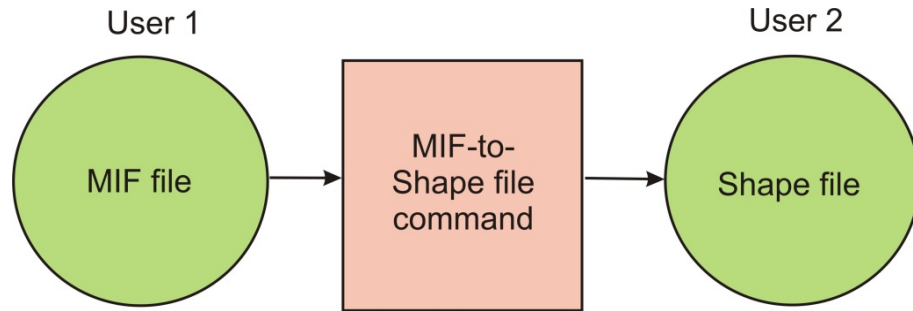
Generally data open to the public are provided in various formats. However, we have to check whether the provided data is compatible or not with the GIS package which we are using. If we find the data provided is incompatible we should opt for data conversion to make it compatible. Data conversion in this context is defined as converting GIS data from one format to another using certain known mechanism.

The mechanism of data conversion may be easy or difficult, it all depends on the type of data format that is being used. Interestingly, proprietary data formats need special translators for data conversion, while neutral or public domain formats requires a GIS package that owns translators to work with these formats.

#### **Direct Translation**

In direct translation method, translator in a GIS package is used to convert geospatial data from one format to another (Fig 10.2). Remarkably, it was the only method used for data conversion earlier to the data standards development. To date most users prefer to use direct translation as it is found to be easier than any other approaches. For example, ArcToolbox in ArcGIS, can translate Microstation's DGN files, AutoCAD's DXF and DWG files, and

MapInfo files into shape files. Similarly, QGIS, known to be user friendly open source GIS, is capable to work with shape file and other file formats.

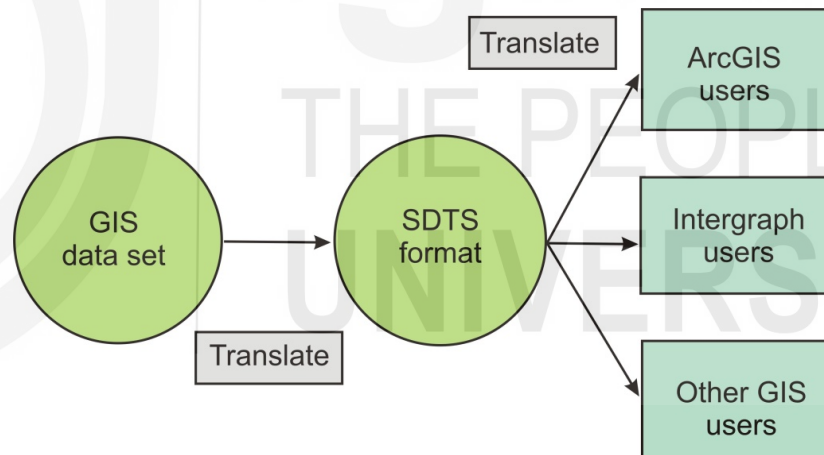


**Fig. 10.2: Conversion of geospatial data from one format to another format.**

(Source: modified after Chang 2019)

### Neutral Format

A neutral format is known as a public or existing format for data exchange. Classical example of a neutral format is the Spatial Data Transfer Standard (SDTS) which is designed and developed to support all types of spatial data and had been accepted in 1992 by the Federal Information Processing Standards Program. In general, the public data is translated by support of government agencies into a neutral format (SDTS format) and the user converts the public data into the required format by using a translator in a GIS package (Fig. 10.3).



**Fig. 10.3: Conversion of geospatial dataset to neutral format (SDTS format) and to the required user format in a GIS.** (Source: modified after Chang 2019)

## SAQ I

- The most common ways of obtaining raster data are by means of \_\_\_\_\_ and \_\_\_\_\_.
- Digital Elevation Model (DEM) is a representation of \_\_\_\_\_ data of a terrain.
- A metadata standard is a document that contains rules or guidelines for \_\_\_\_\_ the content of metadata.
- \_\_\_\_\_ data formats need special translators for data conversion.

## 10.3 CREATING NEW DATA

You have read about existing data covering raster and vector data, metadata and data conversion in the previous section. Now let us discuss the creation of data required for any GIS project to be executed in this section.

For any GIS project to be executed we require not only existing input data, but also data that need to be created. Various data sources from where we can create new geospatial data are i) Remote sensing data ii) In situ data collection iii) Text files data with x, y coordinates iv) digitisation.

### 10.3.1 Remote Sensing Data

We use satellite imageries that can be digitally processed to create wide range of thematic data (land use/land cover, vegetation types, crop health, eroded soils, geologic features, etc.) as required for a GIS project. You have already read that, remote sensing data is sensing data without touching means is the remotely collected data. Remote sensing is the science and technology of obtaining information from a distance wherein it can be used to assess certain features of the Earth, which, one cannot visualise by physically being there. The three most common remote sensing data collection methods are by airplane, satellite and drone. There are several platforms for obtaining remotely sensed data, as detailed below:

- a) Satellite-based Sensors like India's LISS-3 on-board IRS satellites, Microwave sensors on-board INSAT satellites.
- b) Handheld devices like camera, logger, spectrometer etc.
- c) Seaborne devices like dedicated ships for SONAR, Lidar
- d) Airborne devices like Aircraft, Drones etc.

### 10.3.2 In situ Data Collection

An in-situ data collection is the data collected in associated with measurement by some means (i.e. GPS Survey data, Height survey data, etc.) that have the exact measurement of the actual location. For example, if we have some collected remote sensing data, in-situ data will be used to verify it, known as a **ground truthing**. In ground truthing survey the measurement of the data collected will be the same as the actual location on earth. Therefore, in-situ data collection plays most important role to maintain quality/accuracy of a GIS project

Let us discuss some of the methods for in-situ data collection as given below:

#### a) Survey data collection

There are different branch of survey like topographic survey, engineering survey and cadastral survey.

**Topographic surveys:** These kinds of surveys are made for military, industrial, and scientific purposes. To be of value, they must be based upon trigonometric or triangulation surveys, but not necessarily of geodetic accuracy. This is made from nature in the field by measures and sketches on the ground. It is the base map from which many types of maps can be constructed and used for different purposes.

**Cadastral surveys:** It is used for the sole purpose of determining political lines and merges on the one hand into surveys crudely executed with chain and compass. The cadastral map referred as large scale map in India and Great Britain, being that scale in nature which will permit of representing accurately the width of a road and the dimensions of a building.

**Engineering surveys:** These surveys are executed in greater detail than any of the above. They may preferably follow some of them and are preliminary to the construction of engineering works. They are conducted with such detail as to permit the computing of quantities of materials to be moved and the exact location of the various elements of the works which are to be constructed.

### b) Global Navigation Satellite System (GNSS) data collection

There are four GNSS system – NAVSTAR GPS, Galileo, GLONASS, BeiDou or Compass and two regional navigation satellite systems- Indian Regional Navigation Satellite System (IRNSS) and Quasi-Zenith Satellite System (QZSS)/Michibiki.

In today's world, LBS (Location Based Service) are in highly demand. Each satellite system has specific signal characteristics, but each system attempts to be compatible with the others in order to prevent the interferences and attenuation between the signals. It is important to consider that the processing of all signals should be performed using the same receiver, thus a complex receiver design is important. The more in focus is given to receiver design. In user segment of GNSS, receivers are categories with accuracy scenario as given in Table 10.1.

**Table 10.1: GNSS receiver types and horizontal accuracies with differential GPS.**

Type of receiver	Differential GPS capabilities	Real-time differential GPS	Differential GPS with post-processing
Survey	Yes	± 1 cm	± 1 cm
Mapping	Yes	± 1-5 m	± 1-5 m
Enhanced nonprofessional	**	*	Some open source options

\* Requires external radio beacon or built-in capability to receive range corrections

\*\*Requires external hardware device or built in data collection capacity

Therefore, data collection from the GNSS is important to meet the accuracy in a given GIS project.

### c) Manual X, Y coordinate collection

This type of data collection is by means of manual survey and with the help of different survey instruments. In the past there were different surveys instruments used for manual survey and were recorded on paper. But now-a-days due to the availability of modern technology, this work became easier and easy to convert into digital format. Fig 10.4 shows representation of old and modern surveying instruments.



### Map-to-map transformation

A newly digitised map which is manually digitised or traced from a scanned file, is generally created in digitiser units. Digitiser units are represented in inches or dots per inch. Geometric transformation converts the newly digitised map into projected coordinates in a method known as map-to-map transformation.

### Image-to-map transformation

Image-to-map transformation is generally applied to remotely sensed data. In this type of transformation the rows and columns (i.e., the image coordinates) of a satellite image are changed into projected coordinates. Similar to this type of transformation there is another kind of transformation known as georeferencing. In a GIS, image or referenced image can register spatially with other feature or raster layers, in a given condition that the coordinate system is the same.

## SAQ II

- a) What is remote sensing?
- b) In which type of data collection does the ground truthing fall?
- c) What are the significant applications of geotagged photographs?
- d) Define geometric transformation.

## 10.5 SUMMARY

Let us summarise what you have studied in this unit.

- GIS datasets are produced and distributed in a variety of formats: vector, raster, point, line, polygon, image, etc. and are designed for certain computer systems/software programs. There are different available methods and tools for converting spatial data to a format which is compatible with the GIS.
- Raster data can be obtained in a number of ways. The most common ways are by means of aerial photography and satellite remote sensing. There are many sources of existing vector data from where we can obtain vector data. But, we need to be careful while using the vector data such as maps with respect to their appropriateness and accuracy.
- Metadata is a summary document providing content, type, creation, quality and spatial information about a given data set. Thus, it provides some basic information as to when the data was created, by whom it was created, why it was created, where it was created, etc.
- Data conversion in GIS is defined as converting spatial data from one format to another using certain known mechanism. The mechanism of data conversion may be easy or difficult, it all depends on the type of data format that is being used.
- In addition to the existing data, various data sources from where we can create new geospatial data are i) Remote sensing data ii) In situ data collection iii) Text files data with x, y coordinates iv) digitisation.

- Satellite imageries are digitally processed to create wide range of thematic data such as land use/land cover, vegetation types, crop health, soils, geologic features, etc. An in-situ data is the data collected in associated with measurement by some means that have the exact measurement of the actual location.
- Spatial data can be created by using text data that comprises  $x$ ,  $y$  coordinates. The combined pair of  $x$ ,  $y$  coordinates generates a point that helps to generate spatial data related to weather stations, epicentres of earth quakes, etc. from the recorded text files. Digitisation is a procedure to convert features on a paper map or simply tracing a paper map into digital format.
- Geometric transformation is the process of using a set of control points and transformation equations to register a digitised map, a satellite image, or an air photograph onto a projected coordinate system. It is a normal operation in GIS, remote sensing, and photogrammetry.

## 10.6 ACTIVITY

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- Browse the websites with geotagged photos representing metadata and check the  $x$ ,  $y$  coordinates and other characteristics linked with metadata.

## 10.7 TERMINAL QUESTIONS

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1. Discuss the significance of raster and vector data in existing data.
2. Discuss direct translation and neural format in data conversion process with neat diagrams.
3. Explain the various methods of in situ data collection.
4. Explain the process of geometric transformation.

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(The above websites were accessed from 1<sup>st</sup> August 2022 to 31<sup>st</sup> December 2022)

## **10.9 FURTHER/ SUGGESTED READINGS**

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## **10.10 ANSWERS**

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### **SAQ I**

- a) aerial photography, satellite remote sensing
- b) elevation
- c) standardising
- d) proprietary

### **SAQ II**

- a) Remote sensing is the science and technology of obtaining information from a distance wherein it can be used to assess certain features of the Earth, which, one cannot visualise by physically being there.
- b) In situ data collection.
- c) Significant applications of geotagged photos are landmark preferences and tourism purposes.
- d) Geometric transformation is the process of using a set of control points and transformation equations to register a digitised map, a satellite image, or an air photograph onto a projected coordinate system.

### **Terminal Questions**

1. Please refer to section 10.2.1.
2. Please refer to subsection 10.2.3.
3. Please refer to subsection 10.3.2.
4. Please refer to section 10.4.