Indira Gandhi National
Open University
School of Sciences

BGGCT-133
GENERAL CARTOGRAPHY

Block

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Acknowledgement: Dr. K. Nageswara Rao for designing cover page and **P. Bala Prasad** for graphic work.

July, 2020

ISBN-

Further information on the Indira Gandhi National Open University courses may be obtained from the University's office at MaidanGarhi, New Delhi-110 068 or the official website of IGNOU at www.ignou.ac.in.

Printed and published on behalf of Indira Gandhi National Open University, New Delhi by Director, SOS, IGNOU.

Printed at: Gita Offset Printers Pvt. Ltd., C-90, Okhla Industrial Area, Phase-I, New Delhi-20

BGGCT- 133

GENERAL CARTOGRAPHY

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BLOCK 3: SOURCES OF DATA

Quintessentially, the world is witnessing ever swifter nature of changes especially since the time when humans started industrializing and modernizing themselves on this only inhabitable planet earth. Some changes are discernible and some are not (hence intangible but carries the latent potentials to unfold itself in due course of time). Such changes are manifold. Two of the most prominent ones have tried to upset the very existence of floral and faunal existence. First one is the threat to its natural resources by inducing anthropogenic imbalances, into a range of ecosystems encompassing all of its four major life providing spheres. Second one is the pandemics or health disasters, which have recently started penetrating and severely affecting the human lives and their livelihood all across the geographic regions of the World. These drastic changes have invariably started touching upon each and every aspect of our lives, be it personal or professional. Geography is a spatial and special subject which not only studies the areal variations but also tries to blend the knowledge across the boundaries of science and technology, social sciences along with humanities. The cartography is one of the core courses of geography discipline. It serves as a fundamental root to provide the various tools and techniques on which it is based and practiced. For the real-time analysis of prominent issues of environmental management, health management, natural and human resources management etc., vast amounts of data are needed. The spatio-temporal data related to such issues will certainly facilitate in designing of a series of plans to efficiently deal with different aspects of spatial problems which may vary from one place to another place and time as well.

Therefore, we are dealing with the different sources of data. It will provide you the nuanced understanding of various data sources covering the most conventional to that of the latest datasets made possible by the satellite and computer enabled technologies. This block is spread into three units dealing with different aspects of the sources of data.

Unit 8 Sources:

It deals with the two types of data sources; one being the primary and other is secondary. Besides highlighting the aim, it will also provide you an idea to distinguish between the two and enhance your understanding about some important methods used to collect data, particularly primary data to cover the myriad aspects of both natural and cultural features on the earth's surface.

Unit 9 Census and Sample Surveys:

This unit will deal with the history of census operations and subsequent developments. You will learn about the what, why, when, where and how of secondary sources of crucial data being collected by different Government and other agencies periodically at regular intervals. It will highlight the key aspects of census and sample survey system in India.

Unit 3 Remotely Sensed Data:

Last unit will throw light on the latest state-of-the art remotely sensed data products including aerial phots and satellite imageries. You will explore the different aspects on how remotely sensed data is collected, what are its types, resolution, data products and application areas etc.

We hope that after studying this block, you will be able to better understand and appreciate the sources of data including primary and secondary, census and sample survey systems and remotely sensed data in particular.

Our best wishes are always with you in this endeavour.

UNIT 8

SOURCES

Structure

8.1 Introduction
Expected Learning Outcomes
8.2 Primary Sources
8.3 Secondary Sources
8.4 Summary
8.5 Terminal Questions
8.6 Answers
8.7 References/Suggested Further Reading

8.1 INTRODUCTION

You have studied and learnt the basic concepts of cartography along with maps and map scale in Block 1, and map projections and its main types in Block 2 of this course. In this Unit, you will study the sources of data mainly as cartographic input being used to analyse the cause and effect relationship between two or more than two variables in geographical studies. There are mainly two kinds of data sources - primary and secondary. In the next units, you will further study and learn about the 'Census and Sample Surveys' and 'Remotely Sensed Data' in detail along with their usage and importance in the realms of cartography and geographical studies as well.

Many of you are quite familiar with the data and its meaning if you look back in hindsight of your educational journey particularly at senior secondary level. However, you may be curiously thinking about many questions related to the use of data and its sources in higher education. For example, what is data, its use and importance in geographical studies and how many kinds of data sources are there etc.? Basically, data means facts and statistics, which are converted as information for measurements and analysis purposes. Data has very high significance in geographical studies and it forms the core of

cartography. It is greatly needed in geographical studies for quantification and measurements of geographical phenomena to arrive at intended outcomes. As you know that geography is not only concerned with description of the human and earth and its environment but it is also greatly concerned with the explanations of interrelationships and causality. Therefore, the data is required for explanations and examining causality with generalization, summarization, and for drawing inferences from various situations, projections and estimations and for visualization of spatial patterns as well. The data has been classified based on various criteria, like nature and method of data collection. It is further classified in terms of data organization or structure used primarily in data management and modern cartography achieved with the help of the state-of-the-art software driven technological system which is popularly known as 'Geographical Information System'. Examples of this are internal and external data, flat data, hierarchical data, object based data and relational data, etc.

In this unit, our focus will be primarily on the data sources of all sorts of data used as cartographic inputs in geographical studies. However, it is always a good practice that we acquaint ourselves with few basic concepts before embarking into the main theme. There are two types of data i.e. qualitative data and quantitative data. Qualitative data are the ones which are non-numerical types and measured by nominal or ordinal scales whereas quantitative data are the ones which are numerical and measured by interval or ratio data measurement scales. Both the data types are used in cartography and geographical studies. Therefore, it is inevitable to study various data sources as inputs for cartography. This unit will cover various kinds of data and data sources for cartography and geographical studies.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- Explain the importance of various kinds of data and data sources for geographical studies and thematic cartography;
- Describe and formulate a plan to collect the primary sources of data according to the need of the study; and
- Discuss and classify the secondary sources of data for geographical studies and thematic cartography.

8.2 Primary Sources

Primary data are those data which are directly collected by the researcher or user. Refer to fig. 8.1 which shows various methods and tools for collecting primary data from various sources. These are first hand data collected for the first time for special purposes. Primary survey becomes essential when there is no secondary data available for the desired subject or time or the unit of study. It is mainly collected by employing various well defined methods and data collection tools. These methods may be surveys, observations, experiments, questionnaire, and personal interviews, etc. In geographical studies, we also differentiate geographical data as physical, which are primarily spatial and socio-economic data.

There are four types of data measurement scales: nominal, ordinal, interval and ratio.

Nominal Scale is such that uses numbers to represent identities, where no number represents the size or weightage like 1 representing males and 2 representing females.

In **Ordinal Scale**, numbers represent rank order indicating the order of quality or quantity without giving the magnitude of quantity or degree of quality like 1, 2, 3 and 4 representing very good, good, moderate and poor.

Interval Scale includes the number, which have continuity and magnitude of difference. However, it indicates zero as reference point but there is no true zero in like temperature.

Ratio Scale includes numbers like interval scale but it has true zero means absence of the object/phenomena of measurement, like weight or height.

Let us learn about key data collection methods and tools in cartography. Surveys are the methods of data collection. These surveys may be divided into two categories- i) socio-economic survey and ii) physical or spatial survey. Socio-economic survey is conducted to collect the data related to the themes encompassing demography, social, economic development, political, educational and health etc. You will appreciate and learn that such survey tries to cover a whole range of socio-economic issues related with the holistic and inclusive development of the people, society and nation. Physical survey in geography on the other hand includes reconnaissance survey, virtual survey using satellite imageries, field mapping, sample collection, land use and land cover survey, landforms identification and geomorphological mapping, landform association, morphometric survey, environmental survey, ground water survey and mapping, forest, soil, agricultural, wildlife, ground water quality, cadastral or property survey etc.

There are various data collection tools. In socio-economic survey, these tools are questionnaires or schedules, observations, interviews, focussed group discussion and field reports or field diaries. Questionnaires or schedules are the primary data collection tools through direct or indirect interaction with the respondents. The mode of interaction of researcher or investigator in case of schedule is direct and face to face with respondents, whereas in case of questionnaire the interaction is indirect through online mode (like email/online app or social media) or by post. Now the Information and Communication Technology (ICT) has also enabled researchers or investigators to have direct interaction with respondents through various ways, for example, telephone/ tele-conferencing or video conferencing or other social media.

There are certain merits and demerits in using these two tools. These are good for big enquiries. Schedules give more option to the researcher for observing and recording reality, but in questionnaire the respondent may not reveal the truth since there is no observer. In schedule method, respondents are not required to be able to read or write whereas in questionnaire method, these are the prime requirements. And, schedules are costlier method than questionnaire method.

Observations are also the data collection tools. It becomes a scientific tool and the method of data collection for the researcher, when it serves a formulated research purpose, is systematically planned and recorded and is subjected to checks and controls on validity and reliability. In this method, the information is collected by way of investigator's own direct observation without asking from the respondent. Using this method has certain advantages like elimination of subjective bias, if observation is done accurately. In this method, the information related to present situation is captured. It is independent of respondents' willingness to respond and is relatively less demanding of active cooperation on the part of respondents unlike interview or the questionnaire method.

Observation models include structured (planned) and unstructured (unplanned) forms to capture the information. There are two types of observations: i) Participant Observation and ii) Non-Participant Observation. Participant observations are making observations by the researcher or investigator as a part or member of the group experiencing the same with the group. In Non-Participant Observations, the researcher or investigator makes observation as a detached emissary without any attempt on his part to experience through participation what others in the group feel.

However, it has certain limitations as well. It includes relatively higher cost and very limited information gets captured and interference of unforeseen factors is also likely to happen in the observation. In some cases, the units of investigation are rarely accessible for direct observation in the field.

Interviews are the primary data collection tools involving personal verbal interaction either on face to face mode or using electronic medias- telephone, video calls, etc. It is mostly two way communication. There are various kinds of interviews like Focused Interview, Clinical Interview and Non-Directive Interview, etc. In Focused interview, the interviewer has the freedom to decide the manner and sequence in which the questions would be asked and has also the freedom to explore reasons and motives. In Clinical Interview, the broad underlying feelings or motivations or with the course of individual's life experience, based on the interviewer's choice for level of information to be extracted are taken into consideration. In Non-Directive Interview, the interviewer's function is simply to encourage the respondent to talk about the given topic with a bare minimum of direct questioning.

There are certain merits in this method like more information with greater depth can be obtained; interviewer by his own skill can overcome the resistance; greater flexibility under this method as the opportunity to restructure questions; personal information can be obtained easily; samples can be controlled more effectively; flexibility of controlling the sample for better responses; suitable language can be used to avoid misinterpretations; and supplementary information can be collected for interpreting results. However, there are some demerits also like very expensive method depending on geographical spread of sample; possibility of the bias of interviewer as well as that of the respondent; problem of supervision and control of interviewers; certain types of respondents are not easily approachable; relatively more time-consuming; chances of imaginary information to make interview interesting;

selection, training and supervising the field-staff more complex; sometimes very difficult to make prerequisite proper rapport with respondents; etc.

Focussed Group Discussion is a primary data collection tool, which involves the gathering of people of similar backgrounds in a group to get certain information about specific topic through group discussion. It requires a moderator and ideally has 6-12 people in a group. The role of the moderator (generally researcher or investigator) allows free and open discussion by all members. The group members are required to be homogenous but close friends and relatives are to be avoided. In this method, control over dominant voice is required. Qualitative data is captured through this method.

Field Reports or Field Diaries are also important sources of primary data. The observers record their observations and measurements in the field note books and later on translated into data and information.

The primary sources of physical or spatial data are field mapping and remote sensing. Field mapping includes drawings, field measurement books and records. It may be traditional or manual like chain-tape, plane table, prismatic compass, theodolite, etc. Semi-automated or automated field mapping involves Global Positioning System (GPS) or Differential Global Positioning System (DGPS) survey, Electronic Total Station (ETS) survey, etc. Remote sensing is also a method of primary data collection, which involves aerial photography, satellite imaging, radar imaging, Shuttle Radar Topography Mission (SRTM) data, which is high resolution digital topographic data for entire globe, very-very high resolution Light Detection and Ranging (LIDAR) data or laser scanned 3D data and drone imaging/mapping.

There are some non-spatial data related to physical phenomena also which are collected through special field observations like for weather, water, environment and pollution, etc.

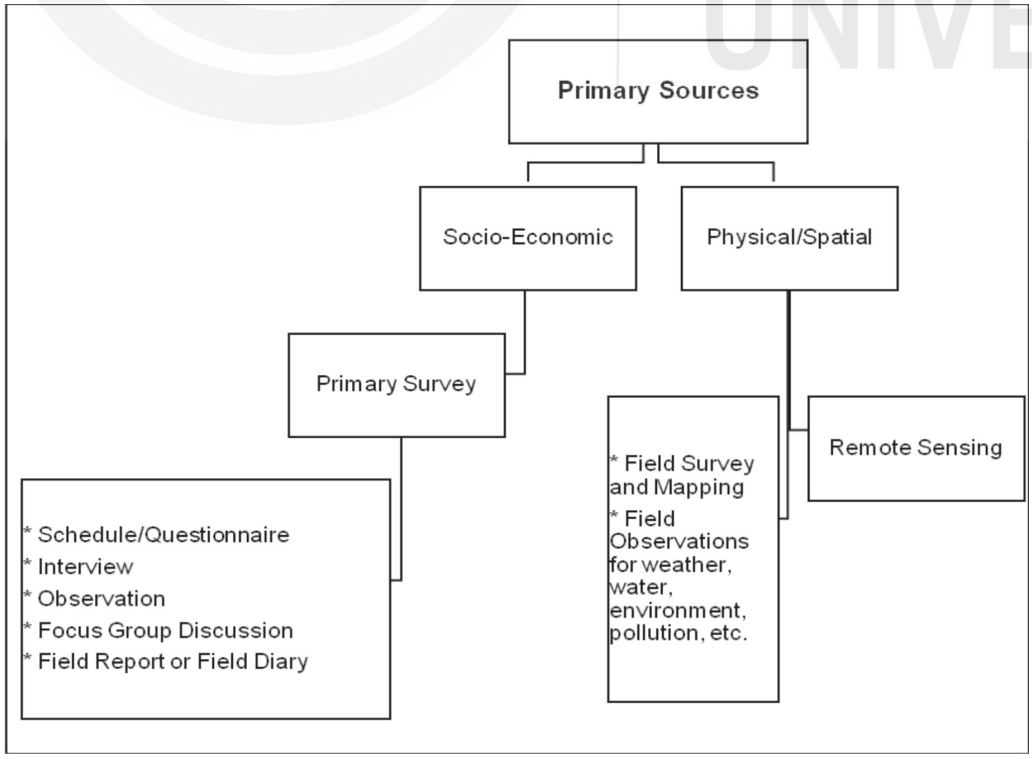

Fig. 8.1: Primary data source for geographical studies and cartography.

SAQ 1

What are various primary sources of socio-economic data? What are various primary sources of physical or spatial data?

8.3 Secondary Sources

Secondary Data are those data which have already been collected and processed or tabulated and may be published or unpublished. In other words, the data created by other than researchers or users are known as secondary sources. The secondary data can be in the form of tabular, textual, pictorial, drawings, maps and imageries. The secondary data sources include published and unpublished documents or data. These are government and non-government sources. Besides, books, journals or periodicals, reports by various government and non-government agencies are also secondary sources for other users. Nowadays, online documents are also considered as secondary sources of data.

There are national and international sources of the useful data being used in cartography and geographical studies. The major international sources are United Nations Organizations which provide various data related to demography, health, education, labour and economy, environment and climate, and many more themes or issues of contemporary relevance. Some private agencies also provide the online data related to environment and daily weather conditions for the entire globe like https://www.timeanddate.com/. However, few provide the disaggregated level data for a country.

In India, there are large number of secondary data sources. For socio-economic data, the largest and oldest has been the 'Census of India' followed by the 'National Sample Survey Organisation'. Sample Registration System has also been a source for vital data. These are provided by the government agencies. Apart from these, 'National Family Health Survey' also provides the data on various aspects of health up to district level since 1992. Though, you will study in details about all these in the next unit of this Block, we will discuss here these briefly. 'All India Educational Survey' also provides the data on school education at hamlet level. 'Unified District Information System for Education' (UDISE) also gives the data on school education at school level. Annual Report of 'University Grants Commission' (UGC) gives the statistics on the status of higher education in the country. Crime Record Bureau provides the crime data at state, district and town level. Some states also provide online crime data. Livestock census provides the data on livestock and agricultural implements. Indian Agricultural Statistics provides the district level crop-wise data on land use. Fertilizer Association of India brings out the data on fertilizer consumption. Agricultural Situation in India provides some data on agricultural production. Department of Statistics and Evaluation provides compiled data for various spheres at state level and also at district level for various states. Some private data providers like 'Centre for Monitoring Indian Economy' also compile and provides the data on various aspects. Different government departments like transport (surface, rail and roads, water and air) give data on transport and

freight. Similarly, various government departments provide data related to their domain including the data on natural resources. There are many other sources which provide various kinds of data for geographical studies and cartographic work.

There are many online data providers. Many government sources provide online data including Census of India. There is one government portal which compiles and provides the data of various sectors - data.gov.in. There are some private data providers also like www.indiastats.com, https://www.skymetweather.com/etc.

The secondary data sources related to maps and similar data for cartography and geographical research are also many and varied. National Remote Sensing Centre (NRSC), Hyderabad is the provider of all kinds of satellite imagery in the country. It also gives various atlases and real time maps for applications like land use/land cover, agriculture, drought, flood, wasteland, watershed desertification, etc. Such kinds of maps are also prepared by the Regional Remote Sensing Centres of Indian Space Research Organisation, ISRO. Similarly, Survey of India (SOI) located at Dehradun in the state of Uttarakhand also provides the toposheets at various scales. National Atlas and Thematic Mapping Organization (NATMO) publish and provide thematic atlases and planning series maps at district level for the entire country. National Bureau of Soil Survey and Land Use planning (NBSS&LUP) and All India Soil & Land Use Survey (AIS&LUS) which were later renamed as Soil & Land Use Survey of India also provides maps and data on land use

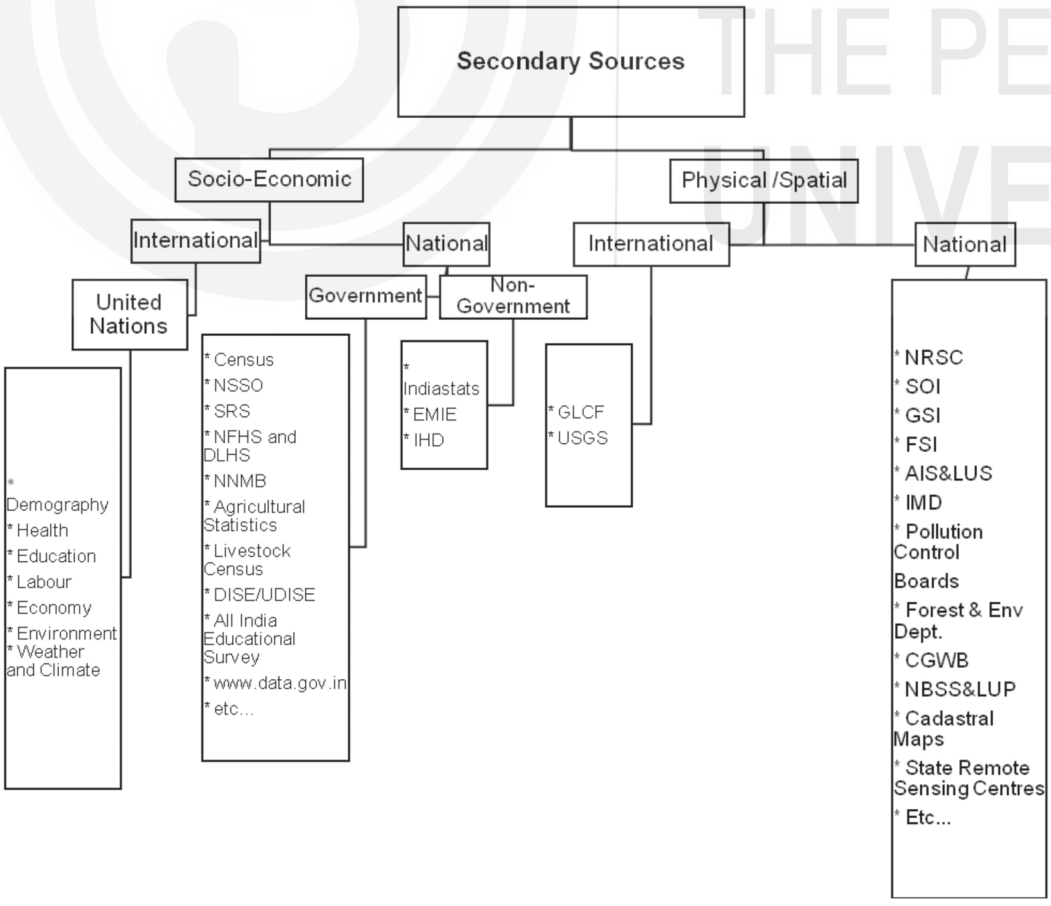

Fig. 8.2: Secondary data sources for geographical studies and cartography.

and soil. Similarly, Geological Survey of India (GSI) provides the geological maps, Indian Metereological Department (IMD) provides the weather maps and charts, Forest Survey of India (FSI) provides the forest maps in India. Census of India also provides some maps related to regions and socio-economic maps. The cadastral maps are also provided by the state governments in print and also in digital formats. Besides these, various state level agencies also provide maps and data especially state remote sensing or space applications centres provide various maps. There are also sources of tabular data on physical aspects of geography like Indian Meteorological Department (IMD), Pollution Control Boards of Central and State Governments, Weather Stations, Department of Forest and Environment, Central Ground Water Board, etc. (Fig. 8.2).

There are online sources of maps and satellite imageries. In India, Bhuvan is the platform from where satellite data and maps can be downloaded. The data from international providers are also available like The Global Land Cover Facility (GLCF) and United States Geological Survey (USGS).

SAQ 2

What are various secondary sources of socio-economic data? What are various secondary sources of physical and spatial data?

8.4 SUMMARY

In this unit, you have studied so far:

- Primary sources of socio-economic data.
- Primary sources of physical or spatial data.
- Secondary sources of socio-economic data.
- Secondary sources of physical or spatial data.
- Besides these, you have also learnt that both the sources of data i.e. primary and secondary are widely used in cartography to show the overall picture that prevails at ground level in reality at a glance in a map on the one hand. Both the data sources are also widely used in geographical studies in order to draw the rational and meaningful inferences for research, teaching and planning purposes etc. on the other hand.

8.5 TERMINAL QUESTIONS

1. Write the importance of data in cartography and geographical studies.
2. Explain the primary sources for socio-economic data.
3. Discuss the primary sources for physical or spatial data.
4. Write about the secondary sources for socio-economic data.
5. Explain the secondary sources for physical or spatial data.

8.6 ANSWERS

Self Assessment Questions

1. Various primary sources of socio-economic data are primary surveys using data collection tools such as schedules and questionnaires, observations, interviews, focus group discussion, field reports or field diaries. The primary sources of physical or spatial data are field survey and mapping and remote sensing.

2. Various secondary sources of socio-economic data are various published and unpublished documents and reports by the Government and non-government agencies including the United Nations and national and international organisations or data providers. These sources are in print or digital/online formats. The secondary sources of physical or spatial data are various international, national, and state level government and non-government agencies providing data in the form of maps and imageries (satellite, radar, laser and magnetic, etc.).

Terminal Questions

1. Your answer should cover the importance of data in cartography and geographical studies in the light of making measurements, generalization, summarization, and drawing inferences from various situations, projections and estimations and also for visualization of spatial patterns. Refer to the Sec. 9.1.

2. List all the primary sources for socio-economic data and explain those sources like primary survey with all data collection tools (schedule and questionnaire, interview, observation, focus group discussion and field report or field diaries). Refer to the Sec. 9.2.

3. Explain the primary sources for physical or spatial data from survey and field mapping and various kinds of remote sensing. Refer to the Sec. 9.2

4. List the secondary sources for socio-economic data including international, national and state level government and non-government sources. Refer to the Sec. 9.3.

5. Explain the secondary sources for physical or spatial data including all the agencies from international to national and state level with various kinds of spatial data provided by them. Refer to the Sec. 9.3.

8.7 REFERENCES/SUGGESTED FURTHER READING

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UNIT 9

CENSUS AND SAMPLE SURVEYS

Structure

9.1 Introduction
Expected Learning Outcomes

9.2 Population Enumeration (Census)

9.3 All India Educational Survey

9.4 Sample Survey
National Sample Survey (NSS)
Sample Registration System (SRS)

9.5 National Family and Health Survey (NFHS) and Daily Livelihood Household Survey (DLHS)

9.6 Agricultural Census and Livestock Survey

9.7 Summary

9.8 Terminal Questions

9.9 Answers

9.10 References/Suggested Further Reading

9.1 INTRODUCTION

You have already studied the introduction to cartography in Block 1 of this course, where we acquainted you with maps and their types. In this unit, you will study the population enumeration or census and sample surveys with various other surveys as these are considered as important data sources for geographical studies. The data gathered from these can be used as a secondary source to prepare certain maps or in thematic cartography. After reading this unit, you will not only come to know about the need of conducting such vast and extensive surveys ranging from a year basis to decades but also explore the answers to certain leading geographical questions. These may cover what, where, why, when and how of census and sample surveys conducted by different Government agencies in India periodically for meeting the varied needs of the country in detail.

You need to understand here that Census is the full head count meaning thereby each and every member is covered in the information. This aspect has

been dealt with in Section 9.2. In next Section 9.3, the details of data collected from all India educational survey has been discussed. In case of Sample Survey, only a proportion of the population is taken into consideration for survey. For sample survey, some techniques are used to select the proportion of population and identification of population for survey. This technique is called sampling technique. You will study all such information in Section 9.4. Next Section 9.5 will highlight the data related to health and other aspects of the population. The last Section 9.6 deals with the data on agriculture and livestock resources of the country.

Expected Learning Outcomes

After completing the study of this unit, you should be able to:

- explain the importance of census and sample surveys as the sources of data for geographical studies and thematic cartography;
- describe the population census;
- discuss the sample surveys; and
- discuss the agriculture census and livestock surveys.

9.2 POPULATION ENUMERATION (CENSUS)

Maintaining statistics on population has been an age-old practice. It was earlier related to taxation and military purposes. The modern Census in the world was started in 17th Century in various parts of the world. In North America and England, the first full census started in 1790 and 1801, respectively. India is one among the countries having successfully conducting Census enumeration for a long time. And even before this, during 800-600 BC, there are some accounts of population count. The written account is found in Kautilya's Arthasastra of 321-296 BC for taxation purpose. Ain-e-Akbari also mentions the collection of some population data. Census of various towns were also conducted at various times by British prior to the Imperial Census held in 1871. For instance, the limited census was conducted in Allahabad (1824), Banaras (1827-28), Dacca (now Dhaka, 1830), Madras (1851-52) and in North Western Provinces (1852). These Censuses were conducted in five years interval till 1872 (known as 1871 Census). In India, the present modern census was started in 1872 with first census starting the process in 1865 with actual head count in various parts of the country. Moreover, a very systematic continuously evolving population census has been in practice since 1881 every decade or 10 years counting fifteenth since 1872.

The 1881 Census provided complete geographical coverage except Kashmir with classification of data under demographic, economic and social characteristics. In 1891, additional coverage was given to the upper parts of Burma (present Myanmar), Kashmir and Sikkim with information on mother tongue and parental tongue with modification on religion, cast, literacy and occupation. The 1901 Census expanded to Baluchistan (present Pakistan), Rajputana, Andaman and Nicobar, Burma, Punjab and remote areas of Kashmir. Provision of house number was introduced with caste records of

Hindus and Jains and tribe or race of people of other religion. The 1911 Census included the knowledge of foreign language "English" and sects of Christian. The 1921 Census covered the Indian Empire and continued the information on caste, tribe or race irrespective of religion. It gives the extensive details of data with ethnographic report containing caste, tribe, race and religion. The 1941 Census included the employment information and refined the question on literacy. The 1951 Census covered the whole country except Jammu and Kashmir and included fertility, unemployment, infirmity and size of family. The 1961 and 1971 Censuses used household/establishment schedule and individual slips to collect various data including fertility and migration details. In 1981, the details were further expanded on education, marital status, migration and employment status through same schedules and lists. The 1991 Census prepared Primary Census Abstract at micro level (village and ward) for rural and urban areas. It captured the data related to literacy with new definition (considering population of age 7 years and above rather than 4 years as taken in 1981). Some dimensions of work were also included. In 2001 Census, possession of assets, disability and travel related information were collected. In 2011, further details on amenities and facilities including gadgets like computer/laptop, mobile/telephone facility, and fuels etc. were collected. It also included the third gender, expansion of type of disability, school attendance status, travel for work and migration were also included in a diversified and integrated manner.

The Census of India collects and provides data under various series. These are:

A – Series Tables: General Population Tables

A-Series tables give general population table including final population & sex ratio, population (0 to 6 years) and sex ratio (0 to 6 years), population of scheduled castes and scheduled tribes, literate population and literacy rate, worker and non-worker, main and marginal worker, and type of worker (e.g., cultivator, agricultural labourer, worker in household industry and other worker). This series gives broad profile of population with above information.

B – Series Tables: Economic Tables

B Series table gives data mainly on economic activities by work status (Main, Marginal, Non-Workers Seeking/Available for work), social groups (SC, ST, Others), age, sex, marital status, religion and other backgrounds like educational level, rural-urban and industrial category. These information are further expanded. This data also gives information at three digit level, i.e. individual occupation level. The data of this series is very important to know about the economic profile in terms of working population by various backgrounds for the assessment of present condition and also for future economic planning.

C – Series: Social and Cultural Tables

C Series data provides information on social and cultural aspects. The data includes marital status, age at marriage, duration of marriage, work status and occupation, educational level, by social groups, age and sex, religion,

population attending educational institution by age, sex and type of educational institution; single year age returns by residence (rural/urban) and sex, population in five year age-group by residence and sex; religious community by age-group and sex; population by bilingualism, trilingualism, age and sex; disabled population by type of disability, age, sex and marital status; and disabled population among main workers, marginal workers, non-workers by type of disability, age and sex. C series data has immense importance to look at the socio-cultural aspect and address the major issues through proper intervention like age at marriage, work status, education, age-sex profile (pyramid), lingualism, language shifts, disability, etc.

D – Series: Migration Tables

D Series data pertains to migration. Population classified by place of birth, age and sex; Migrants classified by place of last residence, sex and duration of residence in place of enumeration; Migrants classified by place of last residence, duration of residence and reason for migration; population by place of last residence, sex and duration of residence in place of enumeration; Migrants by place of last residence, age, sex, educational level and duration of residence; Migrants by place of last residence with duration 0-9 years reporting 'Work/Employment' as reason for migration by age, sex and educational level (by India/State/City); Migrant workers by place of last residence and industrial category; Migrant workers (other than cultivators and agricultural labourers) from place of last residence and occupational division; Migrants by place of last residence, age, sex, marital status and duration of residence 0-9 years; and Persons born and enumerated in districts of the State. Migration data is very important to address the issues related to migration at both places of origin and destination in terms of shortage of labour and lopsided demographic profile at origin and provision of infrastructure and amenities at the destination. It is very important to have migration data for the planning and management during very critical times like present pandemic situation (2020) in the country.

F – Series: Fertility Tables

F Series data gives information on fertility. It includes currently married women by number of children ever born, number of male children ever born and number of surviving children by sex; number of women and ever married women by present age, parity and total children ever born by sex; number of women and ever married women by present age, parity, religious community and total children ever born by sex; number of women and ever married women by present age, parity, educational level and total children ever born by sex; number of women and ever married women by present age, parity, economic activity and total number of children ever born by sex; number of women and ever married women by present age, number of surviving children and total surviving children by sex; number of women and ever married women by present age, religious community, number of surviving children and total surviving children by sex; number of women and ever married women by present age, educational level, number of surviving children and total surviving children by sex; number of women and ever married women by present age, economic activity, number of surviving children and total surviving children – census of India 2001; number of women and ever married women by present

age, economic activity, number of surviving children and total surviving children by sex; number of women and currently married women by present age, number of births last year by sex and birth order; number of women and currently married women by present age, religious community, number of births last year by sex and birth order; number of women and currently married women by present age, educational level, number of births last year by sex and birth order; and ever married women by number of children ever born, number of male children ever born and number of surviving children by sex. These are disaggregated by social groups (SC, ST and Others). These tables are very important for the projection of population, population planning, planning for future needs, maternal and child care and women welfare, etc.

HH – Series: Household Tables

HH Series provides the data on households. Households by composition and size; Normal households by household Size, households by usage, with number of aged persons by sex and household size, household by ; marital Status, sex and age of the head of the household; Religion, sex of the head of the household and household size; by number of literates and religion, by disabled males and females, number of workers, by members without educational levels, by children attending schools, by members seeking/ available for work. The data are provided by social groups also.

H – Series: Tables on Houses, Household Amenities and Assets

H Series provides data on houses, household amenities and assets. The broad coverages are census houses and the use to which they are put, condition of census houses used as residence and residence-cum-other use, distribution of households by condition of census houses occupied by them; distribution of census houses by predominant material of roof, wall and floor; distribution of households living in census houses by predominant material of roof, wall and floor; distribution of census houses used as residence and residence-cum-other use by their type of structure; distribution of households by type of census houses occupied; distribution of households by size and number of dwelling rooms; distribution of households by ownership status of census houses occupied by them and number of dwelling rooms; distribution of households by number of married couples in a household and number of dwelling rooms, total number of married couples and number of married couples having independent sleeping room, distribution of households by amenities like source of drinking water and its location, by source of lighting, by availability of bathroom and type of latrine within the house and type of drainage connectivity for waste water outlet, by availability of separate kitchen and type of fuel used for cooking, by source and location of drinking water and availability of electricity and latrine; and by assets like number of households availing banking services and number of households having each of the specified assets. H series data reflects the living conditions with access to housing, drinking water facilities, toilet and bathroom, fuel, electricity, banking facilities, population with assets, etc. This data is also very helpful in assessment and planning various policies.

SC/ST - Series: Tables on Individual Scheduled Castes (SC) and Scheduled Tribes (ST)

Under this type of data, Primary Census Abstract data provides information on Population, Population (0-6 years), Literates, Total workers, Main workers and Marginal workers, Type of workers: Cultivators, Agricultural labourers, Workers in household industries and Other workers, Non-workers of individual Scheduled Castes (SC) and Scheduled Tribes (ST) in a state by sex and rural/ urban break up Population of individual SCs/STs at district level are available only in compact disc (CD). This data gives the situation among SCs and STs and plan for their upliftment.

These data are extremely valuable in geographical studies and thematic mapping.

SAQ 1

What is population enumeration? Explain.

9.3 ALL INDIA EDUCATIONAL SURVEY

The All India Educational Survey (AIES) was started in 1957 by the National Council of Educational Research and Training (NCERT) to collect, organise and disseminate the information on the overall progress in education in the country. These information act as basic inputs for developing educational policies at micro and macro levels, and monitoring the progress of education by central and state governments. The indicators for which data are collected are availability of schooling facilities in rural habitations, physical and educational facilities in schools, incentive schemes and beneficiaries, medium of instruction and languages taught, enrolment particularly of SCs, STs, girls and educationally backward minority community, teachers and their academic and professional qualifications, library, laboratory, ancillary staff and subject-wise enrolment at +2 stage of education. In addition, the enrolment and teachers in unrecognised schools, Alternative Schools and AIE Centers, Oriental Schools covering Sanskrit Pathshalas, Madarsas and Maktabs; Special Schools for children with disabilities, and Pre-Primary Institutions are covered.

The major objectives of the survey have been to assess the availability of various levels of schooling facilities for habitations by population size and location or distance of availability; to assess the basic facilities available in the school like building, classrooms, drinking water, electricity, toilets, furniture, medical facilities including vaccination, etc; class and subject-wise enrolment, availability of qualified teachers, availability of science laboratories and library, physical education teachers, librarian, guidance counsellor, non-teaching staff in secondary and higher secondary schools; medium of instruction and languages taught, disabilities, etc. The survey included unrecognized and schools/centres under Education Guarantee Scheme & Alternative and Innovative Education (EGS & AIE), oriental schools, like Maktabs, Madarsas and Sanskrit Pathshalas also for information collection along with recognized schools. The social group and gender have also been in consideration in the survey. The other information's are related to estimate the class-wise

enrolment by single age, new entrants, promotees, repeaters and attendance in the context of Universal Elementary Education (UEE).

Such kind of information have been of great use in measuring the furthering of our educational progress in the country by planning and policy formulation, implementing and monitoring.

SAQ 2

What is All India Educational Survey?

9.4 SAMPLE SURVEYS

There are surveys which collect information of various types covering well designed samples so that the statistics or information collected from these samples give maximum representation to the entire population or universe. In India, the National Sample Survey has been one of the oldest and largest such survey. The other surveys are Sample Registration System (SRS) and Civil Registration System.

9.4.1 National Sample Survey (NSS)

After a long initiative since British time, the National Sample Surveys came into being in 1950 to collect information on a variety of socio-economic aspects through sample surveys in the country which came under the National Sample Survey Organization in 1970. It collects information through household surveys, enterprise surveys, village facilities and land and livestock holdings, and special surveys covering a wide range of information.

NSS collects the information related to economic, health, education, villages facilities, slums, social and cultural aspects. Economic information includes employment and unemployment, livelihood, consumer expenditure, Common Property Resources (CPR), trade and finance, non-agricultural enterprises, debt and investment, land and livestock holdings, situation assessment of agricultural, status of work participation under **Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGA**), household expenditure on services and durable goods, etc. Social information includes living conditions and economic activities of tribals, migration & ownership of land by non-tribals in tribal areas, etc. Health and education as social consumption in India are also a part of NSS, which collects the information on maternity, childcare, development milestones of children, morbidity, disabled persons, family planning and utilization of medical services and health under health and literacy, participation and expenditure in education under the category of education.

Besides these, the information on culture, particulars of slums housing conditions and migration, village facilities and domestic tourism are also collected.

9.4.2 Sample Registration System

It is also known as Vital or Civil Registration System. This is a system to

record vital events like births and deaths by the Government of India. In India, the registration of births, still births and death is mandatory because correct and latest information on fertility and mortality is essential for the planning of programmes related to health and health care services. With the enactment of Registration of Births & Deaths Act, 1969, the sample registration of births and deaths in India was started fully in 1969-70 by the Registrar General of India, though it was running on pilot basis from 1964. It is now known as Sample Registration System (SRS).

The main objective of the SRS is to collect and provide reliable estimated data on fertility and mortality measures like birth rate, death rate and neonatal/infant/child mortality rates at disaggregated levels for rural and urban areas with total estimations across the states. It also gives the information on the causes of deaths (rural) under the title "Survey of Causes of Deaths (Rural)." SRS is based on dual record system where a resident part time enumerator does the continuous enumeration of births and deaths in sample unit of area (rural/urban blocks) and also by a full time supervisor on six monthly bases. Finally, the data collected from both are matched and rectified, if there is any discrepancy. Sampling frame is also revised every ten years based on the latest census results for wider representation of the existing population.

SAQ 3

What are sample surveys?

9.5 NFHS AND DLHS

There are some health surveys started in recent times like National Family Health Survey (NFHS) and Reproductive and Child Health- District Level Household Survey (RCH-DLHS). NFHS was started in by International Institute of Population Studies in 1992-93 in collaboration with East West Center, the Population Research Centres and Ministry of Health and Family Welfare, Govt. of India to strengthen the survey research capabilities of population research in India. Since then, four surveys have already been completed and 5th (2018-19) is in progress. NFHS includes the statistics on various aspects of household population and housing characteristics, characteristics of respondents, fertility and fertility preferences, family planning, other proximate determinants of fertility, infant and child mortality, maternal health, child health, nutrition and anaemia and child and adults, morbidity and health care, other adult health issues, Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS) related knowledge, attitudes and behaviour, HIV prevalence, women empowerment and domestic violence.

DLHS has started since 1998-99 by the Ministry of Health and Family Welfare and International Institute of Population Studies (IIPS).

Population and household profile with amenities and facilities, marital status, background characteristics of women, fertility, use of family planning, Unmet Need of Family planning, quality of family planning services, antenatal care, delivery care, women receiving Janani Suraksha Yojana (JSY) benefits,

women having pregnancy related complications, live births, still births, child immunization, child feeding practices, birth weight, awareness about diarrhoea and Acute Respiratory Infection (ARI), treatment of childhood diseases, Awareness of Reproductive Tract Infection/Sexually Transmitted Diseases (RTI/STI) and Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome (HIV/AIDS), utilization of government health services, birth registration, personal habits (age 15 years and above), reported prevalence of morbidity, reported prevalence of chronic illness during last one year, nutritional status of children below 5 years, anaemia status by haemoglobin level, blood sugar level, hypertension, health facilities covered, health programmes at village level, accessibility of health facility, and availability of health infrastructure, staff and services.

SAQ 4

What do you understand by NFHS and DLHS?

9.6 AGRICULTURAL CENSUS AND LIVESTOCK SURVEY

Agricultural Census

Agricultural Census is conducted every five years with full coverage by the Agriculture Census Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India since 1970-71 in collaboration with the States and Union Territories. It is a part of the programme of World Census of Agricultural. Initially, it was sample based for the years 1950s and 1960s. Ten agricultural censuses have been conducted so far, 2015-16 being the last one.

The data is collected social group wise for size class-wise number and area of operational holdings, size class-wise estimated number and area of operational holdings by tenancy status, size class-wise estimated leased in area by terms of leasing, size class-wise estimated area under different land use, size class-wise estimated number of operational holdings by irrigation status, size class-wise estimated number of operational holdings, receiving irrigation and area irrigated by different sources, size class-wise estimated number of wells and tube wells, size class-wise estimated irrigated and unirrigated area, under different crops (paddy, jowar, bajra, maize, ragi, wheat, cereals, gram, tur, urad, pulses, sugarcane, sugar crops, spices & condiments, fruits, vegetables, food crops, groundnuts, sesamum, rapeseed & mustard, sunflower, coconut, soybean, oilseeds, cotton, jute, fibres, dyes & tanning material, tobacco, drugs & narcotics, fodder & green manures, tea, coffee, rubber, plantation crops, floriculture crops, aromatic & medicinal plant, non-food crops).

Livestock Census

Livestock Census began in India in 1919-20 and 19 censuses have already

been conducted since then. It includes complete count of livestock and poultry. It includes the enumeration of number with age and sex of livestock and poultry through survey of households and other establishments or institutions in rural and urban areas. However, the estimation is made annually for the major livestock products like milk, eggs, meat and wool, etc. The survey includes district wise breedwise population of buffalo and cattle. Exotic and Cross bred Cattle, Indigenous Cattle, Buffaloes, Sheep and Goat, Pig, Horses and Ponies, Donkeys/Mithun/Yak, Mules, Camel, Elephant/Dogs/Rabbit and Poultry (Fowl, Ducks, Turkeys, Quails, Other poultry, and number of birds in Farms/ Hatcheries) along with their sexwise characteristics in terms of age and utility.

SAQ 5

What are Agricultural Census and Livestock Survey?

9.7 SUMMARY

In this unit, you have studied so far:

- Population enumeration covering history, evolution and various data captured by the census in India.
- All India Educational Survey with objectives and aspects of data collected, organized and disseminated.
- Sample surveys covering National Sample Surveys and Vital or Civil Registration System known as Sample Registration System in India.
- NFHS and DLHS with their coverages.
- Agricultural census and livestock survey with the nature of data collected under these.

9.8 TERMINAL QUESTIONS

1. What do you mean by population enumeration? Explain in details the evolution of Indian Census and data collected under this.
2. Discuss the objectives of All India Educational Survey and data collected by the survey.
3. Explain in details the purpose and data coverage of sample surveys in India.
4. What are NFHS and DLHS? Give detailed account of data collected under these surveys.
5. What are Agricultural Census and Livestock Survey? Elaborate.

9.9 ANSWERS

Self Assessment Questions

1. Enumeration is a process where the detailed information of each and

every member is collected through schedule. It is also known as census.

2. The All India Educational Survey started in 1957 by the National Council of Educational Research and Training (NCERT) collects, organises and disseminates the information on the overall progress of education in the country in the form of various aspects of school education.

3. Sample surveys are the surveys based on certain samples to collect the information of national importance for planning and development in the country.

4. NFHS and DLHS are health surveys based on samples in the country starting since 1992-92 and 1998-99 respectively with major focus on maternal and child health and health care including various background characteristics.

5. Agriculture census started in 1970-71 is also a kind of enumeration related to social group and size class wise multiple aspects of land like operational holding, tenancy, land use, irrigation and so on. Livestock census started in 1919-20 is conducted to collect the information related to livestock and poultry with complete count.

Terminal Questions

1. Explain population enumeration and give a description of data collected under various series by the Indian Census with their utility. Refer to the Section 9.2.

2. Discuss why All India Educational Surveys are conducted and also mention the data collected by the All India Educational Survey. Refer to the Section 9.3.

3. Discuss why sample surveys were started and what type of data is collected under this. Refer to the Section 9.4.

4. Explain what are NFHS and DLHS and thereafter discuss the types of data collected by NFHS and DLHS. Refer to the Section 9.5.

5. Explain what are agricultural census and livestock survey. List out and discuss the various kinds of data collected under these. Refer to the Section 9.6.

9.10 REFERENCES/SUGGESTED FURTHER READING

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UNIT 10

REMOTELY SENSED DATA

Structure

10.1 Introduction
Expected Learning Outcomes

10.2 Basics of Data Acquisition
Concept of Remote Sensing
Sensors and Platforms
Resolution of Remote Sensing Data

10.3 Aerial Photographs
Basics of Aerial Photography
Scale of Aerial Photo

10.4 Satellite Data
Television Cameras Data
Opto-Mechanical Scanners Data
Pushbroom Cameras Data

10.5 Summary

10.6 Term End Questions

10.7 Answers

10.8 References/Suggested Further Reading

10.1 INTRODUCTION

You have read about basic sources of data including primary and secondary sources, census and sample surveys in previous Units 8 and 9. In this unit, you will study about sources of data which is obtained from latest state-of-the-art remote sensing (RS) methods and techniques. This unit basically provides the background of remote sensing and its array of important data products particularly aerial photographs and satellite imageries. Understanding of remotely sensed data is very necessary for topographical mapping and interpretation of landscape features for its diverse users including a cartographer, geographer, geoscientist or earth scientist, etc.

In Sec. 10.2, we have introduced the basics of data acquisition from the source of remote sensing. From Sec. 10.3, you will understand about the aerial photography and its products. With the passage of time, the continuous advancements in the field of satellite technology coupled with powerful computational systems and software enabled mapping techniques like

geographic information system (GIS) have achieved tremendously greater heights and milestones. Such advancements have definitely landed us an edge over the aerial photography that enabled us to take precise daily and repetitive observation of the minute details with a sub-metre level resolution for the entire globe. It has been made possible through the satellite mounted sophisticated camera systems ranging from a few hundred kilometres to thousands of kilometres in altitude. To understand the satellite data products, which are obtained with the help of different cameras, you need to study Sec. 10.4.

Expected Learning Outcomes

After studying this unit, you should be able to:

- define remote sensing and understand the basics of data acquisition;
- explain about aerial photography;
- describe the satellite technology used in the collection of data of earth's surface features; and
- differentiate various remotely sensed data products used in earth's observation.

10.2 BASICS OF DATA ACQUISITION

You will be wondered to know that our planet earth is a self-contained spaceship. It is apparently maintained by the external energy source which is solely received from the Sun in the Universe. You are well aware that it has its own natural resources for example water, soil, forest and minerals, etc., that supports human existence along with innumerable floral and faunal species. Some of such vital precious bounties of nature are limited in supply and cannot be replenished easily and quickly. The increased burden on these natural resources due to uncontrolled population growth and over exploitation of resources coupled with unscientific practices has put our planet earth's systems in danger. Adverse effects of human activities are not only limited to earth's surface but also affects the surrounding climate and environment resulting into immeasurable local to regional and global impacts. We must use our precious natural resources optimally for meeting the present day needs without much affecting our earth systems by practicing good management strategies so that future generations of humankind can also be sustained. This is the time when everyone should realise, self-actualize and understand the changing scenario through which earth's countless phenomenon and its environment is passing through with a micro to macro level possible details laden with greater sensitivity. Accurate, timely, repetitive and reliable information on various aspects of landuse, agriculture, forest and wastelands, waterbodies, water flowing channels, runoff, coastal depressions, snow accumulation zones and ice melting, ocean salinity, etc., can be acquired by using a variety of remotely sensed data. Such cost effective technologies enable us to take better decisions in order to achieve the global economic and social development by taking proper care of the precious natural resources. For such vital goals, we require to observe our planet earth continuously far away from the earth.

If you go to the building roof top, you may be able to see the roads, surrounding building structures, and many other tangible objects and things. If you try to observe while travelling in aeroplane, you can better watch the large area, but may not be able to see the details of certain information related to various features on the earth's surface as our viewing capacity is limited. It is made possible by taking the synoptic view with the help of satellites in which camera lens or sensors are mounted and fixed. We will be able to scan and capture images of our entire planet within a short span of time through satellite equipped remote sensing technologies.

10.2.1 CONCEPT OF REMOTE SENSING

Let us first know what is remote sensing. Remote sensing is a science because it follows some procedures in terms of measurement, data processing, interpretation and analysis. Remote sensing is a tool because it can be utilized for creating inventories of resources and for solving different spatial problems. Thus, the remote sensing may be defined as a science of obtaining information about an objects or phenomenon from a distance without coming into physical contact, typically from aircraft or satellites. It uses reflected and emitted energy for measuring the physical properties of distant objects and their surroundings.

Now, we will discuss in detail about the concept of remote sensing. The intervening space between the object and the observer should be devoid of any sort of material. The available information about the sensed things must be put into a carrier of medium. Here, it is the ***electromagnetic energy*** that acts as a carrier of discrete array of information. The remotely sensed data basically consists of wavelength intensity information. It is done through the collection of the electromagnetic radiation by leaving the things at definite wavelength and by measurement of its intensity. Basically, the prime source of energy for the same is the Sun.

As defined by the United Nations, "the remote sensing acts as a means of sensing the earth's surface from space by making use of the properties of electromagnetic wave which gets emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resource management, land use and the protection of the environment". The basic process involved in the remote sensing is the interaction or emission of **electromagnetic radiation (EMR)** with the matter or objects. EMR is comprised of both electric and magnetic fields extending from very short wavelength gamma rays to long radio waves. This entire range of EMR is commonly referred to as electromagnetic spectrum. You may refer Fig. 10.1, for understanding the large spectrum of wavelengths. You must remember that in remote sensing we use some portions of the electromagnetic spectrum, not the entire spectrum.

When incident energy gets in touch with surface of the object, it may reflect, absorb, re-radiate or transmit through the material depending upon the nature of the object and the wavelength of the incident radiation. Different objects or materials have varying reflectance values covering in multiple wavelength portions. The remote sensing imageries record various objects containing radiance values. These radiance values are known as Digital Numbers (DN).

The reflectance values of various features are presented in Fig. 10.2. It helps us in studying a remote sensing imagery in which the DN values of multiple classes are scattered in a spectrum.

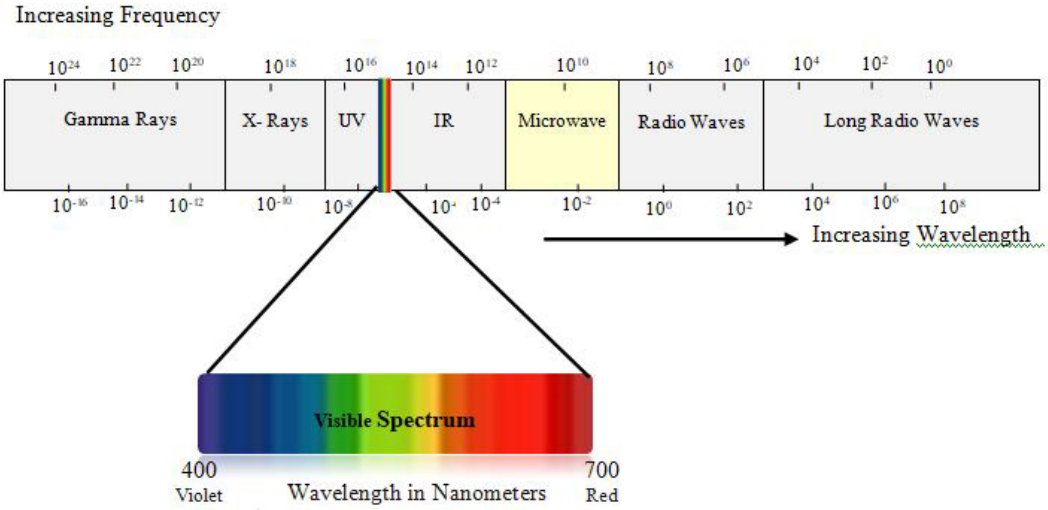

Fig. 10.1: Electromagnetic spectrum showing various wavelength regions.

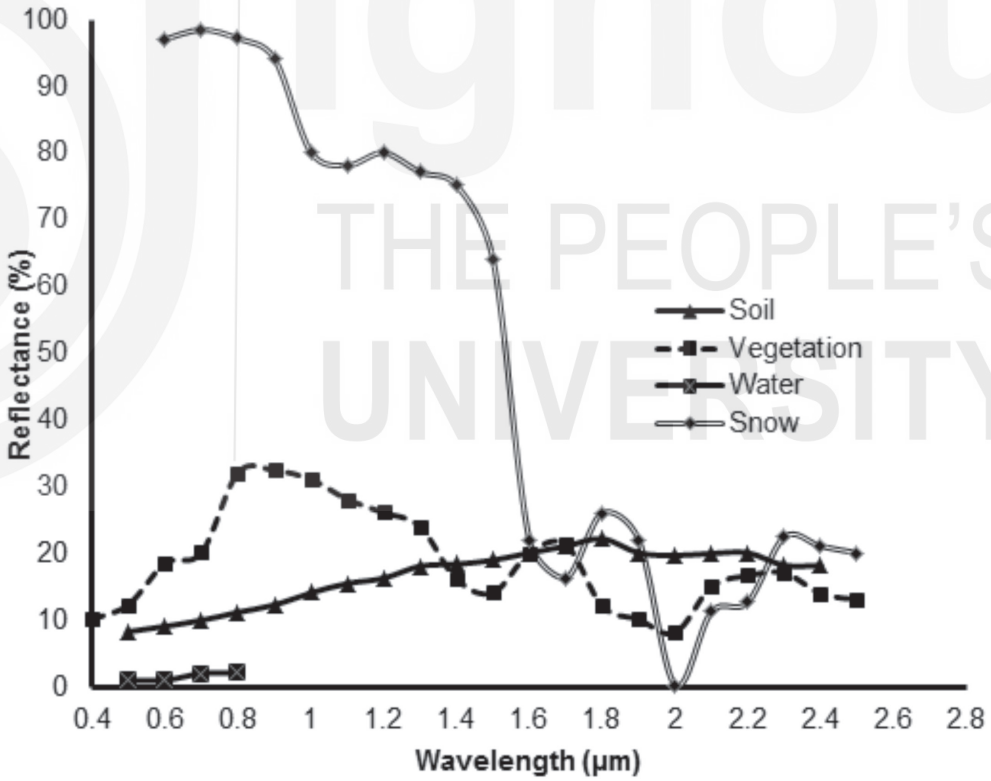

Fig. 10.2: Spectral reflectance values of land cover features.

10.2.3 Sensors and Platforms

You might have understood that remote sensing is a source of basic data, a science, and a tool. Let us now study the basic components of a remote sensing system which enables to make the entire process of remote sensing functional.

Sensors

Sensors are a kind of high end optical camera instruments mounted atop the satellites. These are being used in measuring the reflected or emitted amount of electromagnetic radiation from various objects of surface features. You may think of a sensor installed in the remote control of various electronic devices (e.g. air conditioner, television, etc.) that enables the operation of such appliances with the help of a tiny remote control. In remote sensing, we generally recognize two types of sensors namely passive sensors and active sensors. Passive sensors record the natural radiation which gets emitted or reflected back from the earth's surface. It includes both analogue (aerial photographs and videographs), and digital systems (scanners and radiometers). Active sensors are carried electromagnetic radiation of specified wavelength or band of wavelengths to illuminate the earth's surface. Example of active sensors are Radio Detection and Ranging (RADAR), Side Looking Airborne Radar (SLAR) and Synthetic Aperture Radar (SAR), etc.

Platforms

Platforms are designed to carry sensors while sensors are also designed keeping in view of aircrafts or suitable observation platforms that must be supported and accommodated. Presently, the two most universally and popularly used platforms are satellites and aircrafts. However, balloons, kites and rockets were also used for accommodating sensors during the initial days of aerial photography meant for earth's observation. These platforms may be stationary or mobile and are usually placed at pre-defined altitudes. You must remember that platforms can vary from stepladders to satellites. Acquisition of remote sensing data is said to be very expensive process in consonance with its resolution. In other words, you can understand that finer the resolution of a remotely sensed data, the cost will be more or high price.

Aircrafts are used for surveying in particular areas at short span of time by placing sensors from less than a kilometer to few tens of kilometers depending on the ability of aircraft and region of interest. On the other hand, satellite platforms are placed at a few hundred kilometers to thousands of kilometers capable of monitoring the very large area of the earth's surface with synoptic view. Satellites are primarily placed in two kinds of orbits viz. geostationary or geosynchronous orbit and sun-synchronous or polar orbit. Satellite is placed at an equatorial plane (about 36,000 kilometres), where the period of satellite is equal to that of earth's revolution is referred to as **'geostationary orbit'**. It is capable of taking constant view of a specific part of earth so that it can be used for getting meteorological information. When satellite moves around the poles by covering all points at given latitude as per the mean solar local time is called **'polar orbit'**. It can be repeated in its path from a few hundred to one thousand kilometres for covering the same area at intervals of a fixed number of days.

10.2.4 Resolution of Remote Sensing Data

When the sensing is taken at higher altitudes for observing the earth; we generally get the synoptic view of a larger area, but with a low resolution data.

The quality of remotely sensed datasets or products can be measured by considering parameters namely spatial, spectral, radiometric, and temporal resolution. How well a sensor can record spatial details of small object from its different sizes explains the **spatial resolution** of an image. Higher the spatial resolution, it means that the sensor is able to detect even smaller objects on one spectrum, whereas higher the **radiometric resolution**, smaller will be the radiance differences that can be detected between two objects. The data is recorded in specified wavelength portion of the EM spectrum which is called **spectral resolution**. **Temporal resolution** of satellite data is explained as the sensor's capability to view the same object under similar conditions at regular intervals of time.

Till now, you have understood about the remote sensing and its data that can be obtained through satellites and aircrafts from varying altitudes. The process of electromagnetic radiation while interacting with various ground features over the planet earth is measured by remote sensors mounted on various platforms. The film is used for detection and recording of signals from objects in 'traditional photography'. However, in satellite remote sensing, the collection of data in the form of pictures representing the image or digital data is called 'digital photography'.

Let us now study about the aerial photography and satellite data in detail. Remote sensing data became available since 1930s when photographic images were obtained from the aircrafts for mapping the earth's landscape.

SAQ 1

a) Define remote sensing.

b) What are the main characteristics of geostationary satellites?

10.3 AERIAL PHOTOGRAPHS

Since time immemorial, it is one of the most universal, multipurpose as well as inexpensive category of remote sensing. It is recorded in the literature that in the beginning, a French photographer named Gaspard-Felix Tournachon who was also popularly known as "Nadar" used a tethered balloon for taking first known aerial photograph over Val de Bievre, near Paris, France in 1858. Another person named J.W. Black also captured the earliest known aerial photograph of Boston city from a balloon in 1860.

In the later stage, the kites were used for obtaining aerial photographs. The credit goes to an English meteorologist Archibald, E.D., for kite photography who had clicked the first aerial photograph in 1882. The advantage of airplane instead of balloons and kites seized the opportunity by picking up considerable momentum for commercial utilization of aerial photos obtained from camera platforms since 1908. The main advantages of aerial photography in cartography is that one can study and interpret various features easily, because it provides a bird's eye view of much larger areas, and importantly photographs records permanently the existing scenario of the earth's landscape.

Aerial photographs are clicked with the help of a high-end precision aerial cameras. These may include continuous strip camera, panoramic camera, terrestrial camera and reconnaissance frame camera, etc. You will study and learn about these in the succeeding sections.

10.3.1 Basics of Aerial Photography

Aerial photography is the primary form of remote sensing that records the earth's landscape. Aerial photos can be obtained with the help of airplane on which cameras are installed. There are mainly three components viz. camera, filter, and film used in the areal photographic system. Cameras are fixed generally on stable mounts. However, sometimes adjustable mounts can also be used. The shutter speed of the camera is normally fixed matching with the speed of aeroplane. They carry photosensitive film placed at the focal plane and imaging of ground features that falls in the instantaneous field of view (IFOV) of the camera lens. Aerial mapping cameras are designed to produce small format (30 mm), medium format (70 mm) and large format (240 mm) images.

Large film format cameras are used for imaging sizeable areas with immense information. On the other hand, small format cameras are lighter and low cost used in the professional photography. These 35 mm/70 mm cameras are often taken into the low altitudes and are operated manually for obtaining vertical photos of small regions. Photographic films are generally coated with different types of emulsions according to the need of photographs. These emulsions coated films can record wavelength or spectral regions ranging between 0.3 micro-meter (μm) and 1.2 μm. There are mainly four emulsions namely Panchromatic (PAN), Black and White Infrared (B and W IR), True-colour and Colour Infrared emulsions. These are developed for imaging earth's landscape in this spectral range.

PAN records data in the range of 0.3 to 0.7 μm. These PAN bands are particularly used in creating photomaps and orthophotos. Infrared photographs are mainly used in identifying edges of rivers, lakes, waterbodies and other hydrographic features because water absorbs infrared energy more than visible light. IR images tend to show water in dark grey or black tone. The range of B and W IR films ranges between 0.3 and 0.9 μm.

True-colour film is similar to PAN. However, true-colour films record blue (B), green (G), and red (R) portion of visible energy to produce a realistic multi-colour image. A true-colour photograph can be used in crop monitoring, soil and water studies. Another advanced film is a colour-infrared film. It is sensitive to record green, red, and near-infrared (NIR) energy instead of B, G, and R as recorded in a true-colour film. Colour-IR photographs are typically used in mapping of vegetation damage and flooding areas, and landuse planning, etc.

10.3.2 Scale of Aerial Photo

Now, it is important for you to understand the simple geometry of aerial photography. An aerial photo is a perspective projection of the land surface. It explains how the emission of various ground features or objects passes

through the optical centre of the lenses that are imaged on the film. In this simple case, the scale of photographs can be determined with the help of focal length of camera and the height of aeroplane above the ground (datum), not above the mean sea level.

Scale of aerial photo may be computed as;

$RF = C_f / H$

where RF is the representative fraction; C_f is the camera focal length; and H is the flying height. All units are in feet.

You will better understand after going through the below given example.

Example: If a photo is taken by a camera with 6 inch focal length and flying height of 12,000 ft, what will be the scale of the photograph?

Solution:

Here, C_f = 6 inch = 0.5 feet

H = 12,000 feet

Scale of photograph, $RF = C_f / H = 0.5 / 12,000 = 1 / 24,000$ or 1:24,000

A traditional aerial camera with six-inch focal length produces a photo of 23 x 23 cm which corresponds to approximately 23 square kilometer area on the actual ground. There is a 30% sidelap and 60% overlap between flight lines during the process of aerial photography. Most of the ground features certainly gets covered in two photographs because of such overlaps. Particularly, it will help for stereoscopic viewing of photographs that involves looking at the same area imaged on two adjacent photos resulting into 3-dimensional view of the landscape. The colour-IR images and other photos have been used by cartographers for compilation of topographical maps, landuse mapping, and delineation of natural resources at local and national levels.

Nowadays, large-scale photographs and electronic images are being obtained by various sensing devices mounted on low altitude, slow moving and fixed-winged aircrafts and helicopters, and even drones. However, the main drawback of aerial photography is that it causes relief displacement at edges of the aerial photos that hinders the complete synoptic coverage of an area.

SAQ 2

a) What are the colour regions recorded by true-colour films?

b) An aerial photo is taken by a camera with a 12 inch focal length lens. The flying height of the plane is 10,000 ft. Find out the scale of aerial photograph.

10.4 SATELLITE DATA

The advantages of space platforms including minimum relief distortion, high repetitive coverage, covering of large areas with greater details, etc. have

enabled the earth's imaging from space very accurate. Different methods are used in collecting the remote sensing data since its invention. For easy understanding, these advancements for acquiring data are explained below under the title of satellite technology. You must remember that some of the methods and techniques explained here have also been used in aerial photography for acquiring data from the space.

10.4.1 Television Cameras Data

Since 1960's, the recorded data of satellites from the space began to be controlled from the ground stations. Weather satellites and earth's resources satellite images and data have been transmitted to ground processing facility centres for decoding and its utilization for environment and earth's resources monitoring and mapping purposes.

Television Camera was the first electronic system used for clicking the earth's pictures from the space. In 1960, **Television Infrared Observation Satellite (TIROS) -1** carried Vidicon television camera for viewing the earth for weather studies. These cameras were later used in several meteorological satellites. The initial TIROS cameras used 12.7 mm slow scan vidicon, at 400 TV lines per frame. Subsequently, the improved version of imaging tubes of these cameras got developed. Prominent examples are **Return Beam Vidicon (RBV)**, Image Dissector Tube (IDT), Secondary Electron Conduction Tube (SECT), etc.

The space borne high resolution TV camera i.e. RBV was used in the **LANDSAT** series of satellites for surveying the earth's resources. In 1972, the Earth Resources Technology Satellites (ERTS) program was launched and later it was renamed as LANDSAT in 1975 by **National Oceanic and Atmospheric Administration, (NOAA)** of United States of America.

LANDSAT television camera system consists of 3 RBV tubes with its associated lens filters being used in taking images in 3 spectral bands with 80 m spatial resolution. Each camera is read out sequentially, requiring approximately 3.5 seconds for each of the 3 spectral images.

BHASKARA-I and II, the Indian experimental remote sensing satellites, were installed in a two-band television camera system. One spectral band is operated in 0.54-0.66 micro-meter (μm) wavelength region and the other one in 0.75-0.85 μm region. Each picture frame covers an area of nearly 400 x 400 sq. km. with a spatial resolution of about 1 km. Although, these are efficient cameras but limitations of these tubes are also recorded which includes poor dynamic range, radiometric accuracy and geometric distortion etc.

10.4.2 Opto-Mechanical Scanners Data

To overcome the disadvantages of TV imaging systems, the Opto-Mechanical Scanners were developed. The information from the ground is recorded pixel by pixel by the detector. In these systems, the radiation received by the detector from an area on the ground is determined by the detector size and focal length of the optics. This is referred to as pixel or picture element. Due to motion of the scan mirror, the detector is also be able to observe and scan the

adjacent pixels on the ground. In this way, the collected energy is channelled into a spectral dispersing system (known as spectrometer) to generate multiple imageries in more than one spectral band. These are called **Multispectral Scanners (MSS).**

It is important to know that the MSS are inbuilt scanners with a scan mirror, dispersal system and a collecting optics along with a set of detectors. Scanning is mainly carried out in the object plane mode. In this, a plane mirror is kept at 45° to the optical axis and is rotated around the optical axis. The main aim of dispersal system is to spread the incoming radiation into different spectral bands. The collecting optics collects the reflected or emitted radiation in broad wavelength region extending from visible to thermal IR regions. To achieve good quality images over a wide field of view, a three mirror optical system began to be used in the remote sensing. A detector is a device that produces an output signal. Generally, it converts optical energy into an electrical signal which can be measured easily. You can simply understand that each detector has a specific spectral or wavelength region for which only it can be used.

MSS used in LANDSAT series was the first operational satellite-borne opto-mechanical scanner. Landsat 1/2/3 satellites are also known as Earth Resources Technology Satellites (ERTS) maintained by the National Aeronautical Space Administration (NASA), USA. The details of LANDSAT data can be studied from the Table 10.1. LANDSAT-1/2 MSS had 4 spectral bands with 79 m spatial resolution that covers an area of 185 x 185 sq kms. Other LANDSAT MSSs had inbuilt system with an extra Band 5 to focus on the Thermal wavelength region with 240 m resolution. For more information, you may visit www.usgs.gov.core-science-systems/nli/landsat.

The advanced version of second generation opto-mechanical multispectral scanner carried onboard LANDSAT-4 satellite is known as **Thematic Mapper (TM)** sensor. It records the ground information by covering visible to thermal spectral regions. The Visible (Blue, Green and Red), NIR and SWIR bands produce 30 m spatial resolution imageries and 120 m spatial resolution for Thermal regions. LANDSAT-5 and 7 are having improved versions of TM sensor known as **Enhanced Thematic Mapper (ETM)**. It has an additional band i.e. Panchromatic (PAN) which provides 15 m spatial resolution black and white imageries (see Table 10.1).

The recent Landsat 8 **Operational Land Imager (OLI)** and **Thermal Infrared Sensor (TIRS)** produces images together with a total of 11 bands ranging from ultra blue (B1) to thermal (B11). OLI data consists of nine spectral bands in which band 1 (ultra blue) and band 9 are dedicated for coastal aerosol studies and cirrus cloud detection, respectively. Band 8 (Panchromatic-PAN) provides 15 m spatial resolution. Bands 10 and 11 (Thermal) provides 100 m spatial resolution imageries and are useful for studying surface temperature conditions. Remaining all bands from B1 to B7 in which B5 covers NIR region and B6 and B7 spreads in SWIR wavelength portions produces 30 m resolution imageries. You may refer to Fig. 10.3, for understanding the LANDSAT imagery. There are several other opto-mechanical scanners installed in various spacecrafts and aircrafts for example METEOSAT, INSAT, and so on.

Table 10.1: Details of landsat data.

Satellites	Sensors	No. of Bands	Spectral Resolution (μm)	Orbit
Landsat-1 (1972-78)	RBV & MSS	B1 to B3 & B4 to B7	0.475-0.575 (B1) 0.580-0.680 (B2)	18 days/ 900 kms
Landsat-2 (1975-82)	RBV & MSS	B1 to B3 & B4 to B7	0.69-0.83 (B3) & 0.5-0.6 (B4) 0.6-0.7 (B5) 0.7-0.8 (B6) 0.8-1.1 (B7)	
Landsat-3 (1978-83)	RBV & MSS	A-D (Single Band) & B4 to B8	0.505-0.750 & Same as above MSS (bands B4-B7) with 10.4-12.6 (B8)	
Landsat-4 (1982)	MSS & TM	B1 to B4 & B1 to B7	0.5-0.6 (B1) 0.6-0.7 (B2)	16 days/ 705 kms
Landsat-5 (1984)	MSS & TM	B1 to B3 & B4 to B7	0.7-0.8 (B3) 0.8-1.1 (B4) & 0.45-0.52 (B1) 0.52-0.60 (B2) 0.63-0.69 (B3) 0.76-0.90 (B4) 1.55-1.75 (B5) 10.4-12.5 (B6) 2.08-2.35 (B7)	
Landsat-6 (1993)	Launch failure			
Landsat-7 (1999)	TM & ETM+	B4 to B7 & B8 (PAN)	Same as above for TM bands & 0.50-0.90	
Landsat-8 (2013)	OLI & TIRS	B1 to B7, B8 (PAN) & B10 & B11	0.43-0.45 (B1) (Visible) 0.45-0.51 (B2) (Visible) 0.53-0.59 (B3) (Visible) 0.64-0.67 (B4) (Red) 0.85-0.88 (B5) (NIR) 1.57-1.65 (B6) (SWIR) 2.11-2.29 (B7) (SWIR) 0.50-0.68 (B8) (PAN) 1.36-1.38 (B9) (Cirrus) 10.6-11.19 (B10) (TIRS) 11.50-12.51 (B11) (TIRS)	

(Source: https://landsat.gsfc.nasa.gov/landsat-data-continuity-mission/).

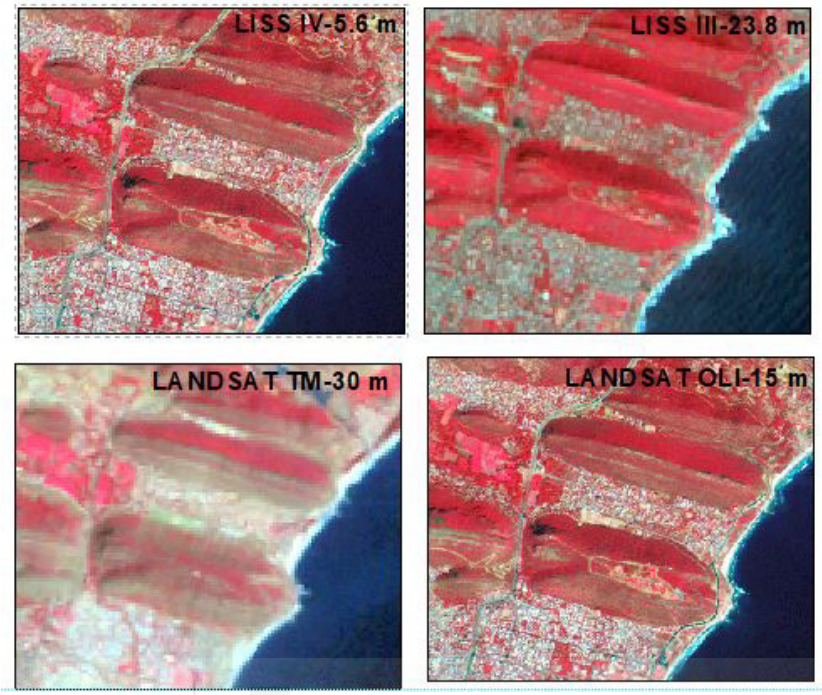

Fig. 10.3: Satellite data products of differents Sensors.

10.4.3 Pushbroom Cameras Data

Pushbroom Cameras in which internal electronic scanning is used instead of mechanical scanning. These are known to be better scanners than opto-mechanical scanners because they provide high spectral or spatial resolution imageries. **Charge Coupled Devices (CCD)**, also called **Solid State Sensors (SSS)**, consists of linear or 2-dimensional array of detectors which are used for acquiring remote sensing data from the space. Instead of scan mirrors, which are used in opto-mechanical systems, the detector array is used to produce one scan line of information. This type of scanning is sometimes referred to as 'Pushbroom Scanning'.

The pushbroom scanning operation was first performed in **SPOT-1** satellite by the French Space Agency, known as Centre National d'Etudes Spatiales (CNES). The full form of SPOT is **Systeme Probatoire d' Observation de la Terre**. SPOT series of satellites were actually commissioned in 1986 with the launch of SPOT-1 satellite into a near-polar orbit (832 kms high altitude).

There are two **High Resolution Visible (HRV)** cameras constructed with a multilinear array of detectors, operating in along the track direction. These are installed for imaging on ground each with 60 kms wide area by providing 3 band multispectral imagers with 20 m resolution and Panchromatic band of 10 m spatial resolution.

The second generation SPOT satellites viz. SPOT-4/5 has an additional band that also covers the Middle Infrared (MIR) region for multispectral imaging. This is named as **High Resolution Visible Infrared (HRVIR)** band. It also carries a new 5 band imaging system known as '**Vegetation Instrument'** which provides 1 km spatial resolution. Vegetation instrument is also having the same spectral bands as like that of HRVIR, with an additional band 1 (Blue band) incorporated for oceanographic applications. Each HRV or HRVIR offers an oblique viewing capability which enables the acquisition of stereoscopic

Table: 10.2. Details of SPOT satellite programmes.

Satellites	Sensors	No. of Bands	Spectral Resolution (μm)	Orbit
SPOT-1 (1986-1990)	HRV	B2 to B4 & PAN	0.50-0.59 (B2) 0.61-0.68 (B3) 0.79-0.89 (B4) & 0.51-0.73 (PAN-Visible)	26 days/ 832 kms
SPOT-2 (1990)				
SPOT-3 (1993)				
SPOT-4 (1998)	HRVIR & Vegetation	B2 to B5 & B1 to B5 (except B2)	0.50-0.59 (B2) 0.61-0.68 (B3) 0.79-0.89 (B4) 1.58 - 1.75 (B5-SWIR) 0.61 - 0.68 (Red-Mono) & 0.43-0.47 (B1) 0.61-0.68 (B3) 0.79-0.89 (B4) 1.58 - 1.75 (B5-SWIR)	
SPOT-5 (2002)	HRG & HRS & Vegetation 2	B1 to B4 and PAN & PAN & B0 to B4	0.50-0.59 (B1) 0.61-0.68 (B2) 0.78-0.89 (B3) 1.58 - 1.75 (B4) 0.48-0.71 (PAN) & 0.49-0.69 (PAN) & 0.45-0.52 (B0) 0.61-0.68 (B2) 0.78-0.89 (B3) 1.58 - 1.75 (B4)	

(Source: https://earth.esa.int/web/eoportal/satellite-missions/s/spot-6-7 & https://www.satimagingcorp.com/satellite-sensors/spot-7/).

imageries. SPOT-5 carries a single '**High Resolution Stereoscopic' (HRS)** instrument, two '**High Resolution Geometric' (HRG)** instruments, and a '**Vegetation instrument'** similar to that mounted on SPOT-4 satellite. The characteristics of SPOT-1 to 5 series of satellites are given in Table 10.2. HRS provides fore-and-aft stereoscopic data which helps to generate Digital Elevation Models (DEM) having 10 m resolution with coverage of 120 kms ground swath. HRG instrument provides imageries with 2.5 or 5 m spatial resolution for PAN, 20 m for mid-IR (B4) and 10 m for remaining bands. The swath width of HRG sensor is 60-80 kms. Vegetation 2 instruments provide 1000 m resolution data by covering 2250 kms swath width.

The images of SPOT satellites are useful in multiple areas of applications like geological, water stress and deficits, agriculture, and snow inventories etc. With high spatial and spectral resolutions, an excellent geometric fidelity, and the possibility of stereoscopic viewing, the SPOT images serve as a good cartographic source material.

Another mode of scanning system in space borne is '**Linear Imaging Self-**

Table: 10.3. Details of IRS satellite sensors.

Satellites	Sensors	No. of Bands	Spectral Resolution (µm and m)	Orbit
IRS-1A (1988-1996)	LISS-I & LISS-II	B1 to B4 & B1 to B4	0.45-0.52 (B1) 0.52-0.59 (B2) 0.62-0.68 (B3) 0.77-0.86 (B4)	22 days/ 904 kms
IRS-1B (1991-2003)	Same as IRS-1A			
IRS-1C (1995-2007)	LISS-III & PAN & WiFS	B2 to B5 & PAN & B3 to B4	0.52-0.59 (B2) 0.62-0.68 (B3) 0.77-0.86 (B4) 1.55-1.70 (B5) & 0.5-0.75 (PAN)	24 days/ 817 kms
IRS-1D (1997-2010)	Same as IRS-1C			
RESOURCESAT (2003-2004)	LISS-IV & LISS-III & WiFS		0.52-0.59 (B2) 0.62-0.68 (B3) 0.77-0.86 (B4) B3-default band for mono & 0.52-0.59 (B2) 0.62-0.68 (B3) 0.77-0.86 (B4) 1.55-1.70 (B5) & 0.52-0.59 (B2) 0.62-0.68 (B3) 0.77-0.86 (B4) 1.55-1.70 (B5)	24 days/ 817 kms

(Source: www.nrsc.gov.in)

Scanning' (LISS). Indian Remote Sensing Satellite (IRS)-1A was the first operational remote sensing satellite launched in 1988 with two payloads employing LISS sensors. **LISS-I** and **LISS-II** cameras were operated in the pushbroom scanning mode using linear CCD array of 2048 elements. The imaging lens assemblies have focal lengths of 162.2 mm and 324.4 mm for LISS-I and LISS-II, respectively. LISS-I and II sensors had four identical spectral bands providing data with 72.5 m and 36.25 m spatial resolutions, respectively. You may refer Table 10.3 for further information on IRS series of satellites.

The second generation satellites IRS-1C/1D had a **Panchromatic (PAN)** camera, 4 bands LISS-III multispectral (MX) and Wide Field Sensor (WiFS) cameras. Wavelength region of PAN is 0.5 to 0.75 µm and spatial resolution is 5.8 m. MX camera covers three bands (B2, B3 and B4) and an additional band (B5) spreading into Shortwave Infrared Region (SWIR). In addition to these, a Wide Field Sensor (WiFS) also carried for imaging in two spectral regions

(Band 3 and Band 4) with a spatial resolution of 188 m covering a swath of 770 kms. **LISS-III** camera is also designed similar to the LISS-I design, except B1 is replaced with B5 in Shortwave Infrared Region.

RESOURCESAT-1 (IRS-P6) satellite has onboard 3 electro optical cameras such as improved **LISS-III** and **Advanced Wide Field Sensor (AWiFS)**, and **LISS-IV** that was launched in 2003. RESOURCESAT-2 has also carried the same multispectral pushbroom scanners with linear array CCDs as detectors. Notably, a new multispectral camera LISS-IV produces a high spatial resolution (5.8 m) images in three spectral bands (B2, B3 and B4). It can be operated in mono or multispectral mode by covering 70 kms swath on the ground. The swath width and spatial resolutions of LISS-III and LISS-IV cameras are 141 kms and 740 kms, and 23.5 m and 56 m, respectively (Fig.10.3).

The basic optics is similar to that of PAN of IRS-1C/1D. All IRS payloads cameras namely LISS-I, II, III, and IV are operated in pushbroom scanning mode using linear CCDs. ResourceSat data find their application in several areas like agricultural crop identification and monitoring, crop acreage/yield estimation, precision farming, water resources, forest mapping, rural infrastructure development and disaster management, etc.

These satellites offer real-time and voluminous amount of data including both spatial and non-spatial data with diverse resolution. Such type of satellite data is being used by the various stakeholders including academia, administrators, architect and town planners along with professionals across the world. The purpose of the data ranges from weather prediction to wetland management to agriculture to water resources to climate change to urban planning and mineral prospecting, environment and disaster management, etc. This list is indicative only. **National Remote Sensing Centre (NRSC)** located at Hyderabad is the main nodal agency that takes care of the distribution of remote sensing satellite data products in India along with neighbouring countries as well. The satellite data is received at the earth station located at Shadnagar i.e. about 55 kms, away from Hyderabad. You must remember that most of the other sensors developed by various countries used in earth's resources satellites are similar to either SPOT-HRV or IRS LISS system configuration.

Particularly, in very high resolution imaging for example IKONOS, the technique known as **Time Delay and Integration (TDI)** is being used. It works on 2-dimensional array instead of single linear array as used in the conventional pushbroom scanners. TDI used in IKONOS satellite which is the first civilian remote sensing satellite system produces 1 m PAN data and also 4 bands (Blue-B, Green-G, Red-R, Near-Infrared-NIR) multispectral imagery effectively with 4 m spatial resolution. You will be amazed to know that our country, India has also demonstrated this technique for providing high resolution imageries. This type of high resolution imaging systems characteristically has smaller swath ranging between 12-15 kms.

Till now, you have studied and learned about two-dimensional images. The third-dimension (or popularly known as 3D) i.e. height can also be measured from the photographs or images. The height data is essentially useful in many applications such as soil erosion studies, hydro-geomorphological mapping

and urban studies, etc. To generate 3D data, we require to take photographs from two locations. This can be achieved by vertical photographs with an overlap (stereo pairs). **Stereo pairs** are generated for an area by looking at from different imaging stations with different viewing angles. French SPOT-1, Japanese ALOS, and Indian Cartosat-1 are equipped to carry the dedicated fore-aft sensors for producing stereo photos. Cartosat is equipped with two cameras to produce high spatial resolution imageries with 2.5 m resolution and 30 kms swath. Panchromatic sensors have immensely helped us to generate digital elevation models from satellite based imaging systems. Several topographical maps have been compiled and revised on various scales by stereo viewing of oblique image pairs with the help of stereo plotting instruments and various photogrammetric softwares across the globe.

In nutshell, the collection of remotely sensed data or satellite imageries is not a big issue now. However, the operating nation's releases category-wise data based on the specific requirement for example public domain, commercial and restricted usage of images to facilitate the study of our earth's environment and resources. In case of public domain category, you will be able to get the data at free of cost from their respective websites. However, for recent data, you have to purchase from their respective organizations by following their procedures and guidelines which may change from time to time readily available in their websites. A few of them are given for acquiring remote sensing and other related data as under:

- https://bhuvan.nrsc.gov.in/bhuvan_links.php
- https://www.usgs.gov/centers/eros
- https://www.fsa.usda.gov/programs-and-services/aerial-photography/
- https://www.nrcan.gc.ca/maps-tools-publications/satellite-imagery-air-photos/air-photos/22030
- https://www.ssd.noaa.gov/
- http://www.surveyofindia.gov.in/

However, since 2020, the Govt. of India has started liberalising its space sector by allowing the private participation in satellite technologies that may enable the better availability and use of such data products in future for observing the planet earth's resources more precisely.

SAQ 3

a) Choose the correct answers- True or False.

i) Return Beam vidicon is a television camera.

ii) The earth's cover is recorded by pixel called opto-mechanical scanning system.

iii) ETM^+ sensor has been introduced in Landsat 5 satellite.

iv) Vegetation Instrument is a LANDSAT Sensor.

v) SPOT is Japanese Satellite Programme.

b) What is LISS? Define its types.

10.5 SUMMARY

In this unit, you have studied so far:

- We are now better equipped to observe the minute details of earth's features from space by studying the remotely sensed data. The main advantage of such datasets or data products lies in providing a great synoptic view of the ground area.
- Remote sensing is the science of making observations and drawing inferences about the objects from measurements, made at a distance without touching the objects. It simply means the sensing of the surface of the earth from space.
- Electromagnetic radiation is the important part of any remote sensing system. The electromagnetic spectrum ranges from gamma rays to radio waves.
- Remote sensors and platforms are predominantly designed based on the requirement of data with pre-defined measurements.
- The quality of any remote sensing data product can be assessed by its spatial resolution, spectral resolution, radiometric resolution and temporal resolution.
- The first known aerial photo was obtained by balloon in 1858 and this is considered as a primary form of data collection from remote sensing.
- Small, medium, and large format photos are produced in aerial survey.
- There are four photographic films namely PAN, B&W-IR, True-colour, Colour Infrared used in imaging the earth's features in the wavelength portions between 0.3 μm and 1.2 μm. PAN photography particularly has many advantages in cartography.
- The RBV television camera is one of the space borne high resolution cameras used initially in the LANDSAT satellites in observing earth's landscape. MSS, TM, ETM, ETM+, OLI sensors are installed in various LANDSAT series.
- HRV, HRVIR, and VI are used in SPOT series of satellites.
- IRS satellites BHASKARA-I and II were also carried in two-band television camera system. LISS-I, II, III, IV, and AWIFS sensors are carried by IRS satellites.
- You have also learned about the availability of important sources of remotely sensed data which are readily available on web for educational and research purposes as well as commercial utilization.

10.6 TERMINAL QUESTIONS

1. Briefly describe about the sensors and platforms used in collecting the remotely sensed data products.

2. Describe about the aerial photography.
3. Write a short note on opto-mechanical scanners employed to collect remotely sensed data.
4. Explain the SPOT Programme.

10.7 ANSWERS

Self Assessment Questions

1. a) Remote sensing is the science of obtaining information about an object from a remote distance without thouching the object.

   b) The orbital altitude of geostationary satellite is about 36,000 kilometres. Orbital period of this satellite corresponds with that of earth's revolution. Such geostationary satellites are capable of clicking regular view of any specific portion of the earth's surface employed in weather forecasting. It is mainly used to procure meteorological data and information.

2. a) These colour regions are blue, green and red.

   b) The scale of aerial photograph is 1:10,000.

3. a) (i) True (ii) True (iii) False (iv) False (v) False

   b) LISS denotes Linear Imaging Self-Scanning. There are four types of LISS sensors namely LISS I, II, III and IV.

Terminal Questions

1. To answer this question, you should be covering the key features of sensors and platforms employed to collect the remotely sensed data by referring to Section 10.2.
2. Refer to the Section 10.3.
3. Refer Section 10.4.2 for precisely highlighting the key elements of opto-mechanical scanners which enables the collection of remotely sensed data.
4. Refer to the Sub-Section 10.4.3.

10.8 REFERENCES/SUGGESTED READINGS

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GLOSSARY

Active Sensors: It means the camera sensors mounted atop a satellite with their own source of illumination or light is known as active sensors during the process of remote sensing. They have the advantage of capturing the data during any time of the day, season or year.

Aerial Photograph: It refers to a photo or an image clicked from the air-borne platforms by using a precision camera sensor.

Agricultural Census: Agricultural census was started in 1970-71 to collect the data on social group and size class wise covering multiple aspects of land like operational holding, tenancy, land use, irrigation and so on.

All India Educational Survey: All India Educational Survey is an activity to collect, organise and disseminate variety of information related to school education from infrastructure to attainments.

Band: It means the specific wavelength interval in the electromagnetic spectrum.

Census Schedule: Census Schedules are large sized proforma containing spaces to capture information related to housing or individuals.

Data Measurement Scales: All the data are classified and measured using certain scales are called data measurement scales. These are nominal, ordinal, interval and ratio.

Digital Image : It refers to an array of digital numbers (DN) organized in rows and columns in tabular from. It has the property of intensity values along with their spatial locations.

Digital Number (DN): It means the intensity value of a pixel in a digital image in remote sensing.

District Level Health Survey (DLHS): DLHS are health surveys based on samples in the country which collects data on household profile with amenities and facilities and maternal and child health and health care at district level since 1998-99.

Electromagnetic Radiation (EMR): It means the amount of energy which gets transmitted at a speed of light from the giant Sun.

Electromagnetic Spectrum: It refers to the entire gamut of EMR or energy ranging from meters to nanometers in wavelength traveling at a speed of light. It propagates through a vacuum such as outer space.

Field Mapping: Field mapping is a map making activity, manual, automatic or semi-automatic, in the field which includes drawings, field measurement and recordings.

Field Reports or **Field Diaries:** These are important sources of primary data, in which the observers record their observations and measurements in the field note books and later on translate into data and information.

Focus Group Discussion: Focus Group Discussion is a primary data collection tool, which involves the gathering of people of similar backgrounds in a group to get certain information about specific topic through group discussion.

Geostationary Satellites: These are located at a very high altitude approximately 36, 000 kilometers above the earth's surface.

Interval Scale: Interval scale includes the number, which has continuity and magnitude of difference. However, it indicates zero as reference point but there is no true zero in like temperature.

Interviews: Interviews are the primary data collection tools involving personal verbal interaction either on face to face mode or using electronic medias-telephone, video calls, etc. It is mostly two way communication.

Livestock Survey: Livestock census was started in 1919-20 to collect the information related to livestock and poultry with complete count. It has now completed the conduct of 19th survey up to the year 2012.

Microwave Remote Sensing: It is confined to the process of remote sensing in higher wavelengths ranging from 1 mm to 1 m. This category has the advantage of even penetrating and capturing the details during the cloudy season or overcast sky conditions.

National Family Health Survey (NFHS): NFHS health surveys based on samples in the country was started since 1992-93. It collects health related data primarily on maternal and child health and health care with background characteristics and many more crucial indicators.

National Sample Survey: These are a kind of surveys based on certain samples to collect the information on various aspects for the planning and development in the country.

Nominal Scale: Nominal scale is such that uses numbers to represent identities, where no number represents the size or weightage like 1 representing males and 2 representing females.

Observations: Observations are also the data collection tools, where the information is collected by way of investigator's own direct observation without asking from the respondent.

Optical remote sensing: It refers to the process of remote sensing in the visible, near infrared and middle infrared regions ranging between 0.3 mm to 3 mm.

Ordinal Scales: In ordinal scale, numbers represent rank order indicating the order of quality or quantity without giving the magnitude of quantity or degree of quality like 1, 2, 3 and 4 representing very good, good, moderate and poor.

Passive Sensors: It refers to the camera sensors which doesn't have its own source of light as like active sensors. Hence, such sensors are capable of recording the wavelength during the naturally available source of Sun's light.

Population Enumeration: Population enumeration or population census is a process where the detailed information of each and every member is collected through schedule. It is also known as census.

Primary Data: Primary data are those data which are directly collected by the researcher or user. These are first hand data collected for the first time for special purposes.

Primary Sources: Primary sources of socio-economic data are those through which the primary data are collected like primary surveys using data collection

tools such as schedules and questionnaires, observations, interviews, focus group discussion, field reports or field diaries. The primary sources of physical or spatial data are field survey and mapping and remote sensing.

Questionnaires: A data collection tool in the form of format with a set of questions with structured questions for the collection of information/data primary data through various modes other than face to face interaction of the investigator and respondent.

Ratio Scale: Ratio scale includes numbers like interval scale, but it has true zero means absence of the object/phenomena of measurement, like weight or height.

Remote Sensing: It is an art and science of obtaining information about an object or earth's phenomenon captured by a sophisticated precision device that is not in contact with the object being sensed.

Resolution: In its broadest sense, resolution refers to the ability of a sensor to record and display finer details being captured from the ground objects during the process of sensing. There are four kinds of resolution namely spatial, spectral, radiometric and temporal taught in the science of remote sensing.

Sample Registration System (SRS): SRS is a term for vital or civil registration system only. It collects and provides reliable estimated data on fertility and mortality measures like birth rate, death rate and neonatal/infant/ child mortality rates at disaggregated levels for rural and urban areas with total estimations across the states.

Secondary Data: The data which have already been collected and processed or tabulated and may be in published or unpublished form.

Secondary Sources: Secondary sources of socio-economic data are those from where the secondary data are collected like various published and unpublished documents and reports by the Government and non-government agencies including the United Nations and national and international organisations or data providers.

Schedules: A data collection tool in the form of format with a set of questions with structured questions for the collection of information/data primary data through face to face interaction of the investigator and respondent.

Socio-economic Survey: The survey through which socio-economic information are collected.

Sun-synchronous Satellites: These are designed to follow an inclined north-south orbit. Such satellites travel from north to south during sunny side in its descending course and travel from south to north during shadowy side in its ascending path.

Thermal Remote Sensing: It refers to the process of remote sensing in which the emitted radiation is captured ranging between 3 mm to 5 mm and 8 mm to 16 mm.

Vital or Civil Registration System: Vital or Civil Registration System is a system to record vital events like births and deaths by the Government.