INDIA

COUNTRY REPORT

GEO ENABLED SUSTAINABLE DEVELOPMENT

AUGUST - 2022

THE UNITED NATIONS COMMITTEE OF EXPERTS ON GLOBAL GEOSPATIAL INFORMATION MANAGEMENT

THE FIRST EVIDENCE OF SPHERICAL EARTH CONCEPT

- Foundation of Modern Geospatial Sciences and Cartography

मध्ये समस्ताण्डस्य भूगोलो व्योम्नि तिष्ठति

In the midst of the Universe, the spherical Earth stays.

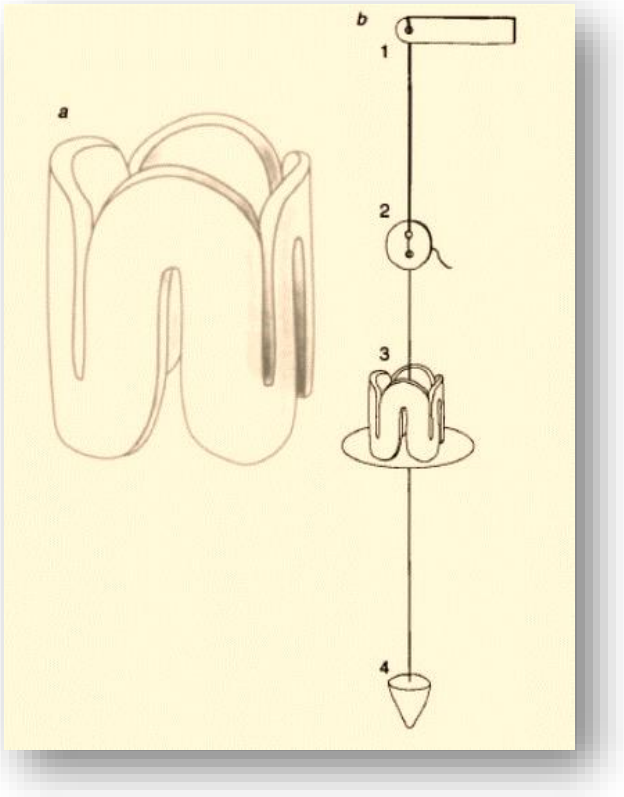
Rig Veda (1500 B.C. – 1200 B.C.)

चक्राणासः परीणहं पर्थिव्या हिरण्येन मणिना शुम्भमानाः |
न हिन्वानासस्तितिरुस्त इन्द्रं परि सपशो अदधात सूर्येण ||

Adorned with jewels, they encircled the earth, but Indra overcame them with the rising sun.

This encircling shows a round path which could be around a spherical shape.

Rig Veda (1500 B.C. – 1200 B.C.)



INDUS CIVILISATION SURVEY INSTRUMENT (2200 B.C.)[1]

In the Vedic literature of over 5000 years ago, the knowledge of land was presented in a graphical form which described the extent and shape of territories. The Brahmand Purana of 500 B.C. to 700 A.D. gives evidence of the art of modern map-making. The art of surveying and techniques of mensuration of areas are described in Sulva Sutra (science of mensuration) and in the Arth Shastra of Chanakya written in the 3rd century B.C. The golden age of Indian Renaissance in the 5th century saw the towering genius Arya Bhat who wrote Surya Siddhant and calculated the earth's circumference to be 25,080 miles - less than 200 miles off modern measurements of the equator. Rajaraja I of Tanjore (985 - 1011 A.D.) carried out careful surveys of the lands and cultivation.[2]

[1] Roy A K, 1967. Ancient Survey Instruments. Journal of Institution of Surveyors, 8 : 371.
[2] https://www.asprs.org/wp-content/uploads/2012/05/03-2014-India.pdf

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INDIAN GEOSPATIAL INFORMATION

MANAGEMENT LANDSCAPE

INTRODUCTION

1. Geospatial information is a critical component of the national infrastructure and knowledge economy. It integrates and leverages a wide variety of government services. All countries and all sectors need geospatial information and enabling technologies for making decisions on national policy, strategic priorities and sustainable development.

2. India, a Union of States, is a Sovereign, Secular and Democratic Republic with a Parliamentary system of Government. It is the second-most populous country (with over 1.3 billion people), the largest democracy as well as the fastest growing economy in the world. Land under active agriculture in India extends to about 1.4 million sq kms. India is one of the oldest and continuously inhabited civilizations of the world and known for its kaleidoscopic variety and rich cultural heritage blended with diversity. There are 28 States and 9 Union Territories (UTs) in the country. From the largest to the smallest, each State/UT of India has unique demography, dress, festivals, language, history and culture. The Indian landmass covers an area of 32,87,263 sq. km (1,269,346 sq mi), extending from the snow-covered Himalayan heights to the tropical rain forests of the south. As the 7th largest country in the world, India stands apart from the rest of the Asia, marked off as it

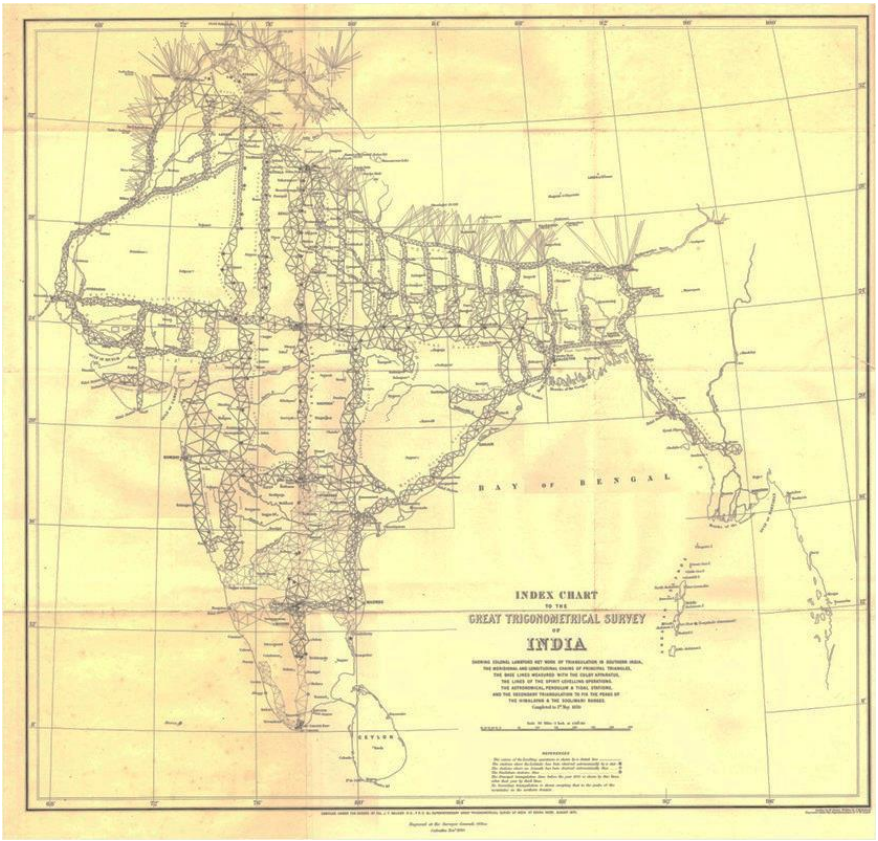
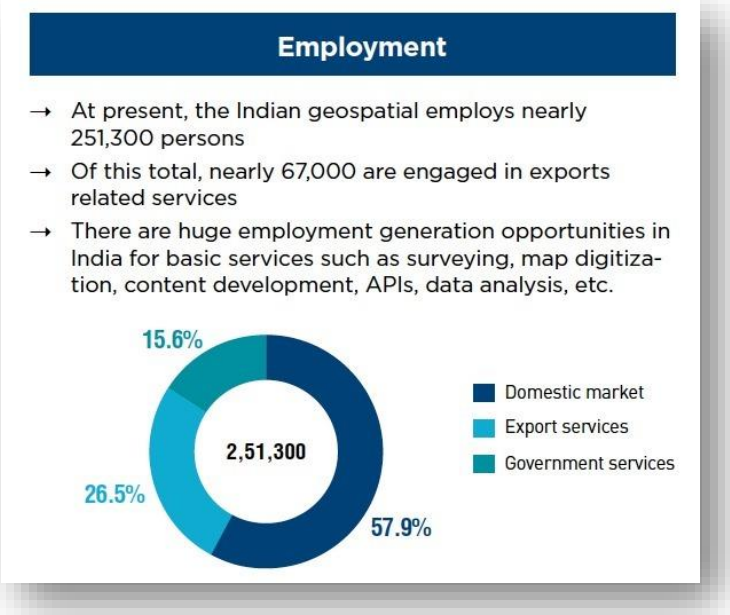
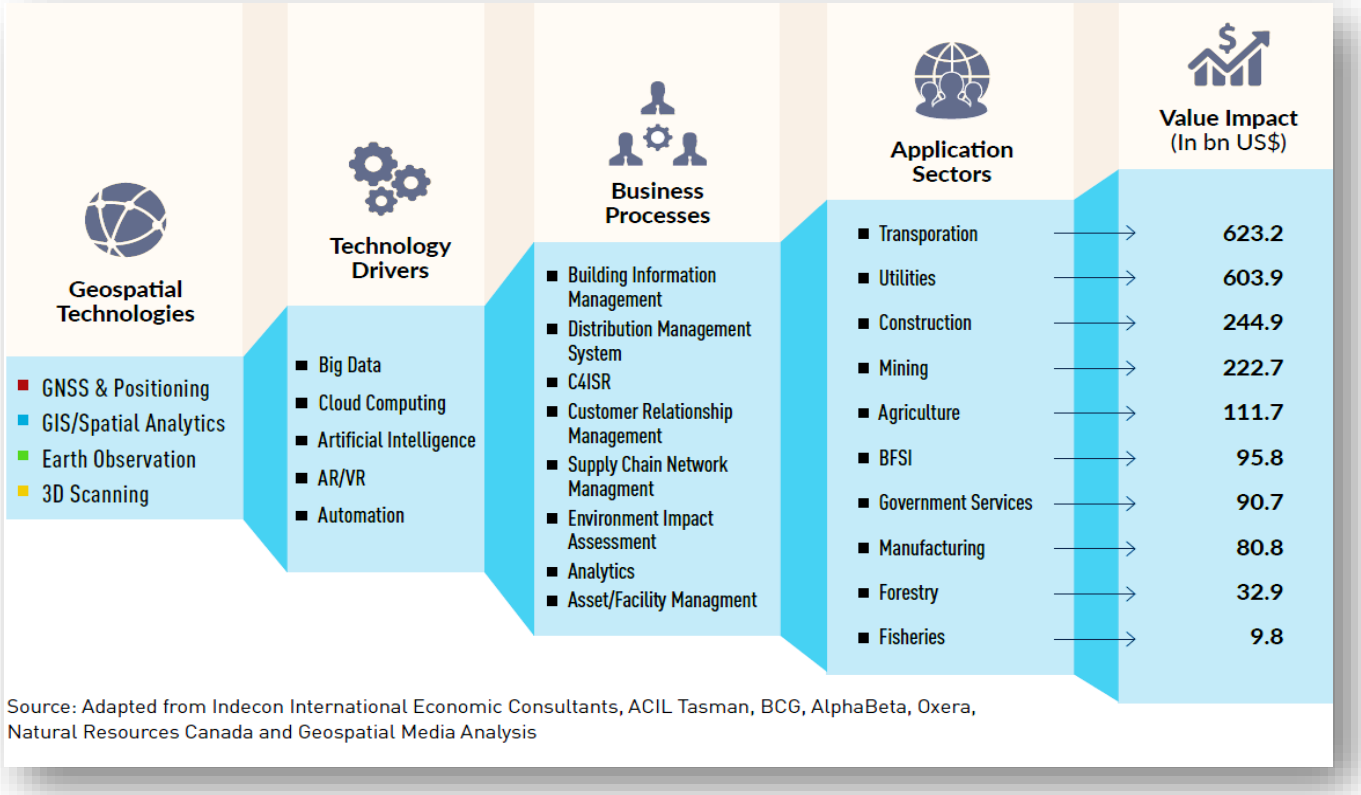


Figure 1. Great Trigonometrical Survey (1802 - 1840) 38 years Long Survey

is by mountains and the sea, which give the country a distinct geographical entity. Bounded by the Great Himalayas in the North, it stretches Southwards and at the Tropic of Cancer, tapers off into the Indian Ocean between the Bay of Bengal on the East and the Arabian Sea on the West. It has a land frontier of about 15,200 km. The total length of the coastline of the mainland, Lakshadweep Islands and Andaman & Nicobar Islands is 7,516.6 km. The landmass can be divided into various regions that includes Northern Mountains, Peninsular Plateau, Thar Desert, Indo-Gangetic Plain, Coastal Plains and the Islands.




Indian Geospatial Economy 2021
Commercial Market
Domestic Market
₹14,050 crore
Export Market
(Solutions/Services)
₹11,122 crore
Government Expenditure
On Geospatial Agencies
₹13,800 crore
₹38,972 crore
Employment
Geospatial Employees
4,70,000
Employee Distribution - 2021
12.40%
18.10%
69.50%
Export Services
Domestic Market
Government Services
Source: Geospatial Artha Report 2021


Geospatial Technologies
GNSS & Positioning
GIS/Spatial Analytics
Earth Observation
3D Scanning
Technology Drivers
Big Data
Cloud Computing
Artificial Intelligence
AR/VR
Automation
Business Processes
Building Information Management
Distribution Management System
C4ISR
Customer Relationship Management
Supply Chain Network Managment
Environment Impact Assessment
Analytics
Asset/Facility Managment
Application Sectors
Transporation
Utilities
Construction
Mining
Agriculture
BFSI
Government Services
Manufacturing
Forestry
Fisheries
Value Impact (In bn US$)
623.2
603.9
244.9
222.7
111.7
95.8
90.7
80.8
32.9
9.8
Source: Adapted from Indecon International Economic Consultants, ACIL Tasman, BCG, AlphaBeta, Oxera, Natural Resources Canada and Geospatial Media Analysis

HISTORY

3. India has possibly the longest known tradition of systemically collecting Spatial Data at national level. The National Mapping Organization (NMO), Survey of India (SOI) has celebrated its 250th year of establishment in year 2017. Other Geospatial data generating organizations are Geological Survey of India, Zoological Survey of India, Botanical Survey of India etc.

4. During 19th century, there used to be a District Gazetteer in each district (the lowest administrative unit), which spatially used to maintain the records of the local assets and infrastructure. The national planning process of India has undergone many changes since its initiation in 1951. Decentralized local level planning is currently accepted as the national planning strategy. Towards this end, the 73rd and 74th Constitutional Amendments in 1992 & 1993 respectively, have empowered the State Governments to form the Institutions of Local Self-Governance (ILG). At the core of this concept lies an integrated approach to planning based on the local resource endowment. This led to the requirement of a large matrix of spatial and non-spatial data on natural resources, demography, socio-economy etc., appropriate data management and analyzing tools and techniques for information generation and integrating them to generate appropriate information required for plan preparation. The development of database technologies, entry of computers in India in the late 70's and first Indian Remote sensing Experiment in 1977 triggered the possibility of introduction and integration of geo spatial information in the planning. The current Government initiatives of Digital India, the Mahatma Gandhi National Rural Employment Guarantee Act, Atma Nirbhar Bharat, Infrastructure Development, Indian Space Missions etc, all have given a boost to the exploitation, integration and utilization of geospatial information in Central (Federal) and State Government planning processes. National Geospatial Guidelines have been promulgated in

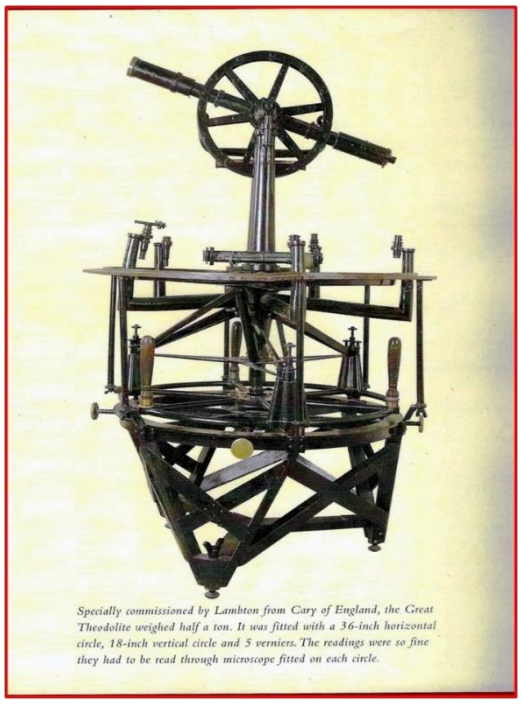


Figure 2. Great Theodolite, 1830

Figure 3. Astronomical Instrument (1830) zenith Sector

year 2021 to nurture and develop the geospatial ecosystem of the country and to encourage spatial thinking, generate geospatial knowledge, strengthen geospatial infrastructure, promote use of Geospatial Data, Products, Solutions and Services.

INDIAN GEOSPATIAL MARKET AND ROLE OF INDUSTRY

5. The Indian geospatial economy is valued at INR 20,629 crore (USD3.07 billion) and employs over 251,300 people across the country. As per a recent study,
Indian geospatial market is currently valued at INR 7,679 crore and is expected to grow at 13.8% CAGR between FY 2017-18 and FY 2020-21 (Figure 4).

6. The key growth driver for geospatial market in India is the thrust provided by the central and state government programs for developing a robust physical infrastructure, effective governance delivery including e-governance and digital economy initiatives, integrated programs on urban and rural development etc. Geospatial data and information and its adoption has so far been a direct beneficiary of the advancements in Information and Communication Technologies (ICT) as it rides conveniently on the matured digital ecosystem and digital infrastructure to deliver value to government, businesses as well as consumers/citizens.

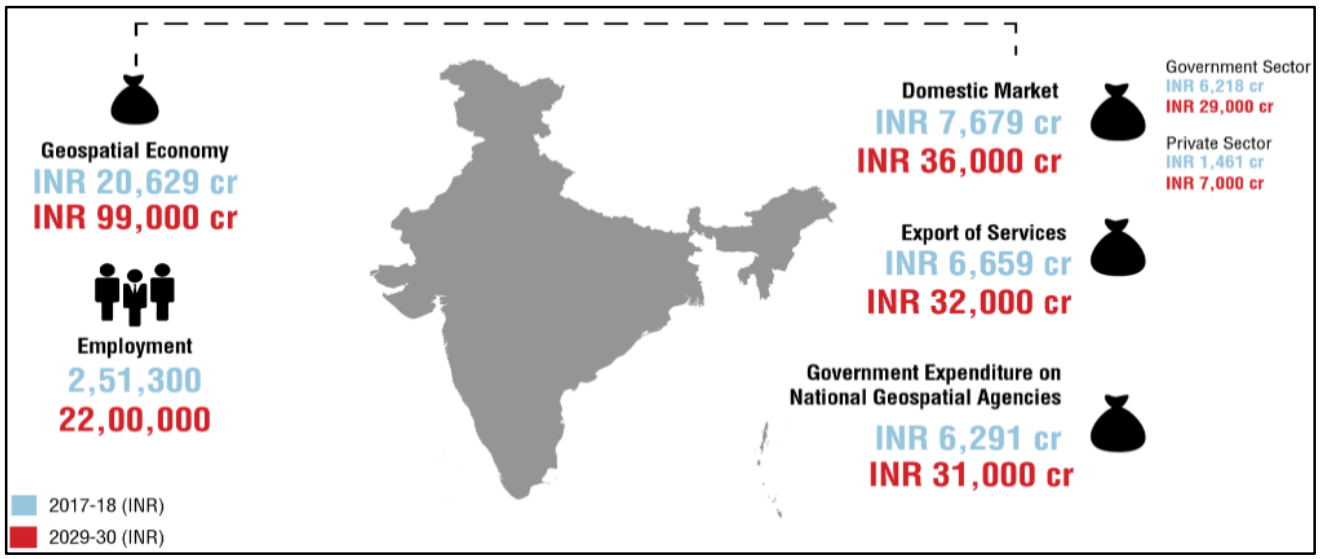


Figure 4. Indian Geospatial Market (Source: India Geospatial Economy Report- 2018)

7. In terms of end-use sectors (or application areas), the geospatial market of India is dominated by Infrastructure, Urban Development and Utilities. Together in 2017-18, these three sectors had an estimated market share of 22.1%, 13.9% and 15.7% respectively, representing nearly half of the total

geospatial market of India Mining, Education and Research. The services segment constitutes the largest part of the Indian geospatial market with 74.4% of market share in FY 2017-18. The major categories of services are land survey (GNSS and optical technology), GIS/Spatial Analytics, LiDAR and 3D scanning, aerial and satellite data/image processing, consultancy and R&D.

ROLE OF INDUSTRY

8. The Indian Geospatial Industry has been playing a quintessential role in building awareness, encouraging adoption and highlighting the value and relevance of geospatial information and technology in India across the central, state and local governments.

9. The Geospatial industry was associated with mapping and Land-Marine surveying techniques historically which has developed into various geospatial technologies such as satellite, location and remote-sensing technologies, artificial intelligence (AI), Internet of Things (IoT), machine learning, and 3D printing for mapping and analysis of an area of land and related activities.

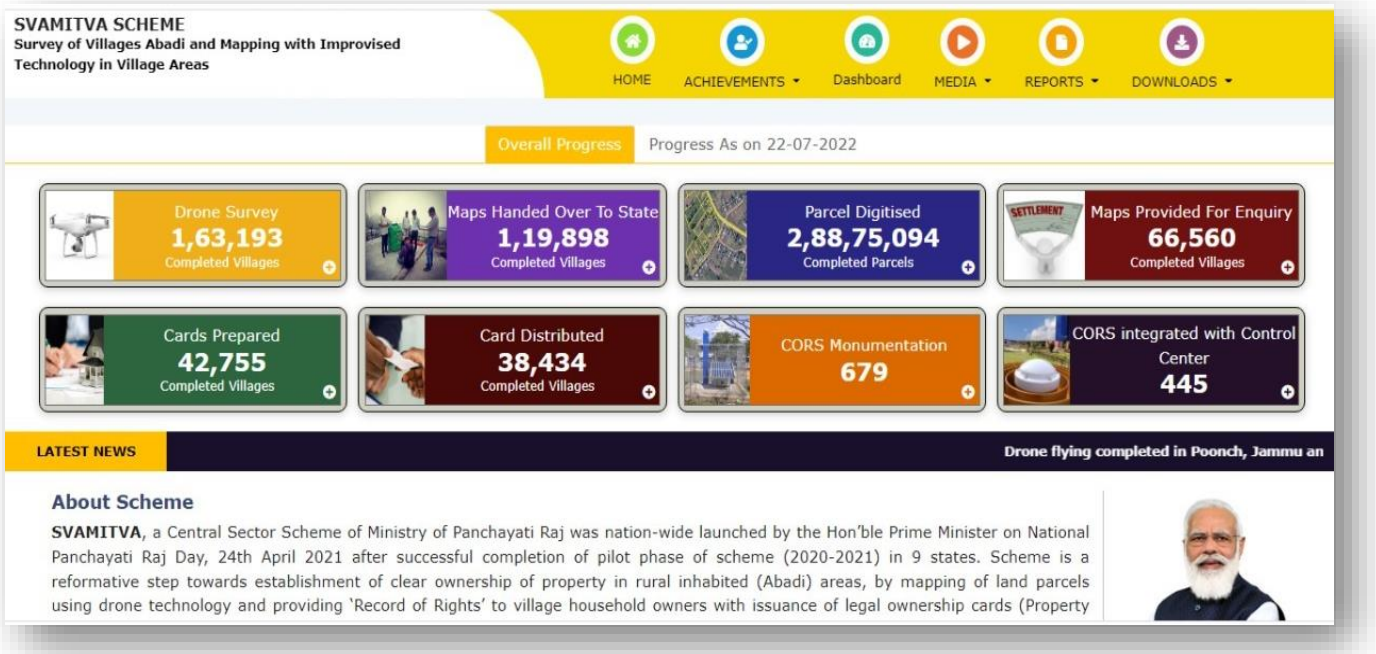
10. The geospatial industry in the country is presently witnessing tremendous opportunity as the Union government has initiated reform projects in several infrastructure segments like rural development, power, land and natural resources and mandated the use of geospatial technologies in these projects.

11. The growth of the commercial geospatial sector has been supported by both state and central government sectors in India. Commercial Geospatial Industry Landscape in India: Software providers are ESRI, Autodesk, Bentley Systems, Leica Geosystems, Intergraph, PCI Geomatics; Hardware providers are HP, Trimble, Sokkia, Leica, Garmin; and Service providers are Rolta, RMSI, TCS, Infotech Enterprises.

GOVERNANCE AND INSTITUTIONS

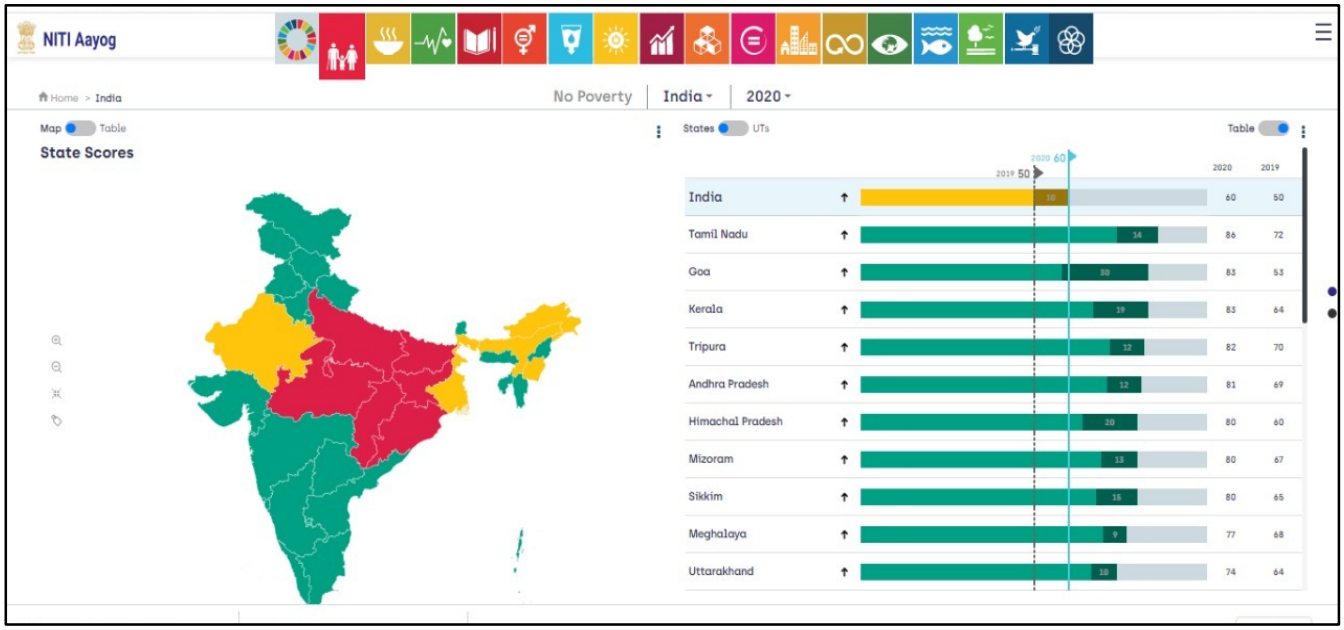
GOVERNING BODIES RESPONSIBLE FOR POLICIES/ LAWS FOR ACQUISITION, MANAGEMENT, USE & DISSEMINATION OF GEOSPATIAL INFORMATION

12. India has a well-developed geospatial organizational infrastructure that covers the entire spectrum of geospatial value chain. Depending on the role, function and field of application, there are a wide number of organizations both within and outside the government which are deeply engaged in catering to the varied multi-dimensional requirements of the users. As per the mandate drawn from Government of India's allocation of business rules 1961, the Department of Science and Technology (DST) which is a part of the Ministry of Science and Technology, is the nodal Ministry which formulates policies that relate to Science and Technology.



13. Further, DST is the nodal Ministry for undertaking all matter concerning to Survey of India and National Atlas and Thematic Mapping Organisation, National Spatial Data Infrastructure and Promotion of Geographic Information System (GIS) in the Country. Basically, DST is responsible for all the geospatial and cartographic activities in the country. The organizations under DST are the

Survey of India (SOI), National Atlas and Thematic Mapping Organization (NATMO) and National Spatial Data Infrastructure (NSDI) which have a well-established network. While, Department of Space through the India Space Research Organization (ISRO) governs all the matters concerning Remote Sensing and its applications.



INDIAN GEOSPATIAL POLICY AND LEGAL FRAMEWORK

14. At national level, the regulatory landscape of Indian geospatial sector comprises of 15 national policies/acts/rules from 06 different ministries/departments to control the use/exchange of geospatial information of which 4 are in draft stage. Geospatial Information acquisition, usage and dissemination in the Country is governed by several mutually exclusive policies viz. data capture, use and dissemination of topographic information is governed by National Map Policy from Department of Science and Technology, National Remote Sensing Agency is responsible for enforcement of Remote Sensing Data Policy 2011.

15. Aerial Flying and Drone Flying rules are governed by Ministry of Civil Aviation. Further, Ministry of Defence and Home affairs ensures that geospatial information is not misused for national security. The various agencies including Department of Science and Technology that has a major role to play in defining and deciding the geospatial policy focus in the country have been listed in the Figure 6

Table 1. National Geospatial Organizations for Geospatial policy framework
(Source:-India- A Global Geospatial Destination-NSCS Report-2019)

MINISTRY	POLICIES
Ministry of Science and Technology	• National Map policy (NMP) (2005) • National Data Sharing & Accessibility Policy (2012) • National Geospatial Policy (Draft 2016) • National Geospatial Guidelines (2021)
Ministry of Finance	• Rules prohibiting export of all maps of 1:250K and larger scales (2005) • Courier Imports and Exports (clearance) Amendment regulations (2010)
Ministry of Defence	• Restriction of Sale, Publication and distribution of Maps (2017) • Policy on digital data of Topographic Maps (1967) • Policy of Aerial Photogenic Survey Aircraft borne Remote Sensing (2006)
Department of Space	• Remote Sensing Data Policy
Ministry of Home Affairs	• The Criminal Law Amendments Act 1961,Act No.23
DGCA, Ministry of Civil Aviation	• Civil Aviation Requirement (Car) (2012) • Operations of UAV-Air Transportation Circular 328 of 2016 • Requirements for Operation of Civil remotely Piloted Aircraft System (RPAs) (Draft- 2017)

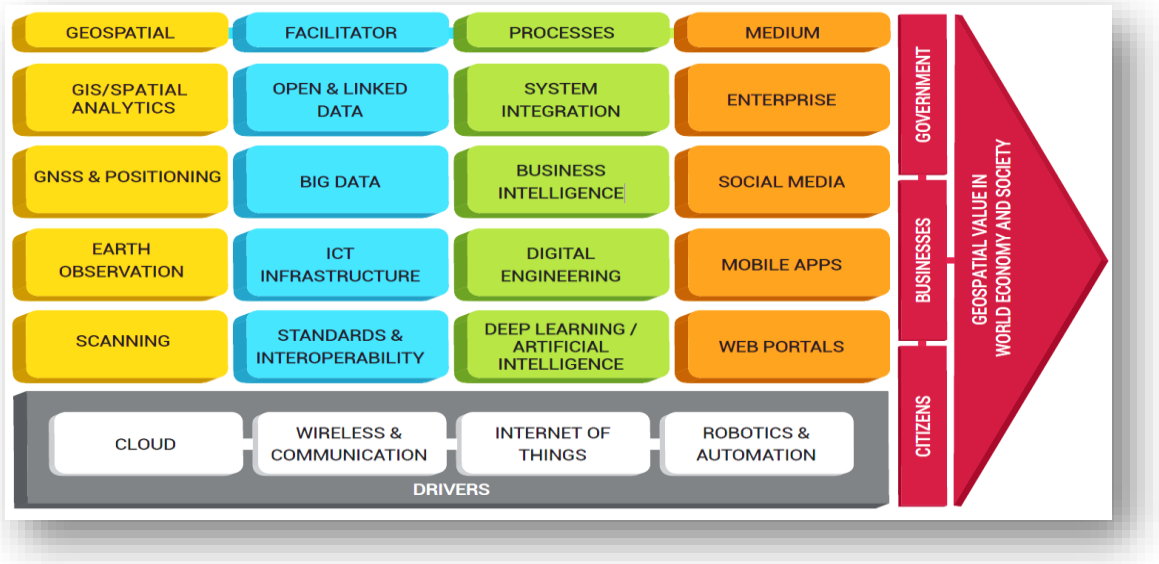


Figure 5. Geospatial Technology yielding Value to Economy & Society
(Source: Geospatial Media Analytics- Industry-Outlook-report-2017)

DATA ACQUISITION

Foundation Data and Infrastructure

16. The government agencies that have been mandated to provide the foundation datasets and infrastructure for the country are Survey of India (SOI), National Spatial Data Infrastructure, National Remote Sensing Centre, National Information Centre and National Centre for Geo-informatics.

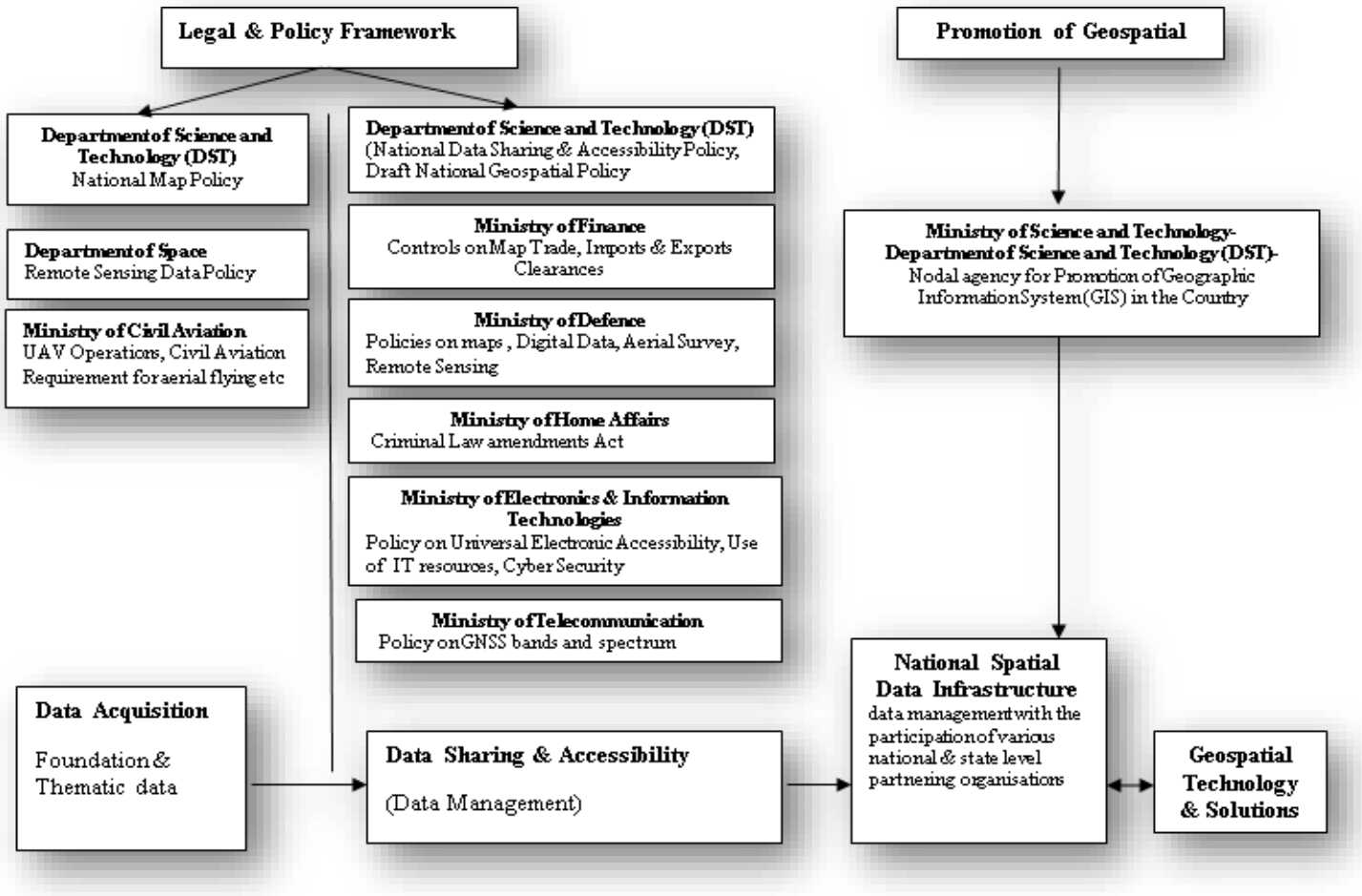


Figure 6. Diagrammatic Representation of the National Geospatial Governance Framework

17. In its assigned role as the nation's Principal Mapping Agency, SOI bears the unique responsibility to provide timely, updated, cost effective and accurate Topographical Data Base for expeditious and integrated development of the country. SOI has been mandated to take a leadership role in liberalizing access of spatial data to user groups without jeopardizing national security.

Thematic Data

18. Geospatial Information for several important themes is captured by various organizations mandated to provide that information. There are several organizations mandated by Government of India to provide thematic spatial data for specific sectors and themes. A comprehensive list of thematic spatial data provided by various organizations has been depicted in Table 2.

Table 2. National Geospatial Organizations responsible for Thematic Data
(Source: NSCS Report, Geospatial Economy Report 2018)

NATIONAL GEOSPATIAL ORGANIZATIONS: THEMATIC DATA	THEMES/ SECTORS
National Atlas and Thematic Mapping Organization (NATMO)	Roadmaps, Rail Maps, City Maps, Health Map etc
National Remote Sensing Centre	Satellite Images
Forest Survey of India	Forest Maps
Geological Survey of India	Geological Maps, District Mineral Resource Maps, Mineral Map of India, Geomorphological Maps, Seismotectonic Maps, Seismic Hazard and Landslide Zonation Maps, etc
Centre Water Commission	River basins and Catchments Maps
Central Ground Water Control Board	Ground Water Maps
National Bureau of Soil Survey Landuse Planning; Soil and Landuse Survey	Soil Maps and Landuse Maps
Town and Country Planning Organisation	Master Plan of the Cities
National Hydrographic Organisation	Hydrographic Maps
Central Pollution Control Board	Environment Zonation Maps

Data Sharing and Accessibility

19. In the country, operational scale geospatial data management activities have been pursued with the launch of the National Spatial Data Infrastructure (NSDI) Initiative of Department of Science and Technology. With the approval of the NSDI through a Cabinet Resolution in June 2006, a two-tier coordination mechanism has been established with the support of the National Survey Agencies and State Level Line Departments. NSDI has a mandate of addressing all issues regarding data standards, data access, interoperability and Governance etc. NSDI, in this effort is also assisted by

a large number of state spatial data infrastructure (SSDIs). Some of the major initiatives of NSDI with particular reference to the geospatial data are discussed below:

(a) State Spatial Data Infrastructure (SSDI). In order to make the higher resolution data sets available with the State level Government Departments/ Agencies accessible to the end users, the State level Spatial Data Infrastructures are being set up. State Geo Portals/ prototypes are operationalized in States like Kerala, Karnataka, Jammu & Kashmir, West Bengal, Few North Eastern States, Haryana, Uttarakhand, Odisha, Jharkhand Madhya Pradesh and Punjab.

(b) Establishing National Data Registry (NDR). NSDI has compiled, updated and served metadata of different central and state Government departments. With increase in publication of standards-based map/ data services by the agencies, there has been a need to effectively and systematically register the data services for correct interpretation and analysis of the data sets. In addition to metadata as per ISO 19115/ BIS 16439 standards, other relevant metadata like definitions of features, registration of features with unique-ids, application schemas, classification code lists, and versions of standards used etc. are also required to be stored, tracked and shared. An operational scale National Data Registry (NDR) is being development by NSDI.

(c) Setting up Geospatial Cloud Platform Based Data Centre**.** A state-of-the-art Geospatial Cloud-based Data Centre is being established for quick on-boarding of NSDI/ State SDI data/application services. The Data Centre is expected to demonstrate the efficacy of Geospatial cloud concepts in managing and processing high resolution data sets from NSDI and State SDIs and also throw light on deciding on sizing/ scaling of Geo-ICT infrastructure resources vis-à-vis requirement of performance and efficiency in the processing of geospatial data sets.

(d) Framing and Using Standards. NSDI in consultation with Geospatial Information Sectional Committee of Bureau of Indian Standards (BIS) (designated as LITD -22) has been involved in framing of relevant national geospatial data and process standards. LITD-22 has been the National Mirror Committee of ISO for developing and publishing the standards. The Geospatial BIS Standards framed/ cobranded are IS 16439:2016 – Metadata standard for Geospatial Information, IS 16626:2017 – Geography Markup Language (GML), IS 16699: 2018 - Web Map Server Interface (WMS), IS 16966:2018 – GI – Location-based Services – Reference Model, IS 16967:2018 – GI - Location-based Services – Tracking and Navigation,

IS 16968:2018 – GI – Location-based Services – Multi-modal Routing and Navigation and IS 16970:2018 – GI – Rules for Application Schema.

(e) ISO/ OGC Linkage**.** ISO standards are adopted by NSDI in design and development of the data nodes. NSDI works closely with the Open Geospatial Consortium (OGC) – India Forum for testing and deploying upcoming international standards. NSDI and OGC-India have conducted joint activities.

INSTITUTIONAL ARRANGEMENTS

20. **Geospatial Science and Technology**. This is essentially a multidisciplinary domain and the Indian Geospatial Institutional Framework too is therefore a multilevel framework spread across multiple Government Ministries and Departments, all Central Agencies; State Agencies coordinated at the level of Government of India.

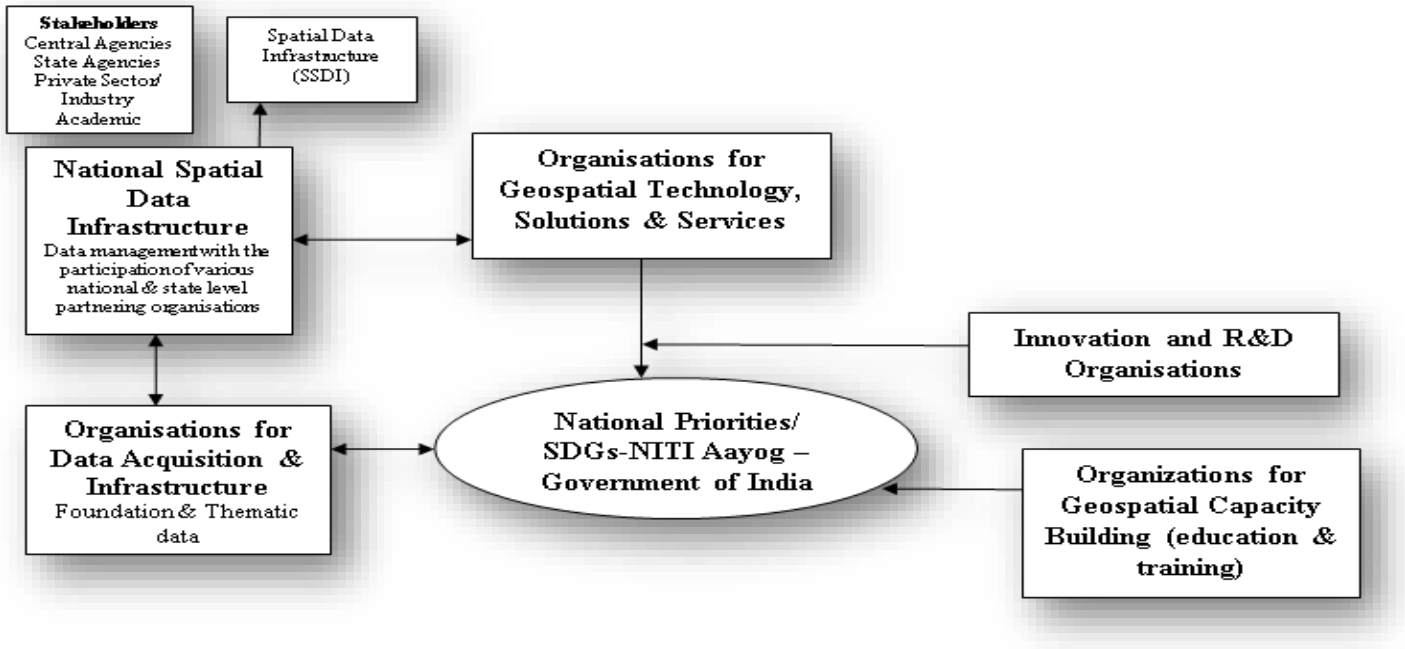


Figure 7. Representation of Geospatial Institutional arrangements in the Country

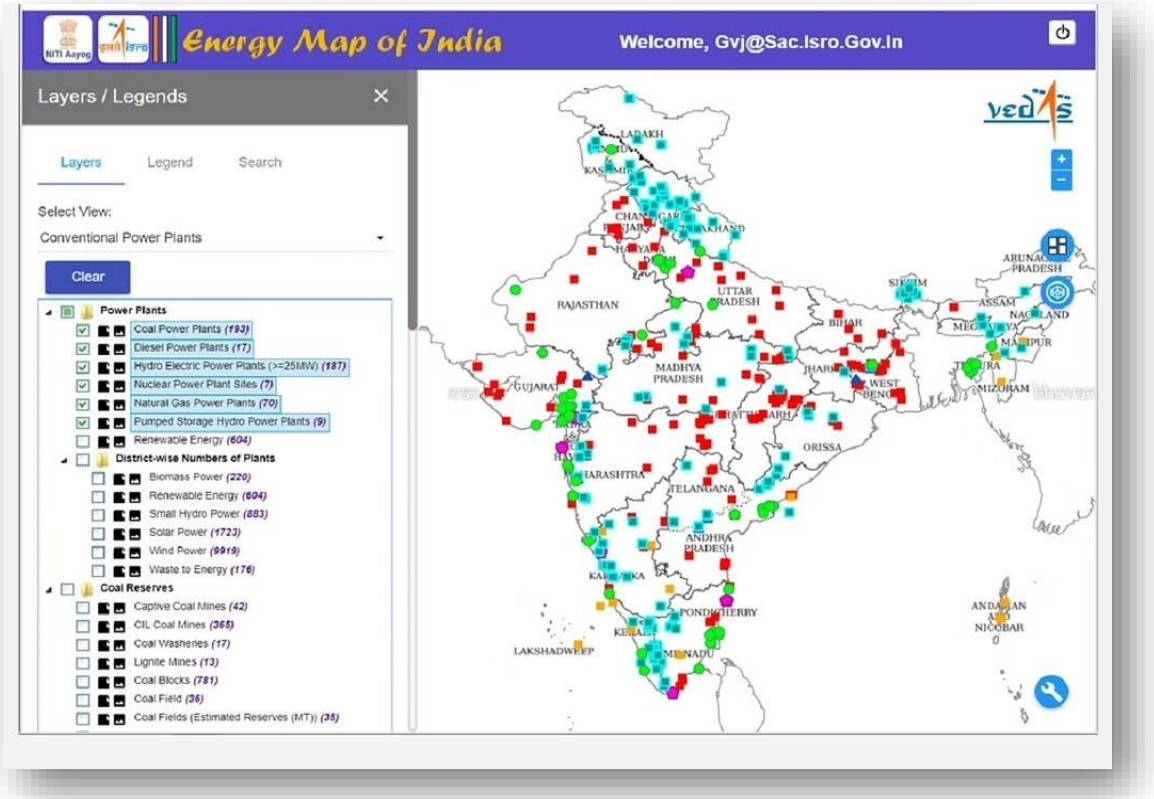
21. The National Geospatial Agencies are the key organizations which form the backbone of Indian geospatial sector. The designated national geospatial agencies are responsible for conducting survey and assessment of national resources, providing the base maps, specific geographical/ environmental information and data sets, representation, scrutiny and certification of national interests of geospatial domain, printing and publication of maps/data along with capacity building, technology adoption and R&D in their respective work areas. Together with other key entities, these agencies play a crucial role

in augmenting the usage of geospatial data and information for social and economic development planning. The major elements of this framework is depicted in Figure 7.

NATIONAL AGENCIES: DATA ACQUISITION, MANAGEMENT & SERVICES

DEPARTMENT OF SPACE (DOS)

22. It is one of the most important organizational elements in Indian Geospatial Institutional Framework and functions directly under the Govt of India. Indian Space Research Organization (ISRO) functions under Department of Space and has several other departments functioning under it with specific roles. These departments are, Vikram Sarabhai Space Centre (VSSC), Liquid Propulsion Systems Centre (LPSC), Satish Dhawan Space Centre (SDSC), U R Rao Satellite Centre (URSC), ISRO Propulsion Complex (IPRC), Space Applications Centre (SAC), National Remote Sensing Centre (NRSC) and ISRO Telemetry, Tracking and Command Network (ISTRAC). In addition, DOS also has two premier institutes of education too which are Indian Institute of Space Technology (IIST) and Indian Institute of Remote Sensing (IIRS).



INDIAN SATELLITE DATA PRODUCTS

23. ISRO has a vibrant Indian Remote Sensing program since 1988 with a gamut of Indian Remote Sensing Missions (IRS) observing Earth with Optical, microwave and hyper-spectral instruments flown on-board to provide necessary data in various spatial, spectral and temporal resolutions to cater to different user requirements in the country and for global usage.

24. Apart from meeting the general requirements, definition of IRS missions based on specific thematic applications like natural resources monitoring, ocean and atmospheric studies and cartographic applications resulted in the realisation of theme-based satellite series, namely,

(a) Land/water resources applications (RESOURCESAT series and RISAT series);

(b) Ocean/atmospheric studies (OCEANSAT series, INSAT-VHRR, INSAT-3D, Megha-Tropiques and SARAL); and

(c) Large scale mapping applications (CARTOSAT series). At present, the array of Indian Earth Observation (EO) Satellites with imaging capabilities in visible, infrared, thermal and microwave regions of the electromagnetic spectrum, including hyper-spectral sensors, have helped the country in realising major operational applications. The imaging sensors have been providing spatial resolution ranging from 1 km to better than 1m; repeat observation (temporal imaging) from 22 days to every 15 minutes and radiometric ranging from 7 bit to 12 bit, which has significantly helped in several applications at national level.

NATIONAL REMOTE SENSING CENTRE

25. National Remote Sensing Centre (NRSC), is a full-fledged center of ISRO. The Centre for hosts Satellite Data Products from more than 13 IRS satellites starting with first mission of IRS-1A and SAR imaging missions. NRSC also acquires and archives data of global regions for disasters, calibrations and specific studies.

26. Near real time data products from IRS weather sensors is delivered for climate and weather models for a global coverage. Geo-referenced, Ortho-kit, Ortho-rectified products are provided in standard formats like Geotiff, HDF etc.

AERIAL DATA COLLECTION AND DIGITAL MAPPING

27. The ASDM wing of National Remote Sensing Centre (NRSC) provides end-to-end Aerial Remote Sensing services and value-added solutions for various large-scale applications like aerial photography, digital mapping, infrastructure planning, scanner surveys, aeromagnetic surveys, large scale base map, topographic and cadastral level mapping etc. ASDM activities include generation of large-scale topographic maps and very high-resolution Digital Terrain Models (DTM) and for 2D/3D mapping in urban areas, infrastructure planning.

MINISTRY OF SCIENCE AND TECHNOLOGY

28. This ministry through its Department of Science and Technology contributes the maximum geospatial information management in the country. Following departments/organizations function under DST responsible for data acquisition, data products and services:

Survey of India (SOI)

29. It is the major National Survey and Mapping Organisation of the country. It is also one of the oldest organisations. The major functions of SOI include Geodetic Control (Horizontal and Vertical),

Geodetic and Geophysical surveys, Topographical Control, Surveys and Mapping within India, Mapping and Production of Geographical Maps and Aeronautical Charts, Surveys for Developmental Projects, Survey of Forests, Cantonments, large scale city surveys, guide maps, cadastral surveys, Survey and Mapping of special maps etc. Survey of India (SOI) has been in the process of cleaning, re-engineering and providing WFS/GML of its component of most of its 1:50,000 Open Series Maps (OSM). As a part of the NSDI's National Foundation Spatial Data (NFSD) Initiative, harmonization of administrative boundary data (up to village/ plot level) has been initiated with the involvement of National Agencies and State Governments (Survey Settlement & Land Records). A series of training workshops also have been organized in consultation with different state space application centres for proper utilization of geospatial data and applications.

30. Over the years, SOI has also undertaken several Geospatial Projects of national importance. Examples of some of these geospatial projects are National Ground Control Points (GCP) Library, Modernization and Expansion of Indian Tide Gauge Network, Redefinition of Indian Vertical Datum, Integrated Coastal Hazard Zone Mapping (ICZM), High Resolution geospatial data generation for National Hydrology Project, Large Scale Revenue Mapping for States using Drones/UAVs, SVAMITVA Project for mapping of rural habited areas in villages and Providing Web GIS services etc. SOI is building geospatial infrastructure for service orchestration e.g. dissemination of GIS data and services via G2G and G2C portals; Development of national level portal for water (WRIS, India Water Tool), surface and ground level water data (by CWC, CGWB) and forest management (e-Greenwatch).

National Atlas and Thematic Mapping Organization (NATMO)

31. The broad objective of NATMO is to prepare atlases and thematic maps of the country to cater the various needs of administrators, planners, politicians, researchers, students and the people at large. Various themes include physiography, hydrology, climate, administrative, political, social, agricultural, industrial, cultural & economic scenario of the nation and the spatio-temporal changes happening in the country. Major products and services of the organisation are:

(a) Atlases and thematic maps for the benefit of various users;

(b) Collaborating with other central and state government organisations to meet their map requirements; &

(c) Providing training in Remote sensing, Geographical Information System, Global Positioning System and Digital Cartography.

MINISTRY OF MINES

32. Ministry of Mines is responsible for survey, exploration and mining of all minerals except Hydro-carbon energy mineral, atomic minerals and coal. Exploration of coal and atomic minerals are limited to regional level survey. Geospatial database and geospatial maps are developed at different scales from the survey and exploration data and made available to open source / public through Geological Survey of India Bhukosh Portal (https://bhukosh.gsi.gov.in/Bhukosh/Public). The Ministry also administers the Offshore areas Mineral, underlying the ocean within the territorial waters or the continental shelf or the exclusive economic zone and other maritime zones of India.

Geological Survey of India (GSI)

33. GSI headquartered at Kolkata is an attached office of MoM and third oldest survey organization of the world established in 1851, is attached to the Ministry of Mines, headquartered at Kolkata. It has six Regional Offices located in different parts of the country. In addition, it has one State Unit offices in almost each state of the country.

34. GSI was set up with an objective to explore, generate and update geo-scientific data, mineral/metal resource exploration and assessment along with energy and water resource assessments for the nation. The objectives are achieved through regional to detailed scale ground geological/geophysical/geochemical surveys, air-borne and marine surveys, mineral prospecting and investigations, multi-disciplinary and fundamental geoscientific research, geo-technical, geo-environmental and natural hazards studies, glaciology, polar studies, seismology and seismotectonic study, etc.

Geological Survey of India Training Institute (GSITI)

35. GSI has established Geological Survey of India Training Institute (GSITI) at Hyderabad, India, of international repute (https://training.gsiti.gsi.gov.in/). The objective is to promotes Training and Capacity Building by turning out thorough-bred professionals, specialists and fundamental researchers in all fields of Geosciences and allied areas both within the department and outside.

36. GSITI is also involved in providing several regular and advanced courses on specialized domains as per the requirement, sponsored by Indian Space Research Organization (ISRO), Ministry of External Affairs (MEA) etc. under Memorandum of Understanding (MOU). Apart from this, GSITI conducts Specialized and International Courses at its TI Headquarters / RTDs on region-specific

geo-scientific topics and need based capsule courses for earth scientists within and outside the department.

37. GSITI provides training on Remote Sensing, Digital Image Processing and Geographic Information System application for mineral exploration to the Indian Technical and Economic Cooperation (ITEC) Programme and its sister Special Commonwealth African Assistance Programme (SCAAP) of Ministry of External Affairs, Government of India, to the ITEC countries.

38. As per the directives of Ministry of Mines, GSITI has been playing a major role in conducting the BHUVISAMVAD programme as a platform to facilitate interaction among the GSI professionals, student / faculty of various universities / colleges in the country.

MINISTRY OF EARTH SCIENCES

39. It is mandated to provide the nation with best possible services in forecasting the monsoons and other weather/climate parameters, ocean state, earthquakes, tsunamis and other phenomena related to earth systems.

Indian National Centre for Ocean Information Services (INCOIS)

40. INCOIS is the central repository for marine geospatial data under Ministry of Earth Sciences (MoES) which plays a key role in providing ocean data, information and advisory services to society, industry, government and scientific communities through sustained ocean observations. *INCOIS has been recognized as the National Oceanographic Data Centre (NODC).* The observing network established by INCOIS receives data from in-situ and satellite ocean observation systems and generate data from the ocean models on various oceanographic and surface meteorological parameters in real/near real time as well as in delayed mode.

41. The data generated is translated into ocean information services through analysis and modelling and disseminated to users. National Oceanographic Data Centre of INCOIS, is recognized by the Intergovernmental Oceanographic Commission (IOC). The various geospatial data generated and available from INCOIS services and observations are: Potential Fishing Zone (PFZ) Advisory Service; Ocean State Forecast Service; Indian Tsunami Early Warning System; Storm Surge Early Warning Service; Coastal Vulnerability Index (CVI) Mapping and Coastal Multi-hazard Vulnerability Mapping (MHVM) etc.

Ministry of Electronics and Information Technology (MeiTY)

42. The mission of MeiTY is to promote e-Governance for empowering citizens through sustainable growth of Electronics, IT & ITeS industries enhancing efficiency through digital services and ensuring a secure cyber space. Its objectives include providing infrastructure and facilitating all the e-domains. National Informatics Centre (NIC) of the MeiTY is providing network backbone and e-Governance support to Central Government, State Governments, UT Administrations, Districts and other Government bodies.

43. It offers a wide range of ICT services including Nationwide Communication Network for decentralised planning, improvement in Government services and wider transparency of national and local Governments. NIC assists in implementing Information Technology Projects, in close collaboration with Central and State Governments, in the areas of (a) Centrally sponsored schemes and Central sector schemes, (b) State sector and State sponsored projects, and (c) District Administration sponsored projects. NIC endeavors to ensure that the latest technology in all areas of IT is available to its users.

Ministry of Statistics and Programme Implementation (MOSPI)

44. The Ministry of Statistics and Programme Implementation (MOSPI) focuses on the coverage and quality aspects of statistics released in the country. The statistics provided by the Ministry are based on scientific sampling methods and the data compiled follows standard statistical techniques, extensive scrutiny and supervision.

45. **Integration of statistical and geospatial information**: MoSPI has undertaken the task of integration of statistical and geospatial information in respect of several of its products in collaboration with SOI and NSDI. MoSPI is working for adding Geo Spatial layer on various MoSPI data in phased manner. Process of Integration of Statistical and Geospatial data for National Economic Census, National Family Health Survey (NFHS) and Annual survey of all higher education institutions has been initiated. Geo spatial layer on official statistics & socio-economic survey data will add visualization and easy interpretation of data by the user.

46. In addition to the above, there are many Ministries Exploiting the Geospatial data through various departments functioning under it. Some examples of such ministries include the **Ministry of Environment, Forest and Climate Change** which through Forest Survey of India (FSI) monitors the forest cover, National Urban Information System (NUIS) is a project of the **Ministry of Urban Development** in collaboration with Survey of India and National Remote Sensing Centre (NRSC).

Under the NUIS, geospatial thematic database (comprising of 12 layers) for 152 towns on 1: 10,000 scale and Aerial survey of 132 towns at 1: 2,000 scale have been developed for enabling formulation of Master Plans by state town planning departments. **Ministry of Agriculture** which through Indian Council of Agricultural research (ICAR) etc. monitors various aspects of agriculture.

47. Other than above national agencies, various State agencies as per Table 3 provide data content and services. Details of the various prominent institutes responsible for Geospatial innovation, research and development as well as Geospatial capacity building and education has been provided in the later section.

Table 3. State Geospatial Organizations
(Source: NSCS Report)

STATE/REGIONAL GEOSPATIAL AGENCIES	THEMES/ SECTOR
State Remote Sensing Application Centres	Remote Sensing Applications and Solutions Development
State Information Technology Department	IT infrastructure, Applications and Solutions Development
Regional Remote Sensing Centre	Remote Sensing Applications and Solutions Development

INDIAN GEOSPATIAL CAPABILITIES:

TECHNOLOGY, APPLICATION & SOLUTIONS

TECHNOLOGICAL CAPABILITIES

48. With various technological solutions at the core of India's vision, geospatial as an empowering technology has the potential to redefine paradigms for delivery of services. The government of India has laid out integrated programs for digital empowerment and economy, Smart Cities, Urban Development, Rail, Road, Water and Air Transport Infrastructure, Water and Irrigation, Health and Sanitation, Skill Development and Security and Safety Management to create a sustainable base for continuing the development in the future. Geospatial technology is aggressively helping in various sectors in India. The key to its usage lies in data acquisition and visualisation. The major sectors using geospatial technology in India are agriculture, telecommunications, oil & gas, environmental management, forestry, public safety, infrastructure, logistics etc.

The different aspects of technology and infrastructure as it affects the geospatial applications is discussed here below -

INDIAN GPS/GNSS SYSTEMS

49. Indian Regional Navigation Satellite System (IRNSS) is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area. An extended service area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East. IRNSS provides two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area. Some applications of IRNSS are, terrestrial, aerial and marine navigation, disaster management, vehicle tracking and fleet management, integration with mobile phones, precise timing, mapping and geodetic data capture, terrestrial navigation aid for hikers and travelers, visual and voice navigation for drivers.

INDIAN GEODETIC CAPABILITIES

50. The Survey of India (SOI), Government of India has undertaken various initiatives for modernization and upgradation of the Geodetic Infrastructure of the country. It has redefined, modernized and launched the beta version of the new Indian Vertical Datum (IVD2009) in year 2018 based on precise field gravity values, High precision levelling and decade long tidal observations along both the coasts of India in line with best practices prevalent in other leading countries of the world in the field of Geodesy.

51. The **Department** of Science and Technology (DST), Government of India has set up a "National Centre for Geodesy" (NCG) at Indian Institute of Technology, Kanpur. The main aim of this National Centre is to nucleate and strengthen activities in the area of Geodesy education and capacity building, carry out state-of-the-art R&D activities and to strengthen national/international collaboration in the field of Geodesy. The major objectives are as follows: (i) setting up of an International GNSS Service (IGS) Station at IIT Kanpur; (ii) establishment of three geodetic very long baseline interferometry (VLBI) stations in India; (iii) installation of a Doppler orbitography and radio-positioning by satellite (DORIS) station at IIT-Kanpur, which becomes one of the International DORIS service (IDS) stations, supporting geodetic, geophysical, and other research studies; (iv) Installing corner reflectors for improving interferometric synthetic aperture (InSAR) radar techniques used in crustal deformation studies; (v) setting up hydrological, seismic and weather sensors for atmospheric and climate change studies.

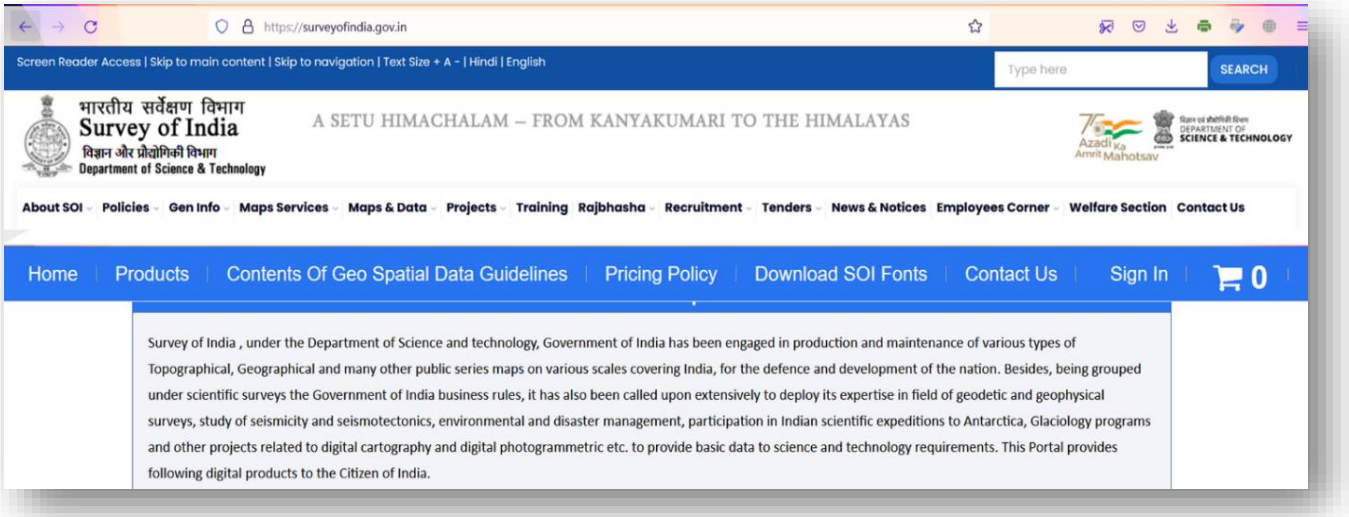
GEOPORTALS

52. Many Ministry/ Departments of Government of India have developed various Geo-portals for data sharing, services and strengthen the E-learning process). Brief description of the few is as follows:

Survey of India Online Maps Portal

https://onlinemaps.surveyofindia.gov.in/

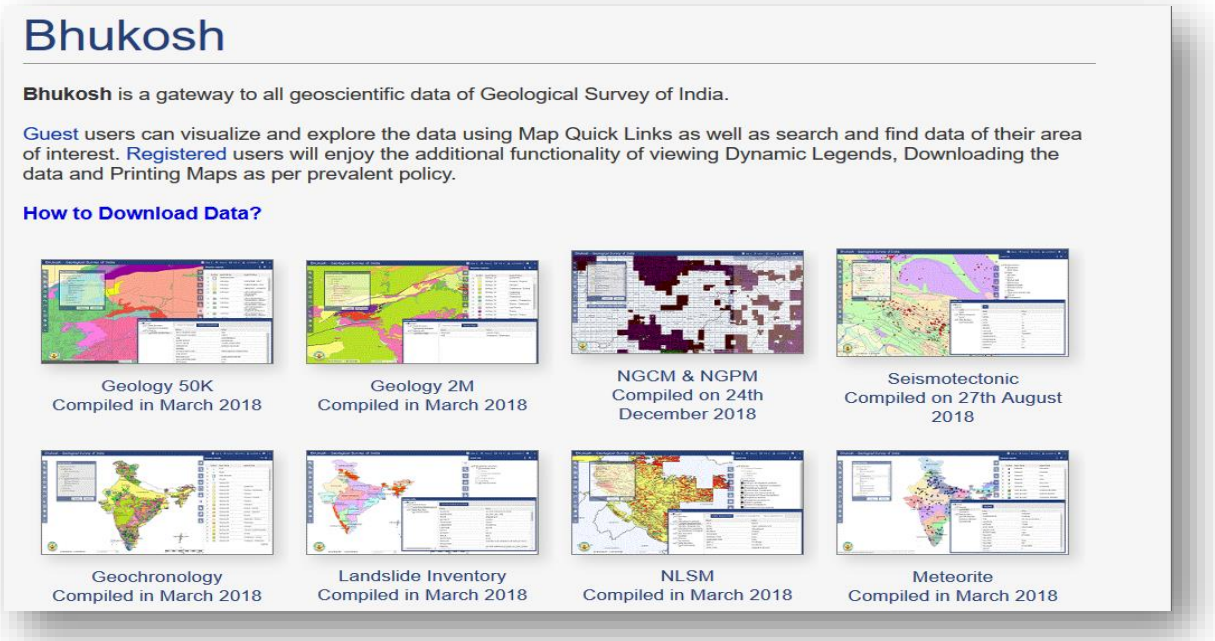
53. It is an online portal for providing the single window access for SoI Map Products and Digital datasets. Users can download various datasets and map products in various formats through this online portal.



GSI Maps Portal - Bhukosh

https://bhukosh.gsi.gov.in/Bhukosh/Public

54. **Bhukosh,** is an open-source geospatial web-portal and gateway to all geoscientific information of Geological Survey of India, MoM, GOI, where user can visualize, explore, search and download multi-thematic geospatial data from geological, geochemical and geophysical domain at different scales. Along with this, the portal also provides high resolution seismotectonics maps, seismic hazard micro-zonation maps and landslide inventory and hazard maps of the country.



BHARAT Maps

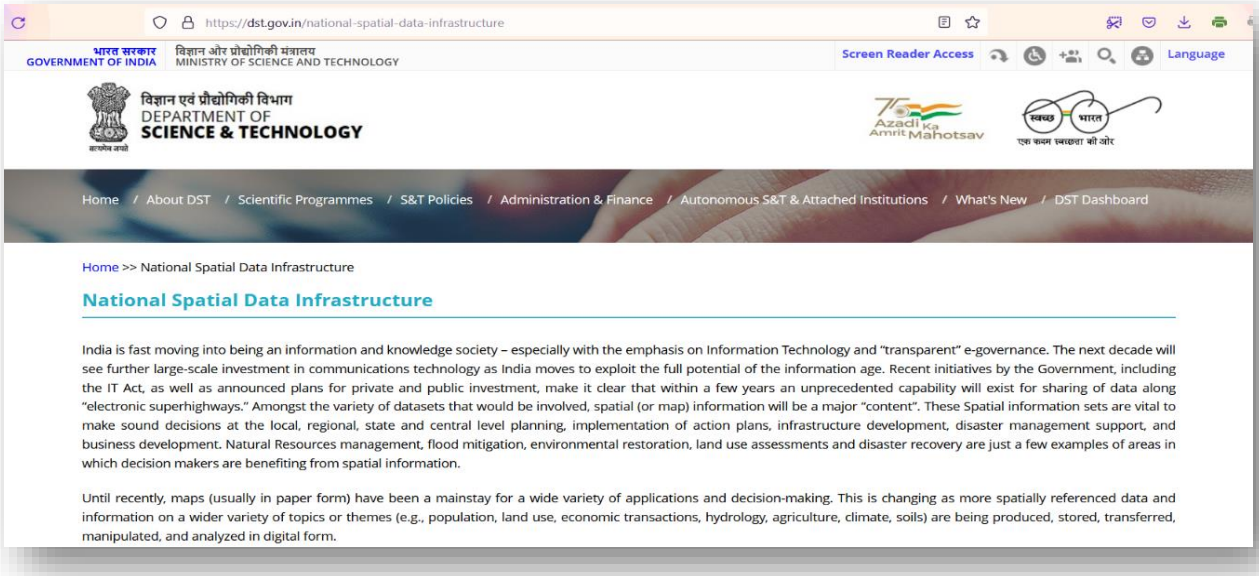
https://bharatmaps.gov.in

55. It is a Multi-Layer GIS Platform depicts core foundation data as "NIC MAPS", an integrated base map service using 1:50,000 scale reference data from Survey of India, ISRO, FSI, RGI and so on. This encompasses 23 layers containing administrative boundaries, transport layers such as roads & railways, forest layer, settlement locations etc., including terrain map services. NIC established RS & GIS Division, in 1996 to carry out innovative projects in the emerging areas of Geographical Information System and Remote Sensing.

India Geo portal

https://nsdiindia.gov.in/nsdi/nsdiportal/index.jsp

56. This is developed by NSDI has been increasingly making accessible the data holdings of various national agencies through interoperable geographic information services like Catalogue Service on Web (CSW), Web Map Service (WMS), Web Feature Service (WFS), and Web Processing Service (WPS). The metadata of the various States having State Geoportals have been also being linked to the Portal.

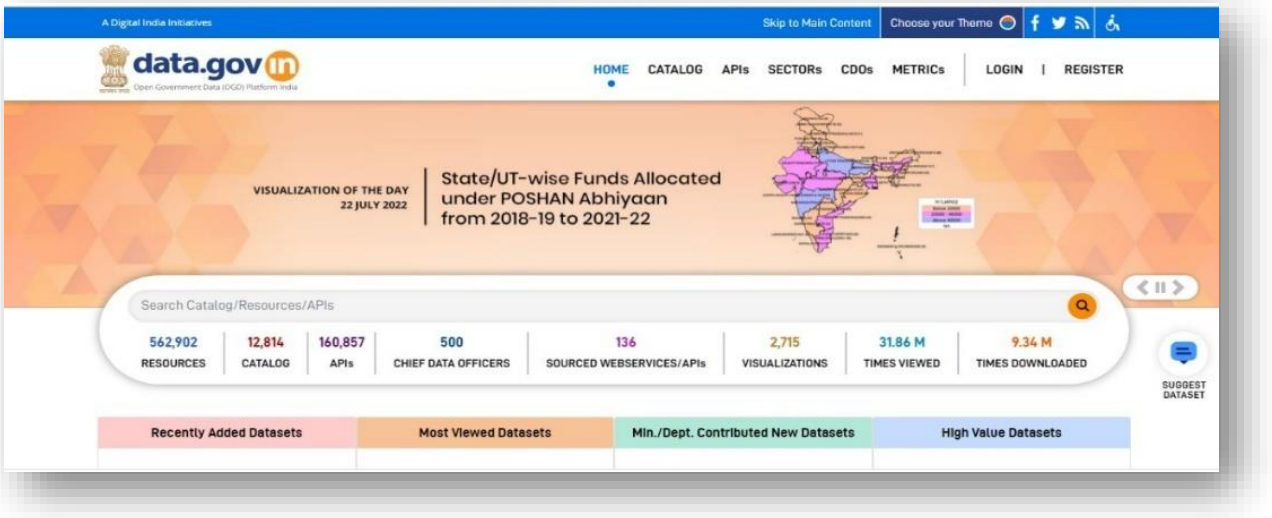


<u>BHOOMI Geo Portal</u>

https://www.bhoomigeoportal-nbsslup.in

57. It is developed by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP) which is maintained on the digital India platform by the name of soil information system maintained by National Centre of Geoinformatics In the Geo-portal Bhoomi the soil and site characteristics in terms of polygon, line and point data and administrative division of the country are arranged in systematic manner and the database structure is kept open to link cadastral boundary.

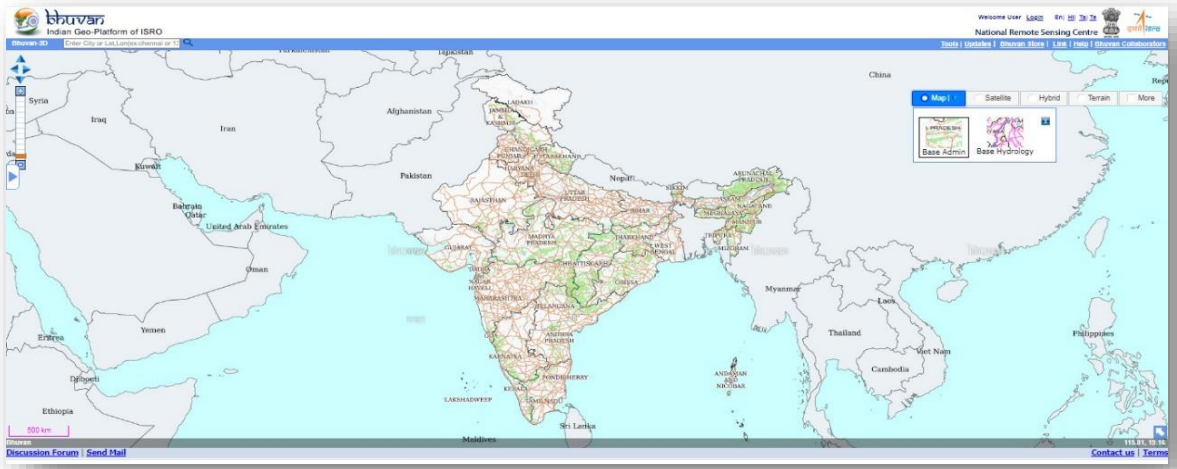
NEGD Portal

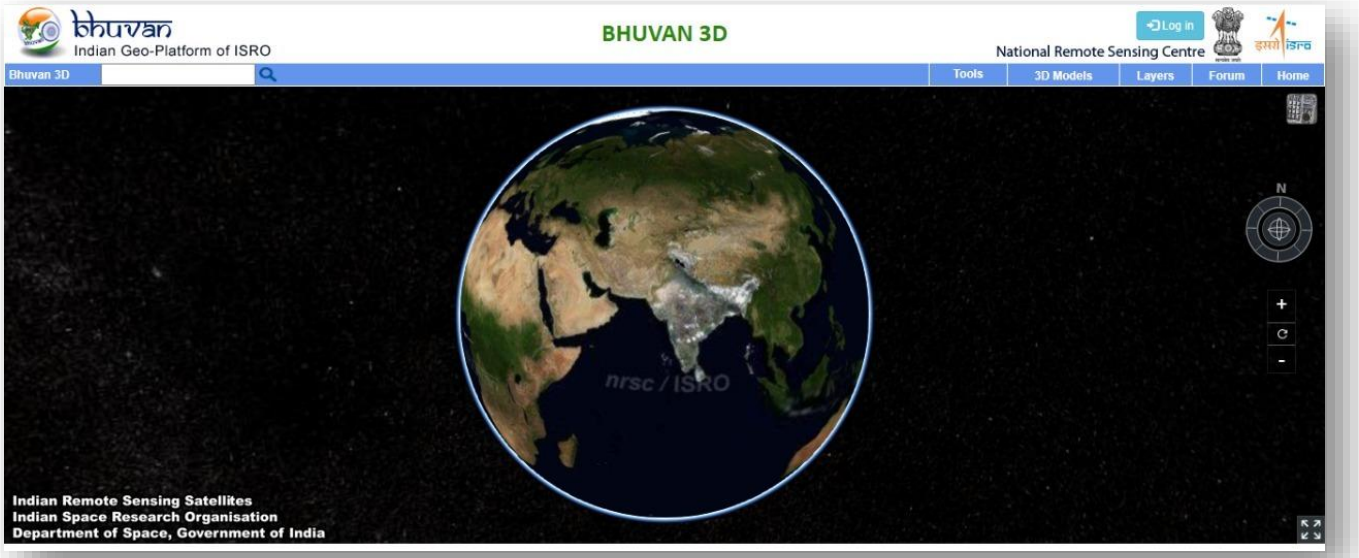


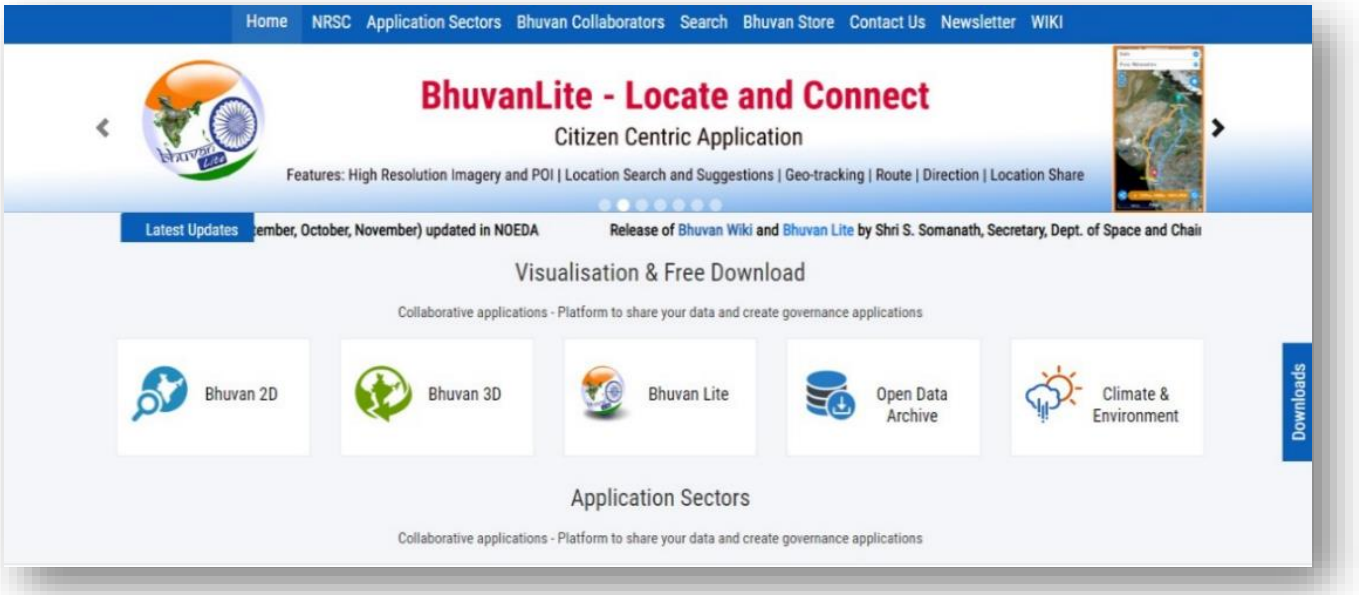
BHUVAN Web portal

https://bhuvan.nrsc.gov.in/bhuvan_links.php

58. NRSC-ISRO launched the beta version of its web-based GIS tool, Bhuvan. It evinces the Indian Earth Observation capabilities from the Indian Remote Sensing (IRS) series of satellites. It is an interactive versatile Earth-Browser which showcases multi-sensor, multi-platform and multi temporal images with capabilities to overlay thematic information, interpreted from such imagery as a vector layer, along with near real-time information from Automatic Weather Stations (AWS), Potential Fishing Zone (PFZ) information, disaster support related information like forest fire alerts, periodic agricultural drought assessment etc.





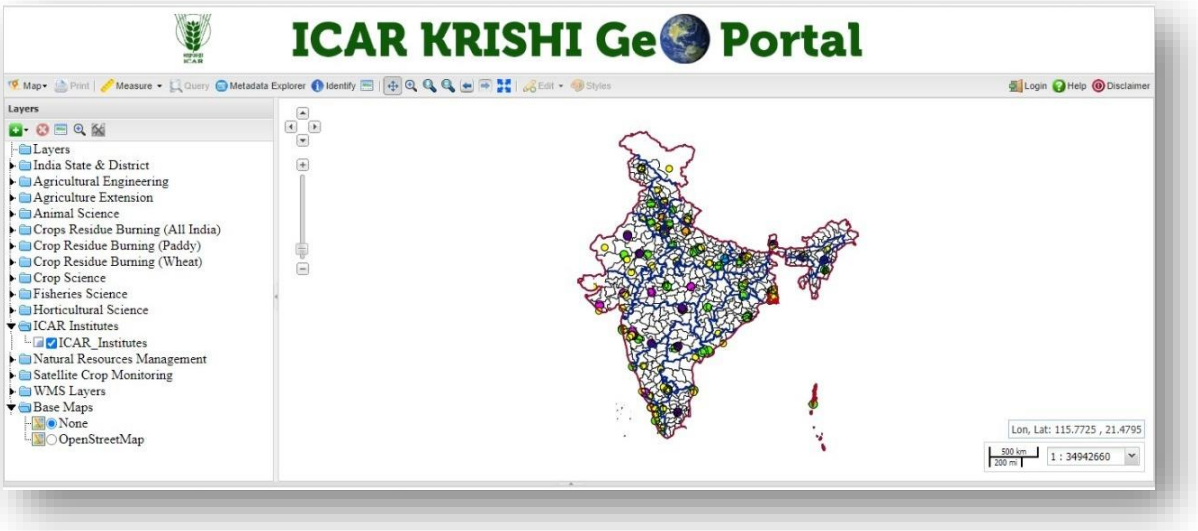


KRISHI Geo Portal

https://krishi.icar.gov.in

59. It is Knowledge based Resources Information Systems Hub for Innovations in agriculture, is an initiative of Indian Council of Agricultural Research (ICAR) to bring its knowledge resources to all stakeholders at one place. It is being developed as a centralized data repository system of ICAR

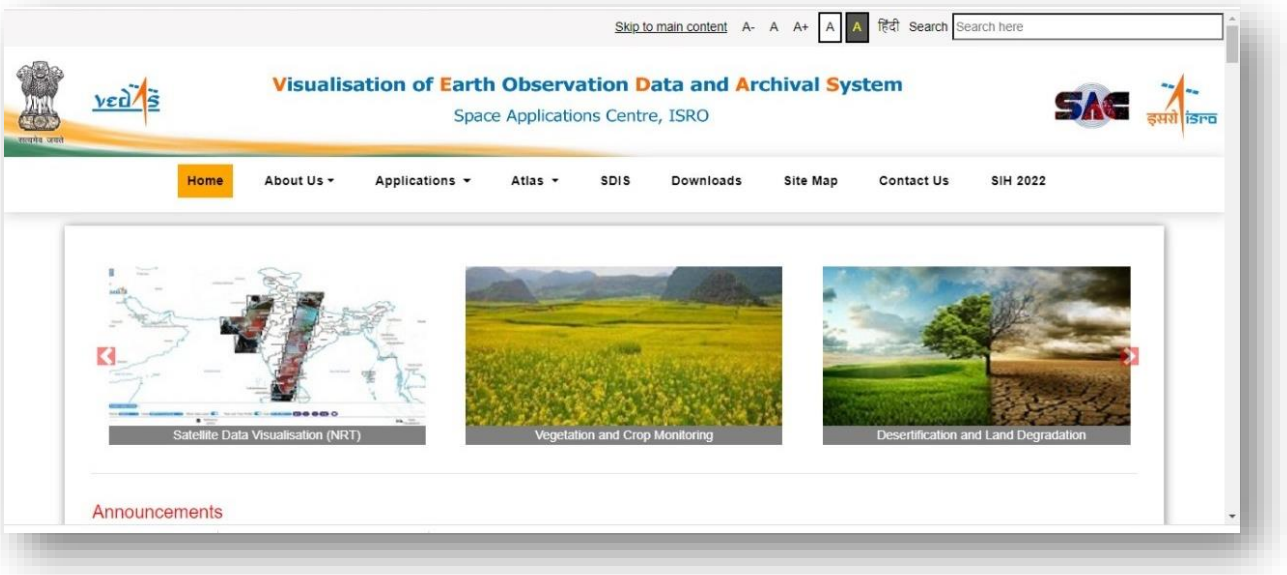
consisting of Technology, Data generated through Experiments/ Surveys/ Observational studies, Geo-spatial data, Publications, Learning Resources.

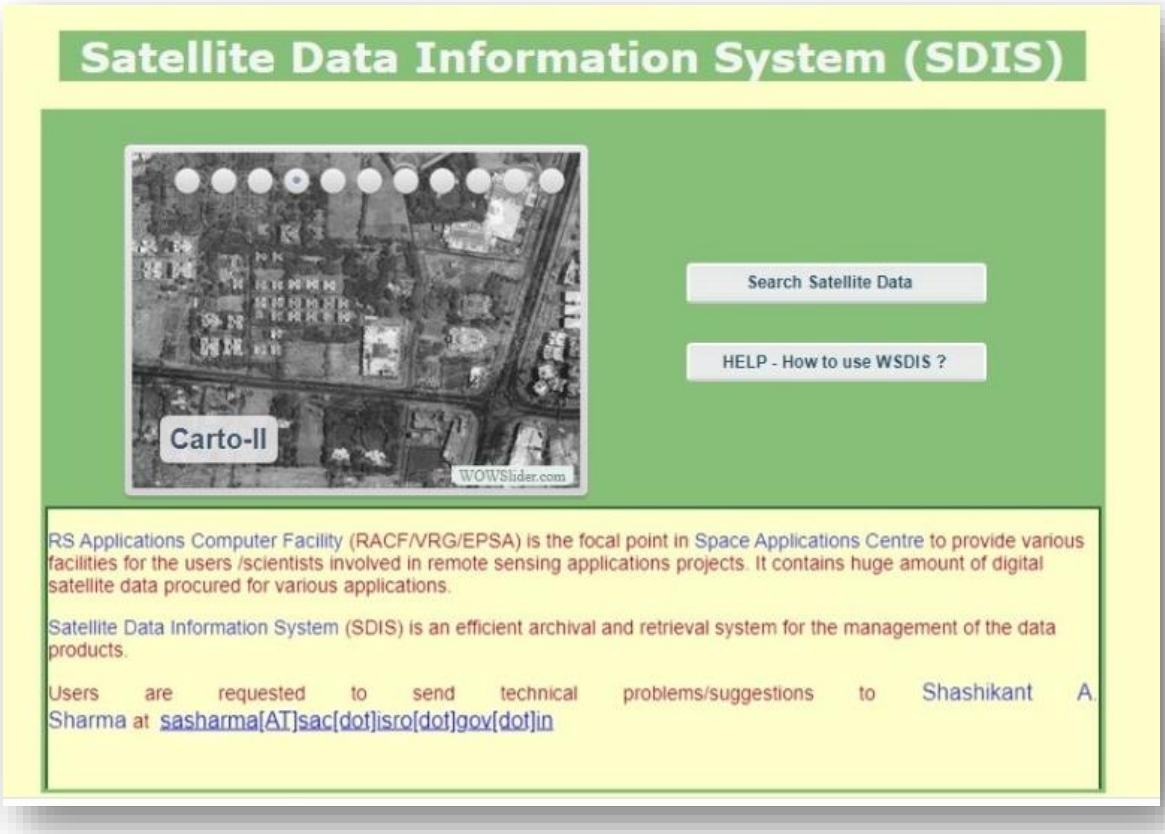


<u>VEDAS-Visualization of Earth observation Data and Archival System</u>

https://vedas.sac.gov.in

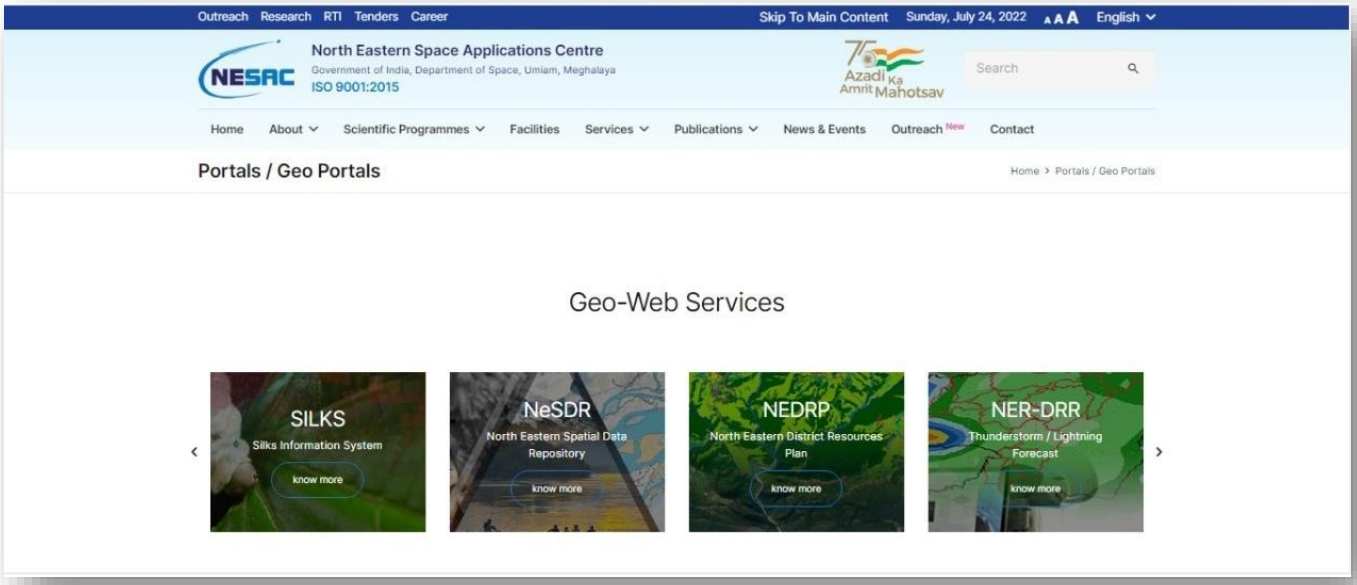
60. This is developed by ISRO. VEDAS is an online geo processing platform using optical, microwave, thermal and hyper spectral EO data covering applications particularly meant for academia, research and problem solving. It also offers Mobile Applications particularly Solar and Wind Calculator.





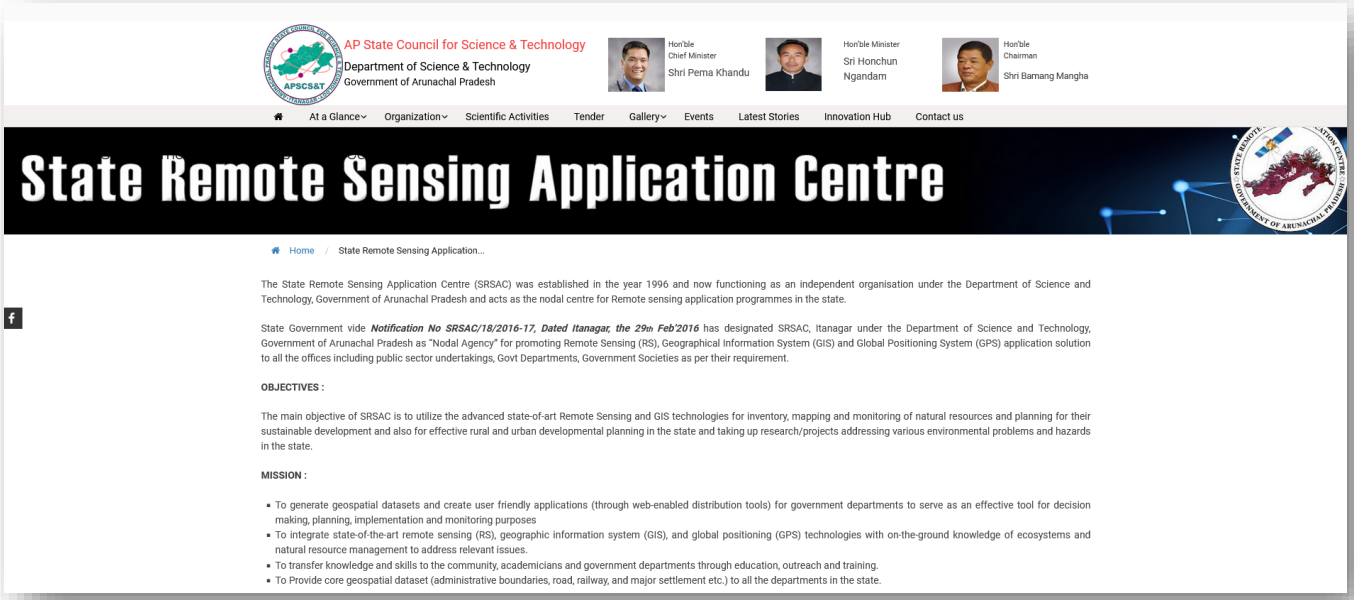
STATE GEOPORTALS / REMOTE SENSING CENTRES

North-Eastern Space Application Centre



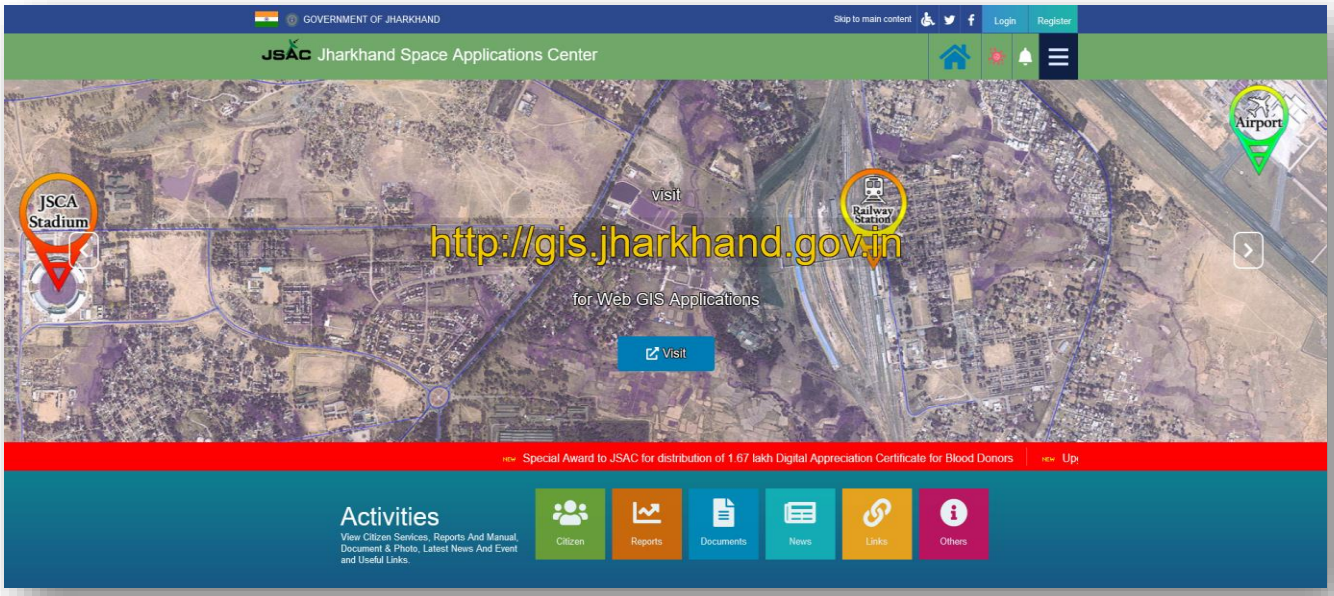
Arunachal Pradesh remote sensing centre

http://ardst.arunachal.gov.in/state-remote-sensoring-application-center/



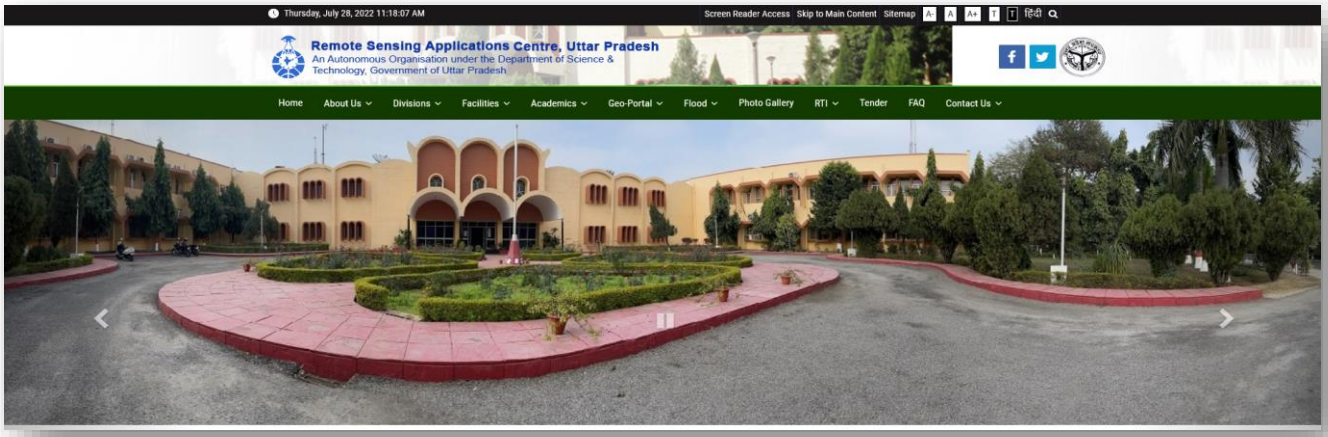
Jharkhand Space Applications Center (JSAC)

https://jsac.jharkhand.gov.in/



Uttar Pradesh Remote Sensing Applications Centre

https://rsac.up.gov.in/

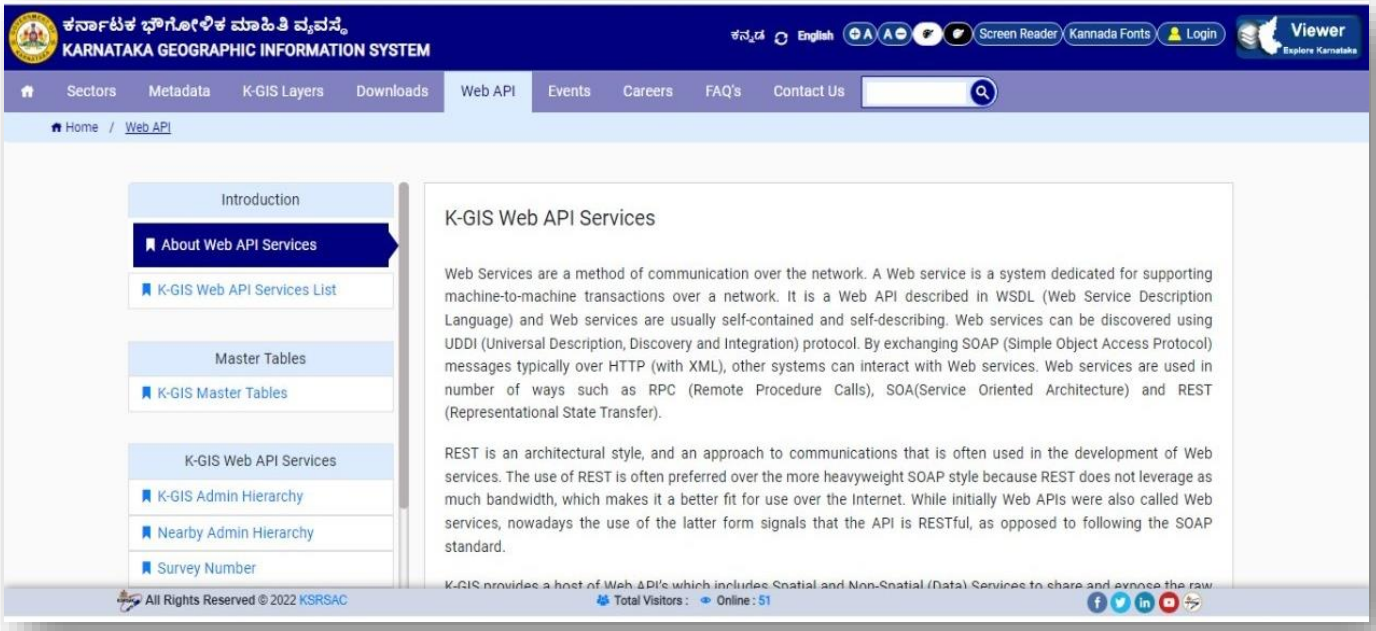


Punjab Remote Sensing Centre

https://prsc.gov.in/

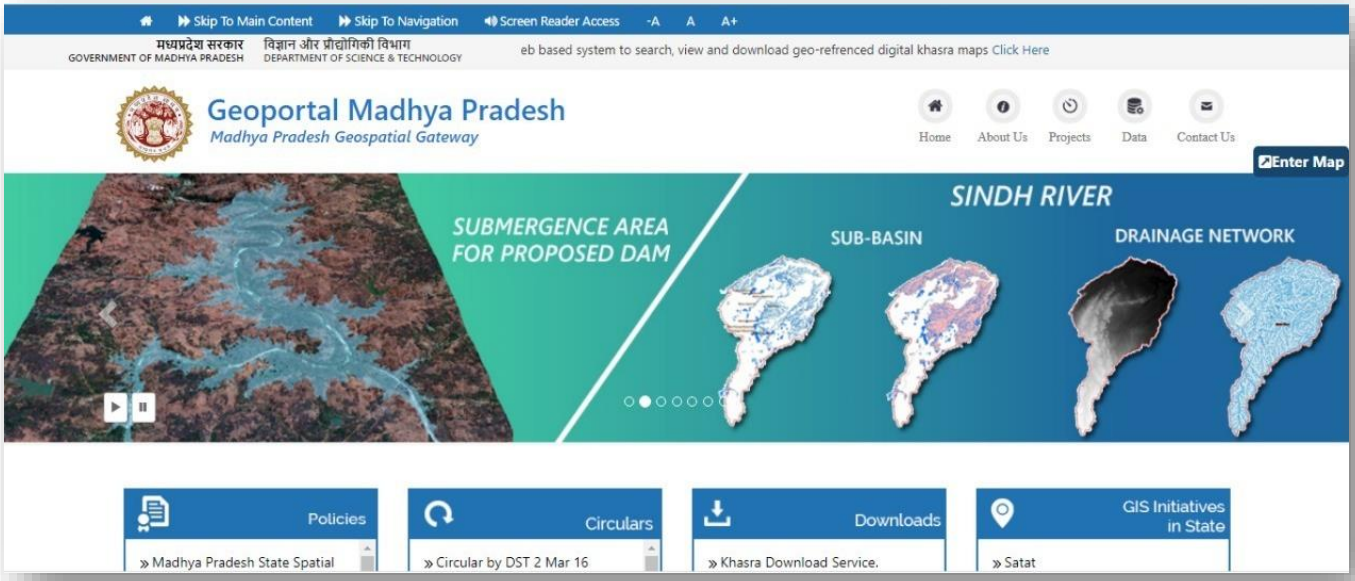
Karnataka Geographic Information System

https://kgis.ksrsac.in/kgis/aboutkgis.aspx



Maharashtra Remote Sensing Application Centre

Geoportal Madhya Pradesh



Odisha Geospatial Portal

https://gisodisha.nic.in/

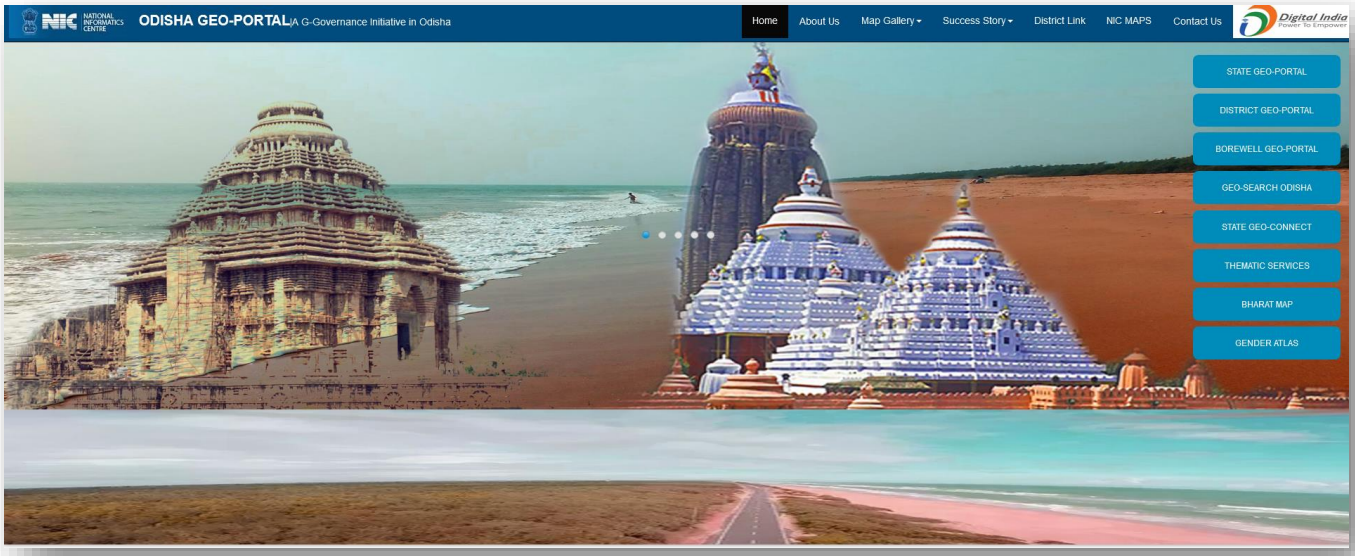


Table 4. Geospatial Portals

GEOSPATIAL ACTIVITY	WEB REFERENCE	BRIEF OVERVIEW
INDIA-PORTAL	https://www.india.gov.in/	National Portal of India provides a single-window access to information and services that are electronically delivered from all Government Departments in India.
SURVEY OF INDIA TOPOGRAPHICAL MAPS	https://onlinemaps.surveyofindia.gov.in/	SoI Online Map Portal provides the online access to Digital Map & Products of Survey of India
ISRO-BHUVAN	https://bhuvan.nrsc.gov.in/home/index.php	BHUVAN - Geo Portal Developed by ISRO. BHUVAN, also called the Indian version of Google Maps, is a multi-purpose end-user satellite application platform. This software application allows the users to explore a 2D/3D representation of the surface of the Earth.
SDG INDIA DASHBOARD	https://sdgindiaindex.niti.gov.in/#/	SDG INDIA Dashboard and Index with state wise and index wise reports and data
OPEN GOVT DATA (OGD) PLATFORM INDIA	https://data.gov.in/	OGD Community Portal will help you to brainstorm ideas based on your interest. Keep visiting the section for Visualizations, Blog Posts, Infographics and updates in the Community section. You can also contribute your Visualizations, Blog Posts and Infographics.
NIC BHARAT MAPS	https://bharatmaps.gov.in/	Multi-Layer GIS Platform providing integrated base map service encompass 23 layers containing administrative boundaries, transport

GEOSPATIAL ACTIVITY	WEB REFERENCE	BRIEF OVERVIEW
		layers (roads & railways), forest layer, settlement locations, including terrain map services.
GSI-BHUKOSH	https://bhukosh.gsi.gov.in/Bhukosh/Public	Bhukosh is gateway to all geoscientific gateway to Geological Survey of India
ISRO-IIRS PORTAL	https://www.iirs.gov.in/	The Indian Institute of Remote Sensing (IIRS) is a key player for training and capacity building in geospatial technology and its applications through training, education and research in Southeast Asia. This portal provides all details and access to their services.
NATMO-THEMATIC MAPS PORTAL	https://geoportal.natmo.gov.in/	National Atlas and Thematic Mapping Organisation is a specialized institution of its kind in the world. It carries out thematic cartography and geographical research at national level. This portal provides access to NATMO Products and services.
INDIA-PORTAL	https://www.india.gov.in/	National Portal of India provides a single-window access to information and services that are electronically delivered from all Government Departments, ...
CENSUS INDIA-PORTAL	https://censusindia.gov.in/census.website/	The Indian Census data repository is the largest single source of various statistical information on demography, economics, anthropology, sociology, statistics and many other disciplines updated on decadal basis.
NDR-HYDROCARBON	https://www.ndrdgh.gov.in/NDR/	National Data Repository (NDR) is a government-sponsored E&P data bank with state-of-the-art facilities and infrastructure for preservation,

GEOSPATIAL ACTIVITY	WEB REFERENCE	BRIEF OVERVIEW
		upkeep and dissemination of data to enable its systematic use for future exploration and development.
INDIA-WRIS PORTAL	https://indiawris.gov.in/wris/#/	India Water Rater Resources Information System (India-WRIS) provides details and access to make non-sensitive data collected through the use of public funds available for legitimate use, enabling better decision making and meeting society's needs.
BHOOMI-GEOPORTAL	http://www.bhoomigeoportal-nbsslup.in/	A Gateway to Soil Geodatabse of india by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)
INDIA BIO-DIVERSITY PORTAL	https://indiabiodiversity.org/map?layers=	Provides access to Indian Biodiversity Repository and maps.
SVAMITVA SCHEME	https://svamitva.nic.in/svamitva/	SVAMITVA Scheme is a reformative step towards establishment of clear ownership of property in rural inhabited (Abadi) areas, by mapping of land parcels using drone technology.
KERALA GEOPORTAL	https://opensdi.kerala.gov.in/	The Kerala State Spatial Data Infrastructure (KSDI) facilitates users of the system to share and explore data related to political and administrative boundaries, natural resources, transportation and infrastructure, demography, agro and socio economy etc. of the state.
KARNATAKA GEOPORTAL	https://www.kscst.org.in/kssdi.html#About%	Karnataka State Spatial Data Infrastructure (KSSDI) was awarded Geospatial Excellence Award for the year 2014 for establishing a citizen

GEOSPATIAL ACTIVITY	WEB REFERENCE	BRIEF OVERVIEW
	20Karnataka%20Geo portal	centric KSSDI portal and for effectively disseminating geospatial information to all users.
MAPMYINDIA PORTAL	https://www.mapmyindia.com/	Indian company geoportal providing various map and location services and products
KRISHI-GEO-PORTAL	https://krishi.icar.gov.in/Geo_Portal.jsp	Indian Council for Agricultural Research Agricultural Knowledge Resources and Information including geo data layers
NESAC-GEO WEB SERVICES	https://nesac.gov.in/portals-geo-portals/	Provides operational remote sensing and GIS aided natural resource information base to support activities on development / management of natural resources and infrastructure planning in the North Eastern region of the India.
MAHARASHTRA-GEO PORTAL	http://mrsac.maharashtra.gov.in/geoportal/	Gateway to the spatial resources and services offered by state of Maharashtra.
ODHISA-GEOSPATIAL PORTAL	https://odisha4kgeo.in/	Odisha 4k Geo portal provides availability of data sharing framework; Standardized, Structured & Updated Geo-spatial Data infrastructure for seamless integration of data of multiple-sources; Standard mechanism for ensuring Data integrity. Technology for dynamically updating of real-time data and live feeds and finally Geo-coordinated location-based data and GIS-based Maps for effective Decision Support.
GEOPORTAL MADHYA PRADESH	https://geoportal.mp.gov.in/geoportal/	State SDI gateway to facilitate creation of multipurpose integrated map data for user departments, including department specific assets, for gap

GEOSPATIAL ACTIVITY	WEB REFERENCE	BRIEF OVERVIEW
		identification and further infrastructure development planning, to develop map-based decision support systems for better informed decision making by state departments
RAJDHARA-PORTAL	https://gis.rajasthan.gov.in/	Rajdharaa Geo Portal is gateway of spatial data being generated by various agencies of the Government of Rajasthan. It would provide a single window service to citizens to increase the efficiency and productivity of all departmental agencies such as Medical & Health, Police, Utilities, Power, Commercial Taxes, Water Resources, Education, Forestry, Agriculture, Urban Development etc.

GEOSPATIAL APPLICATIONS AND SOLUTIONS

Sector-wise Applications

61. A large number of geospatial applications have been carried out in different sectors through various e-Governance projects. Detail of the major initiatives is as follows:

62. **Urban Planning** Following initiatives have been initiated for mapping urban areas, smart cities development and infrastructure development. Examples are

(a) **Pradhan Mantri Awas Yojana**

(b) **Atal Mission**. GIS based Master plan development of 500 cities (Scale -1:4000) under Atal Mission for rejuvenation and urban transformation.

(c) **Smart Cities**. Setting up GIS infrastructure to drive urban transformation initiatives. Smart cities that integrate citizens and other city department stakeholders e.g. Smart City Bhubaneswar, Smart City Bhopal, MCGM (Municipal Corporation of Greater Mumbai).

(d) **City Master Plan**. Digitization of city planning through developing GIS based master plans and mapping the water utility network eg. Master Plan of all mega cities.

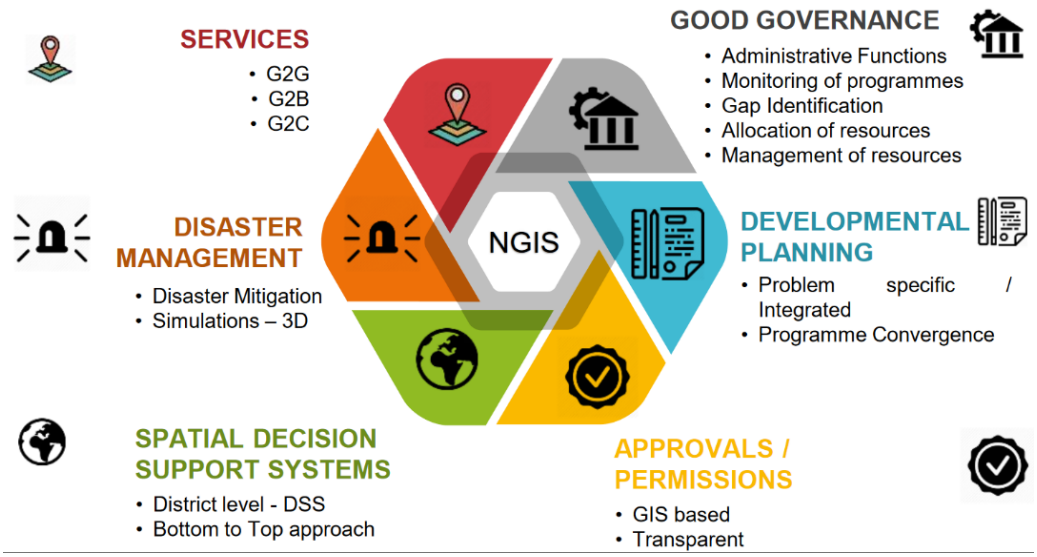


Figure 8. Geospatial Technology, Solutions and Services ecosystem
Source: https://negd.gov.in/sites/default/files/NCoG-TusharJan2019.pdf)

Agriculture

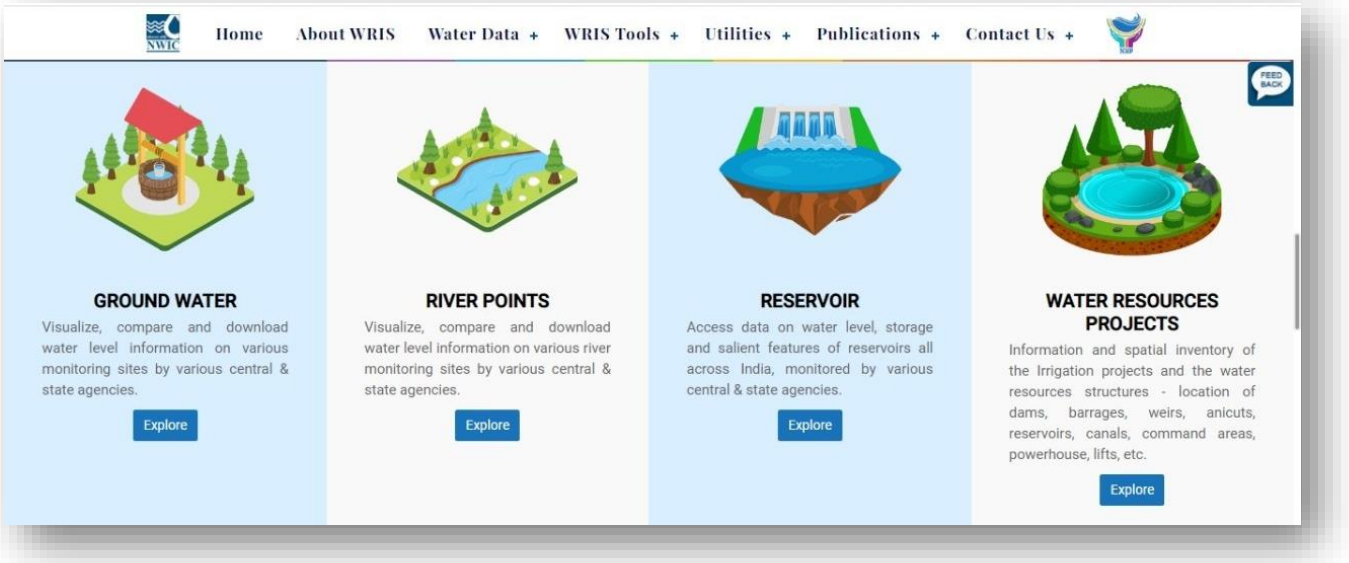
63. Agriculture is a priority area for the Government. Various e-governance projects involving GIS are oriented towards watershed-based development for crop irrigation, soil and water conservation etc.

(a) Integrated watershed Management Plan (ISRO and Ministry of Rural Development.
(b) Accelerated Irrigation Benefit Program (ISRO-Ministry of Water & CWC).
(c) Horticulture Assessment and Management using geo-information (ISRO and Ministry of Agriculture.

64. Other than above, Geospatial is extensively being used in Agriculture insurance. Farmers suffer when their crops are destroyed due to flooding, draught or other reasons. Geospatial is helping insurance companies in assessment of the damage to crops, and faster and accurate processing of insurance claims.

Water

65. GIS is an integral part of various water sector initiatives, from the perspective of not only planning the network from 'source to Tap' but also being effectively used for water resources management and Clean Ganga Mission. Establishing of GIS based state level water data centres for all water management (consolidated at national level) – watershed management, aquifer mapping, surface and ground water management.



Climate Change and Disaster Management

66. Climate change is one of the key focus areas of the United Nations' Sustainable Development Goals (SDGs). India has employed Geospatial technology for improved environment understanding, strategic decision making, monitoring of climate change and ascertaining future risks. As Geospatial optimizes planning, analyses and increases preparedness against calamities such as floods, landslides, earthquakes and so on, the National Disaster Management Authority (NDMA) has specially focused on Geospatial technologies. In 2019, GIS was extensively used in emergency preparedness for cyclone Fani which helped save many lives. During Kerala floods, Geospatial was used extensively for post-disaster recovery, relief and rehabilitation efforts.

Transportation

67. Transportation infrastructure is leading in the utilization of GIS across major initiative viz. Railways is using GIS for national level asset management and drone based surveys for mapping the infrastructure & assets**,** Road expansion, project monitoring and planning new connectivity as a part of Bharatmala project; including development of border roads**;** Modernization of ports, connectivity, land asset management and monetization and improving port efficiency and handing capacities as a part of Sagarmala project of Government of India.

Rural Development

68. GIS is extensively being used in following government initiatives to address the rural development. These initiatives aim at generating employment and socio-economic development of the area by creating/ monitoring infrastructures & assets in rural area of India and providing services for amenities.

(a) Monitoring Rural Development Program by (ISRO and Ministry of Rural Development) (implementing Pradhan Mantri Gram Sadak Yojna, MNREGA, Indira Awas Yojna etc).

(b) Space based Information Support for Decentralized Planning (ISRO - Ministry of Panchayati Raj).

(c) Tribal development program (by ISRO and Ministry of Tribal Affair) in synchronization with MNREGA.

Homeland Security

69. M P Council of Science & Technology (MPCST) and GRP is developing web GIS based applications for quick and effective crime investigation. It includes several modules such as Call Detail Records (CDR) analysis, Visitor Location Register (VLR) analysis, geo-tagged mapping of temporary hiding places of criminals along with the photographs of these places and attributes, digitization of criminal records of notified criminals and geotagging of their known residences along with ground photographs, passenger reservation dump data analysis, mapping of railway tracks, stations etc. All these tools are integrated onto a single platform known as Crime Investigation System.

70. Infrastructure **-** Land is one of the most important factors in economic development today and must be managed well to enhance socioeconomic conditions of communities. In this part geo-informatics, ICT and space technology inputs have been used to create the Web-GIS based Odisha Land Bank for industrial development, and compensatory afforestation is elaborated. High resolution ortho-images, geo-referenced digital cadastral datasets. The system is of great use to state decision makers and being extensively used by officials of state besides, industry, academia and public.

Gati-Shakti Project

71. National Master Plan for Multi-modal Connectivity, essentially a digital platform to bring 16 Ministries including Railways and Roadways together for integrated planning and coordinated implementation of infrastructure connectivity projects. The multi-modal connectivity will provide integrated and seamless connectivity for movement of people, goods and services from one mode of transport to another. It will facilitate the last mile connectivity of infrastructure and also reduce travel time for people.

Health Sector

72. In various Government initiatives such as Ayushman Bharat and Pradhan Mantri Jan Arogya Abhiyan, Geospatial technologies are supporting these programs for effective implementation. Geospatial is also helping in identifying the underserved locations for establishing the health and wellness centres and tracking the effectiveness of various initiatives such as child immunisations, management, control and pre-emptive steps taken to contain vector-borne diseases such as dengue and malaria.

Citizen Services

73. Many initiaves are oriented towards identifying gap areas and providing ease of service. Recent thrust towards digital India and digital economy has surged the demand of satellite internet services.

(a) Automated Warnings at Unmanned Level Crossings by ISRO & Indian railways.

(b) Paperless Tickets for Mumbai Suburban Railway (by ISRO & Western Railway).

(c) Geo-spatial inventory of Post offices (by ISRO and Ministry of Communication).

GEOSPATIAL SOLUTION FOR ADDRESSING COVID-19 CRISIS

74. In India, various government agencies like National Disaster Management Authority (NDMA) and remote sensing/disaster management departments/district magistrates in states like – UP, Jharkhand, Odisha, Karnataka, Maharashtra, Manipur have been utilizing GIS technologies to manage the pandemic.

75. In the context of COVID-19, agencies are integrating data from multiple sources for operational intelligence.

Mobile Application: Aarogya Setu

76. It has been developed by the Government of India for real time tracking of COVID-19 infected patients. The App is being used in contact tracing of the suspected COVID-19 cases, reducing time and error in manual identification, helping the Government to take necessary timely steps for assessing risk of spread of COVID-19 infection, and ensuring isolation where required.

77. **NDMA (National Disaster Management Authority)** has developed a dashboard that helps in keeping the track of the number of cases of COVID-19 reported in the country. The dashboard showcases the total number of cases reported in India as well as the world. It also brings the number of cases reported and the ones that resulted in the death of the patient.

78. **National Research Development Corporation (NRDC)**. A Govt. of India Enterprise has been supporting the development of Digital and Molecular Surveillance platform, which is crucial to detect the genetic sequencing of the virus which can be used to develop the vaccine to treat and

possibly mitigate COVID-19. The digital surveillance data will help to trace the recent movements of infected patients and establish virus transmission chains.

79. Real-time data APIs from expert organisations and government bodies such as World Health Organisation (WHO) and Centres for Disease Control & Prevention (CDCP) are being integrated for a global perspective of the pandemic. National Centre for Disease Control (NCDC), an institute established to function as a national centre of excellence for control of communicable diseases by Ministry of Health and Family Welfare is providing the authoritative data via APIs.

GEOSPATIAL INNOVATION, RESEARCH AND DEVELOPMENT

80. Geospatial domain entails a lot of research and development work both at scientific and applied levels in various application areas such as ecology and environment. The key geospatial Programmes/research institutes in the country in addition to academic institutions have been established to advance knowledge base in designated functional and strategic areas by their respective Ministries or departments.

NATIONAL GEOSPATIAL PROGRAMME (EARLIER NRDMS).

81. Natural Resources Data Management System (NRDMS) programme was initiated in 1982 by the Department of Science and Technology, Government of India as a multi-disciplinary and multi-institutional R&D programme. Vision of the NRDMS programme is enabling people, communities and institutions of local-self Governance with requisite databases and S&T tools for informed participation in local self-governance. Under the programme, other than establishment of NRDMS Geospatial data centers in 30 Districts of Karnataka, 17 Districts of West Bengal, and 13 Districts of Uttarakhand, huge number of extramural research and development projects have been supported in different aspects of Geo-Information management. Many e-governance solutions such as Health Geographic Information Science (HGIS), Village Information System (VIS) and Revival of Village Ponds etc are an outcome of this programme. Considering the changed importance and relevance of the “Natural Resources Data Management System (NRDMS)” in evolving National Geospatial Ecosystem, NRDMS has now evolved into National Geospatial Programme.

SPONSORED RESEARCH (RESPOND) PROGRAMME

82. Space Research Organization (ISRO) of Department of Space has evolved a dedicated program RESPOND, through which financial support is provided for conducting research and development activities related to Space Science in India since 1970. ISRO has also set up Space Technology Cells at premiere institutions like IITs, IISc, and Joint Research Program with University of Pune (UoP) to carry out research activities.

SPACE APPLICATIONS CENTRE (SAC)

83. Built in 1966, Space Applications Centre (SAC), is a major research and development center of the Indian Space Research Organization (ISRO). The core competence of the centre lies in development of space borne and air borne instruments/payloads and their applications for national development and societal benefits. These applications are in diverse areas and primarily meet the communication, navigation and remote sensing needs of the country. Besides these, the centre also contributes significantly in scientific and planetary missions of ISRO like Chandrayan-1, Mars Orbiter Mission etc.

84. SAC designs and develops the optical and microware sensors for the satellites, signal and image processing software, GIS software and many applications for Earth Observation (EO) programme of ISRO. These applications are in diverse areas of Geosciences, Agriculture, Environment and Climate Change, Physical Oceanography, Biological Oceanography, Atmosphere, Cryosphere, Hydrosphere etc.

85. The facilities at SAC includes highly sophisticated payload integration laboratories, electronic and mechanical fabrication facilities, environmental test facilities, systems reliability/assurance group, image processing and analysis facilities, project management support group and a well-stocked library. SAC has active collaborations with industry, academia, national and international institutes for research and development. The **list of other major** research institutions of Government of India listed in Table 5.

86. **Some** prominent **R&D centers.** Specific geospatial R&D activities are also being undertaken by many centers in Universities, National Institutes and other government departments viz. Anna University, Bharatidasan University, Jawaharlal Nehru Technological University, Department of Computer Science and Engineering of IIT Kharagpur, IIT Bombay, Departments of Civil Engineering of IIT Roorkhee, IIT Kanpur, IIT Delhi; Department of Ocean Engineering-IIT Madras; Indian Institute of Information Technology, Hyderabad, Geospatial lab-Indian Institute for Human Settlements, National Geophysical Research Institute (NGRI)- Hyderabad; National Bureau of Soil Survey and Land Use planning, Indian Agricultural Research Institute etc.

Table 5. List of major Research Institutions of Government of India conducting GIS research (Source: Geospatial Economy Report-2018 & others)

INSTITUTIONS	FOCUS AREAS
National Institute of Hydrography, Goa	• Geospatial Research for Hydrology
National Institute of Hydrology, Roorkee	• Key aspects of hydrology and water resources using remote sensing and GIS techniques
Govind Ballabh Pant Institute of Himalayan Environment and Development	• Remote sensing and GIS lab for watershed process, agriculture, socio-economic etc.
Wadia Institute of Himalayan Geology, Dehradun	• Study of geology of Himalayas, geomorphology and environmental geology
Indian Institute of Geomagnetism (IIG), Navi Mumbai	• Scientific research in geomagnetism and allied areas
National Academy of Sciences (NASI), Allahabad	• Research studies on thematic mapping, remote sensing and GIS
Indian Institute of Space Science and Technology (IIST)	• Developing future technologies and applications for space research
National Institute of Rock Mechanics (NIRM)	• Basic and applied research- use of GIS and remote sensing for surveying, 3D modelling, etc.
Central Mine Planning and Design Institute (CMPDI)	• Geomatics division for remote sensing, GIS, GPS, digital photo-grammetry, LiDAR, etc. • Geological Studies • Mine planning and designing- inclusive of field tests or laboratory analyses, engineering planning and designing

GEOSPATIAL EDUCATION, TRAINING AND CAPACITY BUILDING

87. In India's recent journey of sustainable economic growth, knowledge has been identified as one of the key drivers. In this odyssey, India has adopted a new information regime through its 'Digital India' program to support good governance, sustainable development goals and empowerment of its citizens. The challenges of this developmental path are inclusiveness, transparency, efficiency and productivity while balancing economic growth and sustainable development. Over the last three decades, geospatial technologies have proven to be an effective enabler to meet these challenges.

88. In India's evolving geospatial ecosystem, the current focus in on improving the publicness in the provision of geospatial data and information through institutional strengthening for enhancing the performance of organizations. In this context, developing technical capacity at the individual level, remains the key factor for the success of this change process.

89. The process of capacity building in India has accelerated over the last two decades. This has been primarily driven through the development of new policies, ICT infrastructure, availability of data and adoption of geospatial technologies by the public and private sector, academia, research institutions as well as communities Capacity development can be considered at three levels, the individual, institutional, and the systemic. Interactions between these levels are also important to improve the overall capacity. Therefore, capacity building program whether conducted as a short-term endeavor or as a long-term exercise, it is required to address all these three areas; individual, institutional, systematic, to make the outcome successful. All of these three levels have been addressed in India.

90. The proliferation of location-based services even at the enterprise and community level has also been another key driver. Demonstration of economic and social benefits of adoption of geospatial technologies has also enabled quick adoption of this technology by new groups of users and decision makers. This in turn has furthered the development of individual as well as institutional capacity building programs across the country.

91. The report of the National Geospatial Taskforce of the Ministry of Education (erstwhile Ministry of Human Resource Development), Government of India outlines the need for geospatial experts at three levels in a pyramid. The base or the first level being skilled workforce for mapping, ground data collection, GIS operations etc., the second level being technical geospatial professionals having technical knowledge of data processing, analysis, etc., and the top of the pyramid being geospatial experts who have the requisite qualification and expertise in conceptualizing and implementing projects. The development of capacity building programs has been driven largely by the above two drivers and has been addressed at various level as highlighted in the report through various long terms and short-term programs for diverse groups.

92. The government policies on g-governance have led to the development of a plethora of awareness /orientation programs of the adoption of geospatial technologies for diverse groups ranging from staff of the state and central government, education and research institutions and school children as well as the communities at large.

AWARENESS AND OUTREACH PROGRAMMES AT SCHOOLS

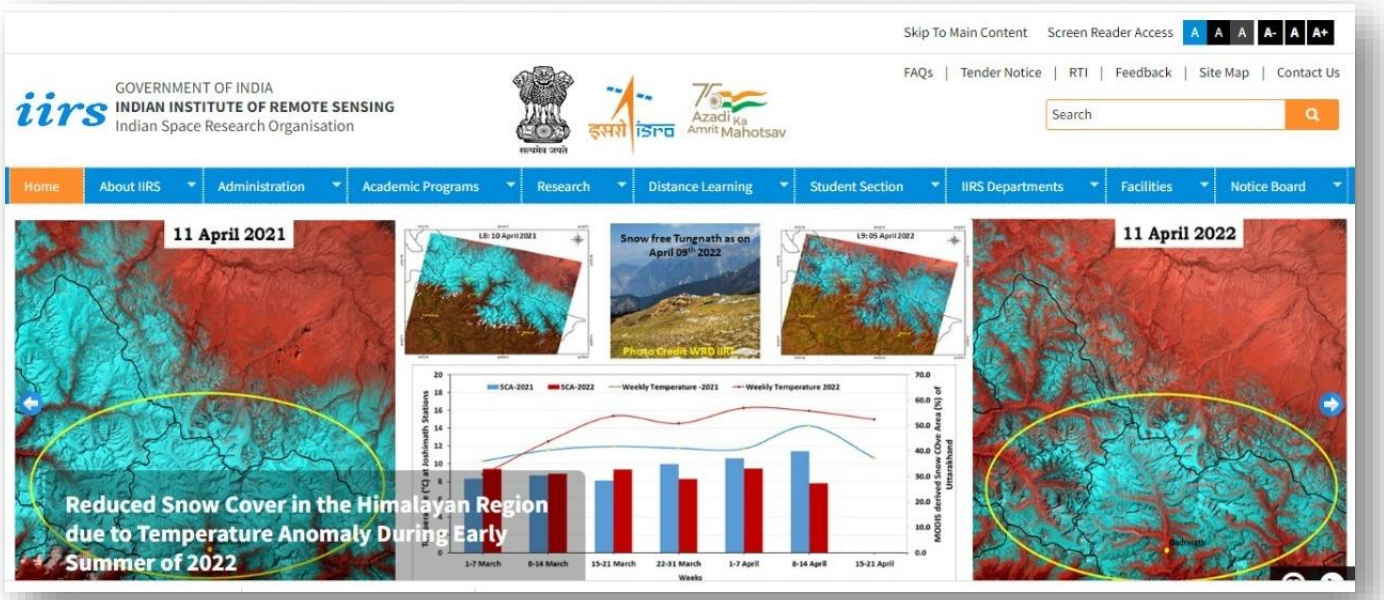
93. In India, GIS was introduced in school curriculum, as part of geography, at higher secondary stage in the year 2000 under National Curriculum Framework for School Education -2000 (NCFSE 2000). However, the adoption has been slow due to the availability of trained teachers. Esri India is helping K-12 segment by providing workshops and hands on training on ArcGIS online and Story maps. **1000+ school students** have been trained through these workshops. These students are now working on projects and research work leveraging the GIS technology for interactive learning.

AWARENESS AND OUTREACH PROGRAMME FOR CAREER PROFESSIONALS

94. A large number of awareness and outreach programs for career professionals have been systemized in India. The establishment of a GIS cell is most Government Departments at the Central, State and Local Body level has resulted in the development of professional development programs.

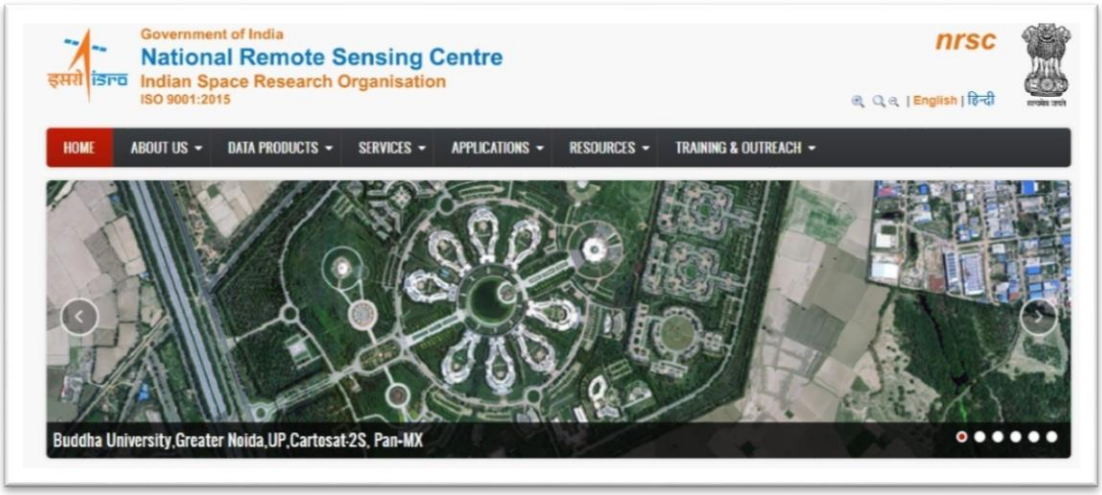
INDIAN INSTITUTE OF REMOTE SENSING (IIRS)

95. The Indian Institute of Remote Sensing (IIRS) conducts a variety of courses targeted at professionals and these range from 4 months Certificate Courses, 2 months NNRMS sponsored courses for University Faculty, 2 weeks on demand Special Courses and one-week duration Overview Course for Decision Makers.



NATIONAL REMOTE SENSING CENTRE (NRSC)

96. Similarly, the National Remote Sensing Centre (NRSC), Hyderabad also conducts one week capacity building in Geospatial Technologies and Applications towards effective utilization of satellite data products for operational, scientific research and societal benefits for oofficials from various government, private, autonomous institutions, NGOs, faculty and researchers from academic institutions working in the domain of geospatial technologies and its applications. The courses range from regular, special / theme-oriented and customized courses for effective use of space inputs for various applications. About 20 programs training around 500 officials / academic scholars per year are regularly conducted.

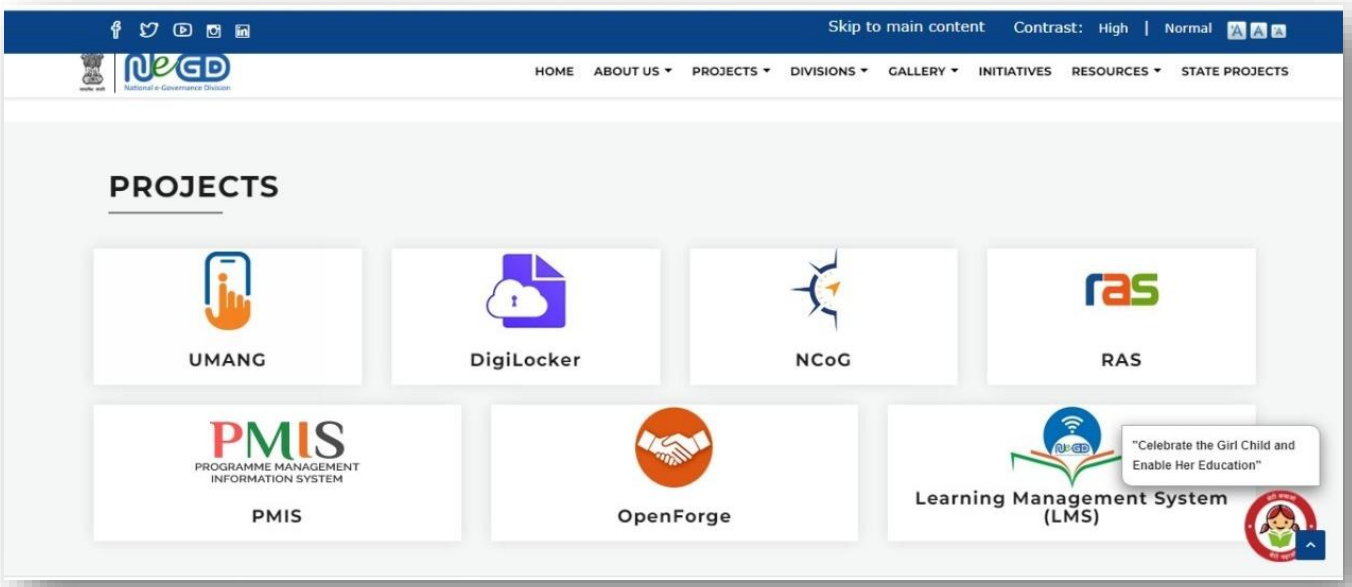


NATIONAL INSTITUTE OF GEO-SCIENCES & TECHNOLOGY (NIGST)

97. It has been recognized as the prestigious training institute in the field of Surveying, Mapping, Geodesy, Photogrammetry, GIS and Cartography to impart training to the Officers and the Staff of Survey of India and other Government Organizations, Private Individuals, and Scholars from other Afro-Asian countries. NIGST has been focusing on development of role-based training courses in niche technology areas.

NATIONAL E-GOVERNANCE DIVISION (NEGD)

98. The **National e-Governance Division (NeGD)** of the Government of India under its capacity building scheme conducts workshops and trainings programs to cover sensitization of programme and project level personnel about the Digital India Programme; spreading awareness of related important frameworks, guidelines, common service infrastructure initiatives, emerging technologies and specialised training programs which are required to develop competencies in specific areas and this includes various aspects of geospatial technologies.



NATIONAL INSTITUTE OR RURAL DEVELOPMENT & PANCHAYAT RAJ (NIRDPR)

99. It facilitates financial support under the Central Scheme of the Ministry of Rural Development, Government of India for strengthening of the training infrastructure and faculty of the institutions. NIRDPR started management education programme of one-year duration in 2015 in the form of Post Graduate Diploma Programme on Geo-spatial Technology Applications in Rural Development (PGDGARD) under CGARD (Centre for Geo Informatics Application for Rural Development) which is engaged in developing Geo-informatics technology-based planning, monitoring, modelling, decision support systems for Watershed (PMKSY), MGNREGS, PMGSY, and capacity building through training in various fields.

100. Specialized theme specific training in geospatial technologies for government officers are also conducted by the **Forest Research Institute (FRI),** the National Power Training Institute, **Ministry of Power** and the **State Administrative Training Institutes** as well as the **National Academy of Administration**.

NATIONAL GEOSPATIAL PROGRAM (NGP)

101. The **National Geospatial Program** (NGP) of the Department of Science and Technology has been conducting 3-day orientation programs and 21-day capacity building programs for decision makers for the last ten years that includes general orientation to geospatial technologies as well as theme specific trainings. A dedicated portal that can be accessed from (www.dst-iget.in) an innovative venture and is the first Indian portal of its kind that is a one stop resource for teaching-learning geospatial science besides networking educators, professionals and scientists. The portal provides software, tutorials for teaching GIS, digital image processing, spatial analysis, customization and new trends such as web GIS and mobile GIS using open-source software and data from the Indian sub-continent making it easy for the learner to relate to. The training manual has framed a common curriculum for geospatial training in the country and has helped build a cadre of professionals with the requisite expertise to meet the needs of the growing geospatial industry. Apart from this it has database of Indian experts who can be called upon by various institutes as a resource person. It has provided a common platform for networking of geospatial educators in the country besides providing access to a large section of society to acquire skills and knowledge related to geospatial technology at relatively cheap costs at their own pace. 166 training programs of three-week duration each have been conducted across the length and breadth of the country over the last

eight years benefitting over 5000 participants from academia, Government and research institutes across India.

102. **National Geospatial Chair Professor Scheme** to establish 15 National Geospatial Professor Positions has been also launched by the Department of Science & Technology, Government of India. The main aim of the scheme is to strengthen the Geo-spatial education and S&T at National and sub-national level in the dynamically evolving geospatial ecosystem in the country.

FORMAL EDUCATION

103. Geospatial science is taught mostly at post graduate level except in engineering courses, where it is being taught at undergraduate level as Bachelor of Engineering (BE)/ B.Tech in Geomatics/ Geoinformatics. It is also taught as one of the elective subjects in BE Civil Engineering, B Planning courses at undergraduate level. A doctoral program in Geoinformatics is also there in some selected Institutions. The post graduate courses offered vary from M.Sc., in Geoinformatics, M.Sc. Applied Geography and Geoinformatics, M.Tech., in Geoinformatics and M.Tech., in Remote sensing, Post Graduate Diploma of six months to one year duration. There are B.Sc. Applied Remote sensing course for one year and certificate courses varying from six months to two months also taught at University level.

104. An internet survey shows that there are 5 institutions conducted a Bachelors program (B.Tech) in Remote Sensing and GIS, 79 Universities offering a Masters program in Geoinformatics, 36 offering a doctoral program in Geoinformatics, 50 offering a postgraduate Diploma/Certificate course and 7 offering programs in the distance mode. Besides this a very large number of Bachelors and Masters courses offer a specialised paper in geospatial technologies enabling the use of this technology in different disciplines. This will go a long way in mainstreaming the use of geospatial technologies in the near future.

GEOSPATIAL SKILL DEVELOPMENT

105. The Ministry of Skill Development & Entrepreneurship (MSDE), Govt of India is responsible for co-ordination of all Skill Development efforts across the country, removal of disconnect between demand and supply of skilled manpower, building the vocational and technical training framework, skill up-gradation, building of new skills and innovative thinking not only for existing jobs but also jobs that are to be created. The Ministry aims to skill on a large scale with speed and high standards in order to achieve it's vision of a 'Skilled India'.

106. It is aided in these initiatives by its functional arms – Directorate General of Training (DGT), National Skill Development Agency (NSDA), National Council for Vocational Education and Training (NCVET), National Skill Development Corporation (NSDC), National Skill Development Fund (NSDF) and 38 Sector Skill Councils (SSCs) as well as 33 National Skill Training Institutes (NSTIs/NSTI(w)), about 15000 Industrial Training Institutes (ITIs) under DGT and 187 training partners registered with NSDC. The Ministry also intends to work with the existing network of Skill Development centres, universities and other alliances in the field. Further, collaborations with relevant Central Ministries, State governments, international organizations, industry and NGOs have been initiated for multi-level engagement and more impactful implementation of Skill Development efforts.

107. Education institutes are setting up GIS competency centres to drive GIS skilling and capacity building; e.g. IIT BHU, Punjab Engineering College, BITS, Pilani etc. GIS adoption in K-12 is beginning to grow. Many schools in the Country have setup GIS Club to enable students gain GIS skills and knowledge.

INTERNATIONAL COLLABORATION

108. National capacity for Geospatial technology development, acquisition and transfer is being developed through various international partnerships/collaborations viz. United Nations Global Geospatial Information Management (UNGGIM), Open Geospatial Consortium (OGC), Brazil Russia India China South Africa (BRICS), Indo-Africa collaborations etc.

UNITED NATIONS COMMITTEE OF EXPERTS ON GLOBAL GEOSPATIAL INFORMATION MANAGEMENT (UNGGIM)

109. India is one of the founder members of UNGGIM and also member of various WGs of UNGGIM-AP. From almost a decade, Indian delegation is participating in UNGGIM/ UNGGIM-AP meetings at various levels.

BRAZIL RUSSIA INDIA CHINA SOUTH AFRICA (BRICS)

110. India is a member of the BRICS Working Group on Geospatial Technology (BRICS WG-GS) under the BRICS Science**,** Technology and Innovation Cooperation Framework. The areas of cooperation promoted under this Working Group are Geodesy, geospatial policies, earth observation and its people centric applications, human resources and capacity building, academia -industry collaboration and catalyzing geospatial technology development.

OGC India Foundation

111. The foundation raises awareness and adoption of OGC Standards in India and supports the interests and needs of Indian organizations. The OGC India Foundation also facilitates the participation of Indian members in OGC international programs. Department of Science and Technology is a permanent member.

International Society for Photogrammetry and Remote Sensing (ISPRS)

112. National Remote Sensing Centre (NRSC) is a sustaining member of ISPRS and contributes to the financial support of the society. Indian Institute of Remote Sensing has taken lead in Commission V

of ISPRS for the term FY 2016-20 to support, promote and motivate capacity building at different levels of professionals, educators and students.

International Cartographic Association (ICA)

113. Survey of India is the national member of ICA while National Hydrographic Organisation and Indian National Cartographic Association are affiliate members.

Group on Earth Observations (GEO)

114. GEO champions global collaboration for improved application of Earth observations for the benefit of humankind. India is represented by ISRO in GEO as a member state while Association of Geospatial Industries (AGI) is a participating organization in GEO.

Committee on Earth Observation Satellites (CEOS)

115. ISRO under Department of Space is one of the 32 members of CEOS and Earth Systems Science Organisation (ESSO) is one of the 28 associate members. Besides, ISRO represents India in Ocean Surface Vector Wind Virtual Constellations, which is a coordinate space-based, ground-based, and/or data delivery systems to meet a common set of requirements within a specific domain.

116. ISRO is also participating actively in other International space forums like, GEOS, ISPRS, APRSAF, UN-ESCAP to reap the benefit of space technology. Under UN-ESCAP program, India is providing technical support for development of Drought monitoring system of SriLanka. ISRO plays a key role in international collaboration programmes like International Charter on Space and Major Disasters, Sentinel Asia, UN-Spider etc. by providing satellite data on the disaster affected areas.

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