

Arc India News

CELEBRATING 25 YEARS OF CUSTOMER SUCCESS WITH GIS

COVER STORY
**EVOLUTION
OF GIS**

CASE STUDY
Geospatial Management
Information System

CUSTOMER SPEAK
Our Customers,
Our Inspiration

Transforming GIS Education
Building Skilled GIS
Workforce with Symbiosis

Partner Showcase
Readleaf Collaborates with
Esri India



Esri India Locations

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Delhi NCR

Jaipur

Kolkata

Mumbai

Hyderabad

Bengaluru

Bengaluru

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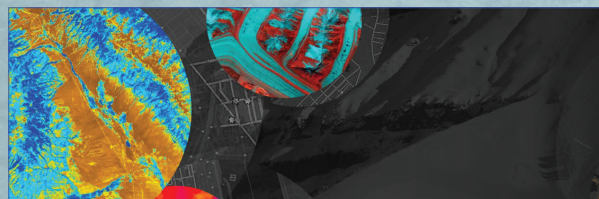
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It has been a marvelous journey of 25 years for Esri in India. As we celebrate 25th anniversary of Esri India, I take this opportunity to thank all our customers, users, partners, and staff for their valuable contribution in helping us reach this milestone. Without your support, we would not have reached where we have, in these 25 years. Looking back, it gives us a great sense of satisfaction to have supported various Government Organizations, Research Laboratories, Smart Cities, Municipalities, Utilities and Telecom Organizations, Education Institutes in the country over the last two and half decades. Listening to our users has been an enriching learning experience, which we have constantly attempted to plough back into our efforts to deliver improved user-centric solutions and services.



Agendra Kumar
Managing Director, Esri India

Esri technology has played a key role in the success of numerous government programs. MGNREGA, NNRIMS, Digital India, AMRUT and Smart Cities mission are some examples. It has always been our earnest endeavor to help businesses and governments solve complex problems with the “The Science of Where” towards bringing a positive change.

Digitalization is the way forward and there is no looking back. With changing market and consumer dynamics, businesses are being challenged constantly to adapt and transform themselves to stay ahead. Technologies like 5G and Cloud are rapidly transforming the IT systems, with faster connectivity and virtual infrastructures taking center stage. As technology usage proliferates, customers are increasingly optimizing their time and efforts by prioritizing their focus on solutions and outcomes.

With digitalization comes the explosion of data. This also means that customers are now challenged to mine this data - for insights and decision support. There is a realization that 80% of data generated today has a context of geographic location attached, which can be effectively harnessed for improving business operations and providing better services to customers. With the proliferation of location information and context it provides, our customers are taking cognizance of the fast-changing consumer behavior with a strong desire for location-rich personalized experiences. Given the rapidly deteriorating global climate and its impact on businesses and society, adapting to climate change is also taking becoming paramount. Undeniably, this will be critical for steering economic, environmental, and social progress, sustainability, and inclusively while safeguarding our future on the planet.

Technologically, the near future will be driven by the convergence of cloud, edge, 5G, artificial intelligence (AI), the Internet of Things (IoT), and data and analytics. As per predictions, the thrust is shifting from “Big Data” to “Small Data” and AI solutions around them will be way forward for better agility and resilience. The context of the location will be a gamechanger. Digital Twins and Autonomous vehicles are soon expected to transform how we interact with our surroundings. Numerous opportunities to capitalize geo-information using spatial modeling and analytics, artificial intelligence, machine learning, and deep

learning are waiting to be exploited.

With more and more earth observation sensors such as satellites and UAV's providing a greater variety and flexibility to acquire application/project-specific data at desired spatial resolutions and temporal frequency, customers will be able to make optimized choices for their specific requirements. Emerging cloud-based geospatial content management capabilities are expected to revolutionize capture, maintenance, and management, helping organizations to focus on harnessing the geospatial data for their requirements while taking away the burden of managing the infrastructure and associated challenges.

Continued developments in image recognition and feature extraction, coupled with reduced storage costs, are fostering faster data capture and geospatial content creation. While offering cost arbitrage these automated capabilities are expected to free up time-consuming and resource-intensive tasks benefitting organizations with faster turnaround times, better operational efficiencies, and enhanced cost savings. As the web-based service infrastructures gain popularity, a new wave of customized GIS tools that can be rapidly configured and deployed by users themselves are likely to emerge. With mobiles, we are already harnessing geoinformation anywhere, anytime for basic needs. In near future, business applications too will be powered by hand-held "Virtual GIS Engines", taking away the need for a laptop or computer.

Recently concluded COP26 in the UK, once again reiterated the need for mitigation, adaptation, and collaboration to address the climate change concerns world is faced with. Geospatial information combined with socio-economic and other statistical data will continue to provide critical inputs for addressing the complex challenges of climate change while supporting in accomplishing sustainable goals.

In the last two decades, the uptake of geospatial technologies in India has been relatively slow for various reasons. For post-COVID recovery and sustainable growth, enhanced situational awareness and actionable intelligence through data and insights are need of the hour for governments and businesses alike. Technological advances with recent policy changes are opening floodgates of opportunities. With 3A's (awareness, accessibility, and affordability), we foresee an unprecedented change in which geoinformation will shape the Indian economy.

Startups have been redefining Indian economy. Helping budding Indian entrepreneurs to navigate into territories that were chartered never before, Esri India's startup program has been providing a geo-ecosystem to startuppreneurs keen on harnessing the power of location. By bringing together

the 3I'S (Innovators, Investors, and Industry), Esri India's Startup program has been helping them to bring down their turnaround times to commercialize their geo-enabled solutions and rapidly scale. Our recently launched "ArcGIS Platform-as-a-Service (PaaS)" is an effort to provide powerful mapping and location capabilities to our vibrant developer community and startups to help them rapidly build scalable solutions and deploy.

Academia is instrumental in the shaping future of the nation. It has been our constant endeavor to support and empower academia with state-of-art geospatial infrastructure so that every student across the country is able to dream big and soar high in their professional pursuits. To augment classroom learning, Esri India has been offering various e-learning options and advanced learning resources that are easily accessible to the faculty, researchers, and students with a convenience to unravel the mystique of geospatial technologies, anytime, anywhere. Our hugely popular Learn ArcGIS program is being accessed by thousands of students across the country every day.

Esri India is launching "Indo ArcGIS", which provides ready solution products and data sets, created by engineers at Esri India for variety of applications. Indo ArcGIS's user-centric approach will help Esri India customers to leverage the existing datasets and rapidly build geospatial infrastructure for harnessing the power of GIS anywhere, anytime.

With immense pleasure, I would like to share on this occasion that Esri India is launching "Indo ArcGIS", which provides ready solution products and data sets, created by engineers at Esri India for variety of applications. Indo ArcGIS's user-centric approach will help Esri India customers to leverage the existing datasets and rapidly build geospatial infrastructure for harnessing the power of GIS anywhere, anytime. A few months back, we launched "Site Scan for ArcGIS" which is an end-to-end cloud-based UAV / drone mapping solution hosted in India.

Indo ArcGIS, ArcGIS Platform and Site Scan for ArcGIS are part of our efforts to strengthen the "Atmanirbhar Bharat" initiative of the Government of India through indigenous efforts for solving complex economic, social, and environmental challenges the country faces. We are in exciting times, and we look forward with work closely with our customers and partners to collectively address the challenges ahead of us.

Esri India Mapping Software 'Site Scan for ArcGIS' Wins 'Excellence in Innovative Technology' Award

Esri India, country's leading Geographic Information System (GIS) Software & Solutions provider has been conferred with the "Excellence in Innovative Technology Award" for its recently launched end-to-end cloud-based drone mapping software 'Site Scan for ArcGIS'. The award presented acknowledges the high-end capabilities exhibited by the software, encompassing flight planning, data capture, data processing, analysis, data sharing, and drone fleet management. Site Scan for ArcGIS is a comprehensive cloud-based drone mapping solution offered as 'Software as a Service' (SaaS) with unlimited storage and computing. Hosted in India on a cloud approved by the Government of India, the drone mapping software ensures that the drone data is stored and processed within India in compliance with the government regulations.

Many recent government announcements like the New Drone Rules 2021 by the Ministry of Civil Aviation, New Geospatial Data Guidelines announced by the Department of Science and Technology, among others relaxed the requirements to access and collect geospatial data through drones which today is of paramount importance to the successful implementation of government schemes like SVAMITVA, Smart City program, Bharatmala project, Interlinking of Rivers, National Mission for Clean Ganga, and various other infrastructure development projects. Owing to the automation and scalability of Site Scan for ArcGIS, the data acquired by drones can now be processed rapidly, cost-effectively, and with no human intervention, benefitting its users ranging from drone service providers to critical infrastructure organizations, governments, and businesses.

The 'Excellence in Innovative Technology' Award is a testament to Esri India's promise of constant innovation to enable our customers to solve social and business challenges using GIS.



Esri India's ArcGIS Platform to give Thrust to 'Make in India'



Esri India to offer high-quality location services, data and mapping tools for building apps and innovative solutions. Aims to reach 1 million developers in next 3 years.

Esri India, country's leading Geographic Information System (GIS) software & solutions provider, today announced the launch of ArcGIS Platform as-a-service (PaaS) that includes maps and location services. With a full range of SDKs, APIs, and low-code options, the platform will reduce time to market and promote creative design, enabling an open location-focused PaaS for software developers, businesses, and organizations that need to bring maps and location services into their products, solutions, and systems.

With this launch, developers in India will now be able to get seamless access to Esri India's leading geospatial technology and capabilities. The developers can also access these services using their preferred APIs - including open-source mapping libraries as well as Esri's web and native APIs. This will allow them to speed up the development of apps, helping them to accurately monitor service usage, deliver enormous value and reduce time to market.

Agendra Kumar, Managing Director, Esri India, said, *"Industry estimates suggest that by 2023 India will surpass the US to become the leading country with largest number of developers. This launch is our attempt to empower India's developer community so that they can build world class software solutions and systems right here in India and be able to deliver these globally. With the launch of ArcGIS platform as-a-service, Indian developer community and start-ups will have easy access to the most comprehensive, high-quality set of location services, data, and mapping tools to bring their ideas to a reality!"*

The launch of ArcGIS Platform will offer a full suite of developer tools and resources - from technical documentation to software development kits (SDKs), sample source code, reference guides, and virtual sandboxes, required for testing and developing new applications and products. Developers can access ArcGIS Platform by signing up for a free developer account. Esri India invites developers in India to explore its new ArcGIS Platform and unlock the power of location and maps.

Geospatial Technology to Play a Key Role in Mapping Rural India

Hon'ble Prime Minister launched the survey of Villages and Mapping with Improved Technology in Village Areas (SVAMITVA) Scheme to survey inhabited areas of villages using progressive technology to provide an integrated solution for property validation in rural India. Through this scheme, the government of India intends to provide a 'record of rights' to village household owners and enable them to use their houses as financial assets to take loans and other financial benefits from banks. The scheme will benefit millions of rural property owners across India. However, the surveying of land parcels using drone technology and processing of accessed data requires technology intervention and multi-agency collaboration. Geographic Information System (GIS) and geospatial technologies have been at the forefront of addressing many national and local government initiatives and projects via providing location intelligence that empowers smart decisions in many areas.

GIS will play a key role in the SVAMITVA as the objective of the scheme aims at the creation of survey infrastructure and GIS maps that can be leveraged by any department for their use and also provide support in the preparation of better-quality Gram Panchayat Development Plan (GPDP) by making use of GIS maps. GIS technology is being used across various government departments such as forest, electric, healthcare, emergency management, public safety, land management, public works, agriculture, water, urban and municipal.

Esri India GIS technology provides advanced mapping, spatial & imagery analytics capabilities that help businesses and governments understand their data better. One such capability is the mapping of land through a complete drone mapping software fully hosted on the India cloud that comprises imagery data collection, processing, and analysis. Mapping land through a drone comprises planning a flight path for the drone to capture data followed by image processing on a cloud to generate derived products and share results to make informed decisions. By implementing cloud-based processing, it reduces project timeline while also helping reduce field to lab turnaround time for drone data processing.

Most of the national mapping agencies such as Survey of

India (Sol), Geological Survey of India (GSI), and National Atlas and Thematic Mapping Organization (NATMO) are using ArcGIS for enterprise production mapping i.e., creating authoritative thematic maps and data for India. Esri GIS technology is the core foundation in major mission mode programs like Digital India, Smart cities, Clean Ganga Mission, Jal Jeevan Mission, R-APDRP, and will play a key role in the SVAMITVA scheme as well.

Esri Releases ArcGIS GeoBIM, Bringing Spatial Context to AEC Operations

New Product Connects with Autodesk Construction Cloud to Bridge GIS and BIM

Global construction challenges, from affordable housing availability to infrastructure stress as a result of climate change, have increased in recent years. As a result, governments and commercial organizations will need to invest trillions of dollars in the next decade in mitigation and recovery processes. By adopting building information modeling (BIM) and geographic information system (GIS) technology, the architecture, engineering, and construction (AEC) industry improved construction, design, and operations efficiency. Recognizing the benefits for project outcomes that a combined BIM and GIS software would present, Esri, the global

leader in location intelligence, joined forces with Autodesk in 2017. The partnership produced new technology, integrating the power of mapping into the BIM process.

In October, Esri has released a new product that expands the ability for BIM project teams to benefit from GIS. ArcGIS GeoBIM provides an innovative, easy-to-use web-based experience for AEC teams to explore and collaborate using data from multiple systems in a geospatial context. ArcGIS GeoBIM connects to Autodesk BIM Collaborate Pro, a cloud-based design collaboration, coordination, and model coauthoring software built on the Autodesk Construction Cloud.

“With many global initiatives under way to improve construction, design, and planning practices, it is critical that today’s AEC professionals can collaborate together with a common view of assets in a geospatial context,” said Jack Dangermond, Esri founder and president. “The ability to operate without siloed data provides AEC professionals with the flexibility they need to work together and meet the challenges of building in the future on an unprecedented scale.”

ArcGIS GeoBIM will provide project leaders and stakeholders in industries like infrastructure, construction, planning, water, and transportation with a common view of asset locations, costs, issues, risks, and timelines throughout the project life cycle.

“Autodesk and Esri’s cloud-to-cloud connection gives our shared customers a unified experience and the information they need at their fingertips—regardless of whether it’s BIM or GIS data,” said Amy Bunszel, Autodesk executive vice president of AEC Design Solutions. “This will improve efficiency and decision-making during planning, construction, and operations. Ultimately, our collaboration will help enable the industry to deliver more sustainable and resilient infrastructure.”

AEC team members can track design, coordination, quality, safety, and commissioning issues by linking data from Autodesk BIM Collaborate with ArcGIS GeoBIM.

“What we need is a single, authoritative source of truth access point for everyone on our team, a way to bring data and information together that originates from multiple formats,” said Darin Welch, HNTB associate vice president and national geospatial and virtual engagement manager. “Esri’s ArcGIS GeoBIM connection to the Autodesk Construction Cloud combines survey, design, and planning workflows that offer a blended BIM-GIS data experience that equips our team with more informed decision-making.”

Esri in India

View from Jack Dangermond, Founder & President, Esri Inc.

It has been a glorious 25 years of Esri in India pushing the boundaries of geographic science and opening the world to the possibilities of geospatial technologies towards bringing a positive change. Rooted in purpose and service, Esri India has been relentlessly carrying forward Esri’s essence of “The Science of Where” since 1996 helping customers embrace digital transformation initiatives to overcome some of the most difficult problems in the subcontinent.

From NIIT-GIS to Esri India the journey has been an exciting one. Esri has been at the forefront of addressing the challenges faced by governments and businesses today and has been supporting its customers with a better understanding of the emerging challenges and providing solutions to solve problems. Starting with the Indian Space Research organization’s (ISRO) National (Natural) Resource Information System in 1997, conceptualized for providing a nationwide database for natural resources management in the country, ArcGIS solutions have come a long way in supporting scientific research, economic activities, and policy making in the country.



Since then, cutting across governments, businesses, and academia, Esri solutions have been helping our customers to stay relevant to the times while supporting them to be competitively aligned with the transforming business landscape. The Planning commission of India (Now NITI Aayog) adopted Esri solutions for strengthening policy making and providing GIS services to central and state governments. To strengthen geospatial infrastructure in the country, Survey of India (National Mapping Agency), National Water Informatics Centre (NWIC), National Remote Sensing Centre (NRSC), Space Application Center (SAC), Regional Remote Sensing Centers (RRSC), and others have augmented their capabilities with Esri solutions for efficient geospatial data production and management. All the major telecom and power utilities in the country have been using ArcGIS Solutions for planning, designing, and managing nation and state-wide networks and customer services. ArcGIS solutions are powering Smart cities for improving citizen services, revenue collection, and disaster response while improving operational efficiencies. Many IITs, universities, and research institutions across the country have chosen ArcGIS for strengthening their pedagogy and research activities in geospatial sciences.

The past two years have been a big deal for the GIS community worldwide. The COVID-19 pandemic has disrupted every system that existed. GIS community demonstrated to the world that they add value beyond their missions. Across the globe, we saw ArcGIS solutions supporting governments, communities, and organizations with maps, analytics, and dashboards, as they ramped up their efforts to deal with the emerging situations. Esri's Disaster Response Program (DRP) is still supporting requests for assistance coming in from all over the world – from governments, communities, and organizations to confront the situations as they emerge. DRP Program is a free service that Esri offers as part of its corporate citizenship. The program is designed to help customers who need additional GIS capabilities as they respond to disasters such as hurricanes, floods, tornados, epidemics, and pandemics.

Post COVID-19, "The Science of Where" has become critical more than ever. The disruptions triggered by the pandemic will only worsen the already fragile situation as more people are pushed below poverty lines, and the digital divide will go up. With the entire world still trying to combat the deadly virus, and adjust to the new normal, the role of geospatial has become foundational.

As a growing economy with a large population, on its way back to normalcy, India is faced with complex challenges ahead. Environment degradation, climate change, water security, and food security are issues that are still as relevant as ever and affecting the planet and our existence. With a direct bearing on a large section of economic activities, GIS technologies will be a force-multiplier to accelerate economic growth and strengthen the nation's resilience.

From direct productivity benefits and cost savings, GIS

technologies offer numerous community benefits via enhanced convenience, time savings, and better quality of life. Notwithstanding the societal benefits including employment generation, sustainable natural resource management, and better preparedness and response to extreme climate events and natural disasters that GIS technologies provide.

Keeping pace with the complex challenges the world faces, Esri technologies have been evolving and helping our customers to become smarter and efficient.

While our desktop solutions continue to help our customers solve complex problems innovatively, our cloud solutions are helping them to harness geoinformation anytime, from anywhere. Esri Solutions are bringing real-time data and consumer-facing information to the forefront, by empowering smart decisions in many areas.

We have engineered advanced analytics that allows users to harness the location information and make meaningful sense from them for informed decisions. Revolutionizing data collection, processing, and analysis, our customers can now directly publish their drone data to perform advanced analytics such as object detection and application of artificial intelligence in a cloud-based environment.

Esri's continued advancements in data storage and parallel and distributed computing makes solving problems at the intersection of machine learning (ML) and GIS increasingly possible. This focus on innovation will continue to empower ArcGIS users to take advantage of the latest advances in technology and computing, while still focusing on solving problems in a fundamentally spatial way.

Moving towards a geospatial infrastructure of distributed services, our Kubernetes platform now allows taking up any server like enterprise and breaking it into pieces, microservices, and then putting those pieces into independently scalable services. Coming soon are additions to our portfolio for cloud-based massive image processing and analytics capabilities in an open environment and developer support for third-party clients which have GIS inside.

As one of the fastest-growing economies in the world, our customers' work in India will be a cornerstone for ensuring a sustainable future for us all as the world continues to evolve. Esri India will continue to play an important role in the India growth story by connecting the systems among individuals and across the national, state, and local governments; private businesses; and society. Our users will facilitate this through an intelligent nervous system that enables everyone to build better outcomes for their communities.



Building Skilled GIS Workforce

In today's fast-transforming technology environment, while businesses try to keep pace with new advancements, the industry leaders unanimously agree that in order to stay relevant and innovate, a capable tech-conversant workforce is necessary. Companies look for top-notch efficiency in professionals possessing, critical thinking and research capabilities to further add value to a business and give better direction to policy and decision-makers. The significance and adoption of Geographic Information System (GIS) as a foundational technology across the length and breadth of diverse business workflows is increasing rapidly. Nearly every sector whether under government or private purview has realized the relevance of leveraging location intelligence through GIS in their business strategies. As Geospatial Technology plays a prominent role in the overall development of society and making human life better in various aspects, there is indeed a need for skilled manpower in this domain; educating the future workforce with necessary GIS skills has become an imperative.

Symbiosis Institute of Geoinformatics, Pune (SIG), one of the leading institutes in India is working in the same direction. SIG offers dedicated programs in M.Sc. in Geoinformatics, M. Sc in Data Science, and M.Tech. program that aims to provide the students with an opportunity to explore and acquire a critical understanding of the nature of Geospatial data and spatial environment related processes. For the past 17 years, the institute has been consistently working towards training the future

leaders of tomorrow with the right set of skills to make them capable to solve different real-world issues with geospatial technology. The institute also offers data science program that includes spatial components to understand data variety, volume, velocity veracity, and visibility. SIG incorporates GIS in different research domains ranging from natural resources to transportation and infrastructure.

The use of appropriate tools to explore the geospatial data has its importance, without the use of which it is a difficult task to explore and understand the nature of Geospatial data. As business landscapes are changing rapidly and sectors like healthcare, emergency management, governance, infrastructure, among others embrace location intelligence in their business strategies to decode data, GIS is increasingly becoming the need of the hour.

With everyone using mapping in daily life, integration of GIS with emerging technologies like AI, ML, Big Data, and (IoT) are finding new-world applications. Also, integration, analysis, and visualization of vector as well raster data is challenging and requires more computational efforts. Esri India is working with Symbiosis Institute of Geoinformatics, Pune (SIG) to support the academic community with learning and entrepreneurship in location analytics. The user-friendly products offered by Esri India enable the students to understand the workflow of geospatial data and improve their capabilities to explore it more and also inspire them to implement their ideas for solving different real-world challenges.

Geospatial Management Information System (GMIS) – A step towards effective management @ Smart Cities Mission



Project Summary

GMIS (Geospatial Management Information System) was made open to the 100 smart cities of India in December 2020 by the Ministry of Housing and Urban Affairs (MoHUA) as a Management Information System for all existing/new Smart City Projects. Formally launched in February 2021, the system has been used effectively by the 100 Smart cities, and by MoHUA for real-time monitoring the progress of 7,000 + projects worth over USD 30 Billion.

The objective behind the creation of GMIS was to provide better insights for mission management, create an extensive data repository of important mission-related data, introduce geospatial capabilities, and create a single engagement and monitoring platform for all officials involved in mission implementation. Geospatial mapping of projects with watermarked tags containing project ID, date and time, location in latitude and longitude opens new horizons for evidence-based planning, project monitoring, evaluation, and providing the information for policy making.

Challenges

Before the introduction of GMIS, there existed an MIS without geospatial visualization capabilities. Moreover, several operational challenges that prevented the department from achieving the desired results. The issues were deeply analyzed and as a result, the department decided to conceptualize and design the new platform GMIS, with superior capabilities than the earlier MIS, thus greatly amplifying the mission's management capabilities.

To better connect with cities, state officials, and other Smart City stakeholders on the Smart Cities Mission efforts and achievements, MoHUA was looking for a system that can collate all project-

related data in real-time and enable effective monitoring of projects. The challenge was to have an intervention that can provide inputs for policy formulation from all the reports which can be created through this data.

With an objective to:

- Map all projects on one platform
- Have all data in one single place
- Provide a comprehensive progress view of the 100 Smart Cities
- Create a user-friendly platform
- Enable evidence-based monitoring
- Integrate geospatial capabilities
- Facilitate knowledge sharing
- Monitor SLAs in real-time
- Align mission achievements with SDGs
- Track outcomes and impacts
- Create trust with stakeholders
- Bring transparency in program execution

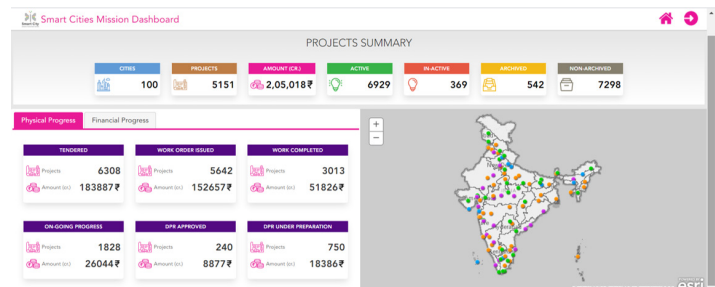


Fig 1. Geo-spatial dashboard showing Smart City projects status

GMIS was introduced and launched by MoHUA to further boost the efforts towards making cities more self-reliant and meet the needs of and provide services to their citizens.

Solution

To overcome the challenges and ensure a streamlined flow of real-time information, MoHUA created a Geospatial Management Information System (GMIS). The three guiding principles which formed the basis of GMIS were:

1. Principle of Inclusivity
2. Principle of Competition
3. Principle of outcome orientation

GMIS is a web application developed on the Esri ArcGIS system. This application is designed for the advancement, and smooth running of services across the Smart Cities program and for enhanced monitoring using GIS (Geographic Information System) enabled services.

With GMIS, more than 7,000 Smart Cities projects have been mapped, enabling one to know their geo-coordinates, physical & financial progress, and view recent photos for every ongoing and completed project. The photos have been uploaded by cities using a mobile app which is configured on ArcGIS Survey123 for updating and visualizing the project status and progress of work. Only the authorized personnel have the necessary login and passwords to update the projects from the ground, conduct surveys via the survey app to update project details and its image and geo-tag. Once the project details are updated, it is categorized as 'active' on the GMIS portal.

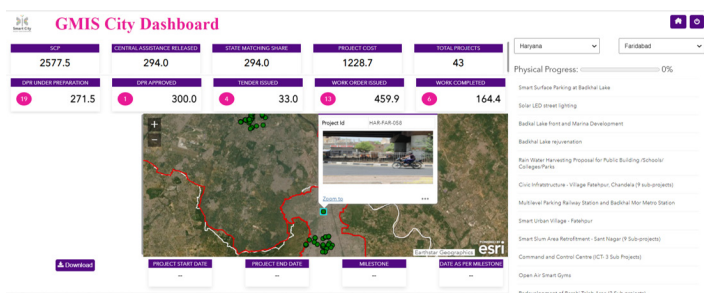


Figure 2: Project tracking through mobile apps

Business rules, which drive the entire operation, make up a critical management tool behind the whole exercise. The app is connected to the GMIS portal and synchronized with existing project IDs. This enhances the monitoring capabilities and transparency of all smart cities.

GMIS has the following modules:

- **Ranking Module:** To track the city's performance and benchmark other cities towards achieving the Smart City goals.
- **Smart City Performance Module:** This module gives visibility to the rank's movement

w.r.t original rank to current rank.

- **Reports:** Various reports can be generated for different cities on all ongoing projects, geo-tagged projects, updated projects, and active/inactive projects.
- **Output-Outcome Measurement Module:** Provides information of various outcomes and impacts being generated by the Mission.
- **SDG Module:** Helps align Mission performance with the achievement of SDGs.
- **Vendor Repository Module:** Provides a view of existing vendors and adds new vendors for different smart city projects to have a record in place while providing transparency, ownership of projects, and SLAs.
- **City Progress Module:** This module provides the visibility of the physical progress of the projects in a city.
- **NIP (National Infrastructure Pipeline):** Launched in August 2020, NIP is meant for Augmenting India's infrastructure through Identifying key projects for investments. The users can click the edit button of a respective project to redirect it to NIP by filling the form.

GMIS also works as a gateway to all the platforms and initiatives launched under the Mission. Through a seamless and unified interface, the website aggregates all mission-related information and initiatives from the various platforms. The app drives convergence by fetching data and information directly from authorized personnel and automatic updates through APIs, eventually integrating action around the 5Ps: Planning, Project, Process, People, and Partnerships.

Benefits

GMIS is a simple, user-friendly platform with geo-enablement that is facilitating the cities to provide the details of their projects and support evidence-based monitoring of the projects. The system is flexible and highly customizable to keep real-time data handy for monitoring and alignment with various stakeholders. It can be accessed at the city, state, and national levels. The platform helps create trust, transparency, and collaboration.

So far, the GMIS has been used effectively by the 100 smart cities, and the mission management unit at Delhi for real-time monitoring of 7,000+ projects worth over \$30 billion. Following are the few key benefits:

- Provides accessibility anytime and anywhere.
- Collaboration between cities, states, and central government through one single

application.

- Supports the mission in generating project-related data, which acts both as a source of truth and an instrument for data management and evidence-based project monitoring.
- Seamlessly integrates mobile-based data collection, geo-enabled MIS, geospatial dashboards, knowledge repositories over one platform.
- Ensures better investments in the projects for citizens, improving their living conditions.
- Provides real-time information to key stakeholders.
- Provides a comparison between cities, states, and thus helps in defining strategies for further action.
- Serves as a program management tool that helps in feeding policies from all the reports which are created with help of data available on GMIS.
- Monitoring of smart city projects at the city, state, and center through geospatial dashboards providing details of milestones achieved.

GMIS is new age Mission Management at its very best! Smart Cities Mission is an ambitious, hugely complex, and decentralized program of the Government of India. What GMIS has done is to make it simple to manage the Mission and strengthen the focus on achievement of outcomes."

Shri Kunal Kumar, IAS, Joint Secretary & Mission Director - Smart Cities, Ministry of Housing & Urban Affairs, Government of India

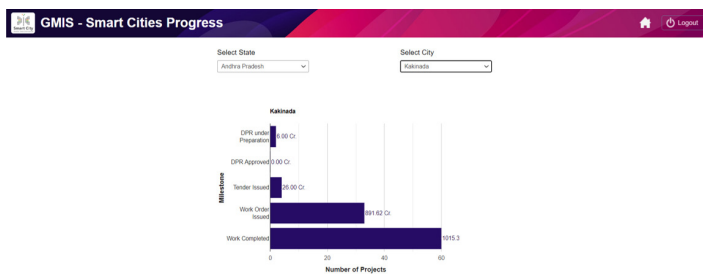


Figure 3: Charts showing the progress of different projects in Smart Cities

S.No.	City	Project ID	Project Name	Milestone	Photo Captured URL	Remark	Status Active	Review Status
1	Bangalore	BH-BHA-001	Request for Proposal (RFP) of construction of Thermal in Bangalore, State with operation & maintenance for a period of five years under Smart City Mission (SCM) on term Rate Contract	Work Order Issued			On	+
2	Bangalore	BH-BHA-002	Installation of different capacity rooftop Solar Photovoltaic Power Plants on Government Buildings	Work Order Issued			On	+
3	Bangalore	BH-BHA-003	Development of 20km Smart Road Network term rate contract	Work Order Issued			On	+
4	Bangalore	BH-BHA-004	Master System Integrator for Implementation of Command Center Integrated Smart Solution	Tender Issued			On	+
5	Bangalore	BH-BHA-005	Integrated BIM Collection, Transportation, Transfer Station Development, Processing of waste	Tender Issued			On	+
6	Bangalore	BH-BHA-006	Design Engineering, Procurement & Construction of CCOC Building (2+4 floors) including Utility services under "Bangalore Smart City Mission", Bangalore, State on EPC basis	Work Order Issued			On	+
7	Bangalore	BH-BHA-007	Development of Night Shelter at Meenakshi Hospital Complex, Bangalore	Work Order Issued			On	+

Figure 4: Images with location and date showing project status

New Project

Project Details

1) State *
Tamil Nadu

2) City *
Erode

3) Project ID *
TAM-ERO-089

4) Project Name *
[Text Field]

5) Category *
Please select a value

6) Sector *
Please select a value

7) Impact *
Please select a value

8) Project being taken up by *
☐ Govt. Department ☒ SPV ☐ Others

9) Name of Implementing Agency *
[Text Field]

10) Whether DPR Applicable
☐

11) National Infrastructure Pipeline
☐

Figure 5: Adding projects at Geo Location

Client
Ministry of Housing and Urban Affairs (MoHUA)

Website
<https://gmis.smartcities.gov.in/>

Location
New Delhi

Industry
Urban

Organization Profile

The Ministry of Housing and Urban Affairs (MoHUA) formulates policies, coordinates the activities of various authorities, and monitors programs concerning urban development in India. MoHUA is also responsible for implementing the National Smart Cities Mission, urban renewal, and retrofitting program.

Solution
ArcGIS



In Conversation with

Rajesh C. Mathur

Former President, Esri India

What does it take to build the country's leading Geographic Information System (GIS) Software & Solutions company?

What led to the establishment of Esri India at a time when Esri was already doing GIS business in India?

Esri ventured into the Indian market in the late eighties by way of a business relationship with NIIT. At that time, the GIS industry was at a nascent stage in India with very limited adoption of the technology. The early adopters of GIS were national mapping agencies like Survey of India, ISRO, NIC, academic and research organizations, among others. While a lot of good work was being done by the user community on Esri software, however, the utilization was nowhere near the potential. The primary reason was lack of awareness of GIS, inadequate availability of technical manpower, spatial data availability, and limited access to solution providers with ready-to-implement GIS support. Esri decided to address these issues by enhancing its presence in the country and formed a joint venture with its Indian partner NIIT. Esri India was established as a GIS-focused products and services company - a source of not just Esri software but also a host of professional services including technical support, education and training, data conversion, and application development services.

Please share a view of how the GIS industry was back in 1996 when you started Esri India?

Like other countries, in India as well the early adopters of GIS were the national mapping agencies who built capacity to create geospatial data products; organizations like Survey of India, Geological Survey of India, NATMO, et al. ISRO, RRSCs, and State Remote Sensing Centres implemented several GIS-based pilot projects across a range of domains like water resource management, forestry, urban planning, etc. to demonstrate the applications of GIS and remote sensing. Several universities built GIS and remote sensing labs to create human resource capacity and also undertook research projects. The market offered us the opportunity to build on the work already done and scale it to extend usage to a larger base. The commercial segment was another promising opportunity that was highly underleveraged. On the technology front, Esri software was available on desktops – running on both MS-DOS and Windows. In the mid-90s engineering workstations running UNIX workstations were the preferred desktop platform - both stand-alone and client-server mode – for high-end applications.

Since the industry was in its early years, there must be many challenges when it came to GIS adoption. What approach did you take to address those challenges?

Setting up a financially sustainable GIS-focused company was a huge challenge since the market was already small with low adoption. Further, most of the business came from government organizations with usual processing delays and L1 syndrome. Another challenge was accessing quality

technical manpower, so we adopted a multi-pronged strategy to address these hurdles and I can say with justifiable pride that we have been very successful in our endeavor. Our primary focus was to educate potential users on the applicability of location data in their workflows and how geo-enabled business processes will enable deep insights into their operations leading to more informed decision making. Our technical team conducted several proof of concepts to showcase the technology and its applicability. We also engaged with various apex bodies of the government to create and deliver training programs to expose serving bureaucrats to GIS technology. To meet the growing manpower needs of our users, we supported several universities in developing and delivering courses on geospatial technologies.

Esri India has been a market leader in the last 25 years. What factors do you think have contributed to this success?

I believe the depth and breadth of the Esri product suite is the primary reason for the leadership position company enjoys globally including here in India. Esri is always ahead of its competitors in terms of product offerings which makes it the preferred choice for users across domains and application areas. Esri consistently leverages the advancements in the information technology space which enables its users to exploit the latest advancements in the IT world like IoT, AI/ML, AR, Big Data Analytics, etc. Our partner network has also played an important role in expanding the market by offering solutions for new and underdeveloped markets. Our engagement with academic institutions has helped in creating a pool of technical resources trained on Esri technology to support our users, partners, and our organization. Our users have been another major contributor to our success by using our technology innovatively to solve business and social problems. However, I believe the biggest contributor to our success has been the Esri India team which has some of the finest people in the geospatial industry.

With recent changes in policies by the Government of India, how do you see GIS adoption changing in India?

Data is the fuel that powers GIS adoption. In the past, the

availability of data has been a big challenge which forced most of the users to invest in data creation for their use leading to cost and time escalation. The policy guidelines released recently require sharing of data. Further, national mapping agencies will build geo-platform to expose the data created by them to all potential users – both government and private sector. Thus, users will be able to consume the data as a service instead of investing in its creation or acquisition. Further, we can expect a spurt in data creation activities since the government has removed all restrictions on these activities. Increased availability of data will boost GIS adoption and expand the market. The end goal should be to build geospatial infrastructure, a federated system of systems that will enable users to access and consume data from various data providers as required by their application.

What would be your advice to the GIS user community in India?

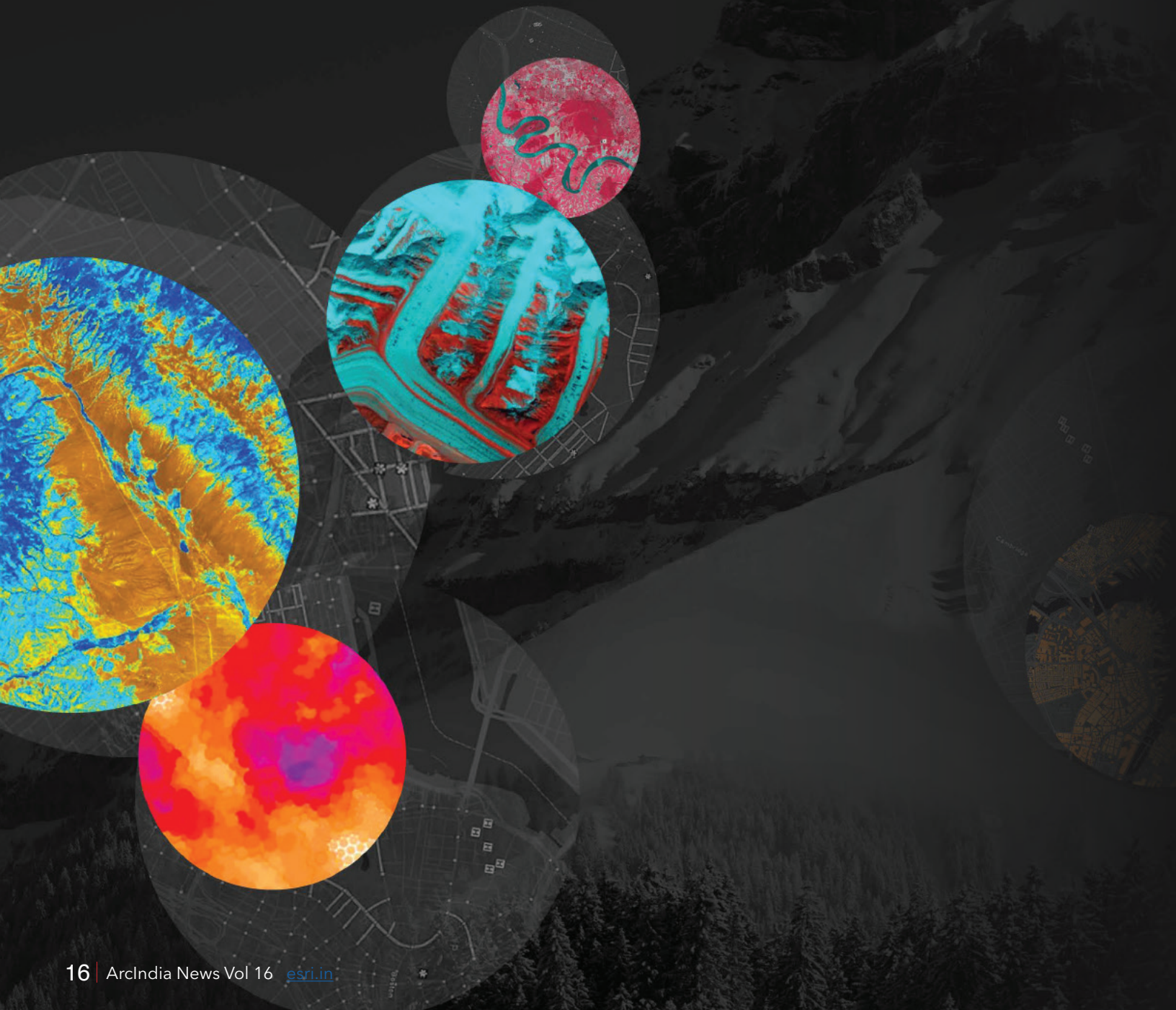
Over the past three decades, excellent work has been done by our user community. During our annual user conference, we get the opportunity to witness their incredible work. There are very few sectors, especially in the government, that have not benefited from GIS. Now is the time to consolidate this work and scale-up.

My message to our esteemed users is – Think Enterprise. Build a collaborative platform that will enable more users in your organization to integrate location data with their workflows.

Further, explore and adopt current technological advancements like integration of ArcGIS with IoT, AI/ML, AR, Big Data which will enrich your existing business processes and provide deep insights. Share your best practices and solutions developed with other organizations that are addressing similar challenges. Invest in human resource development to ensure that your team members can effectively leverage the power of contemporary GIS. Having a dedicated GIS team at the organization will bring more focus to GIS adoption. Last but not least reach out to us so that we can together develop your medium to long-term GIS strategy.

COVER STORY

Evolution of GIS



Geography often referred to as “the world discipline” has been the strongest “bridge” between the economies, natural resources, people, communities, environment and their interactions in space and time. Geographical thinking is deep-rooted in humans and subconsciously we harness it to think and do things. “We’re often unaware of how much spatial thinking we do because it is so ingrained in us. We move through the world so easily that it seems we do it without attention or effort, almost unconsciously.” says Jack Dangermond, Founder and President of Esri.

Human Cognition (the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses) consists of a) objects, events, processes, background environment and b) their acquisition, storage and retrieval and manipulation. As human brain gathers visual information about an object, it also gathers information about its surroundings, and associates the two. Every time we think of “what”, invariably context of “where” follows. This is how the human brain is wired. Every piece of information is processed by human brain in space and time to contextualize and help us take decisions in everyday life.

Early humans are known to have depicted geographic information symbolically on flat surfaces (stones, bones, rocks, etc) in the form of patterns and pictures. With times information got better organized, different mediums of communication came into use and became popular as “maps”. First recorded use of geographic information dates to prehistoric times (2.5 million years ago to 1,200 B.C. - Stone Age, Bronze Age, and Iron Age). Through ages humans have relied on geographic information for wide range of activities including military superiority, navigation, and administration. Over time the applications of maps evolved into every aspect of human life.

It was in 1960’s, when computers revolutionized the way geographic information could be used. The first “Geographic Information System (GIS)” built in 1963, was used for storing, analyzing, and manipulating land information in a map-based environment. Over time, with advances in computing and communication technologies GIS has become a powerful and versatile tool with enhanced capabilities and diverse applications. While continuing to be based on basic principles of cartography, today’s GIS can integrate diverse disciplines and technologies such as Remote sensing, Positioning, Surveying, Photogrammetry, Analytics, Modeling, Data Science, Artificial Intelligence, Machine Learning and Deep Learning. Cutting across the sectors these advanced capabilities on a unified GIS platform provide numerous benefits to the stakeholders.

From times when map making was a tedious, time consuming affair and had to be carried out by experts, today’s GIS gives people the ability to create their own digital maps to help solve real-world problems. From data processing tool in the past, today’s GIS has graduated into a means for data sharing and collaboration, inspiring a vision that is now rapidly becoming a reality—a continuous, overlapping, and interoperable database of the world, about virtually all subjects.

The word “map” is believed to have originated from the medieval Latin “Mappa mundi”, wherein “mappa” meant napkin or cloth and “mundi” the world. “Map” became a shortened term referring to a two-dimensional representation of the surface of the world.

Past

Cartography

While cartography continues to be foundation of today's GIS, its history is very fascinating. The earliest surviving maps are cave paintings and etchings on tusk and stone, followed by extensive maps produced by ancient Babylon, Greece and Rome, China, and India.



Clay tablet with map of the Babylonian city of Nippur (ca. 1400 BC) Image Courtesy

Cave painting and rock carvings used simple visual elements that may have aided in recognizing landscape features, such as hills or dwellings. A map-like representation of a mountain, river, valleys and routes around Pavlov in the Czech Republic, carved on a mammoth tusk, has been dated to 25,000 BC, making it possibly the oldest known map of all time. Maps in Ancient Babylonia were made by using accurate surveying techniques. Oldest preserved maps on Babylonian clay tablets date to 2300 BC.

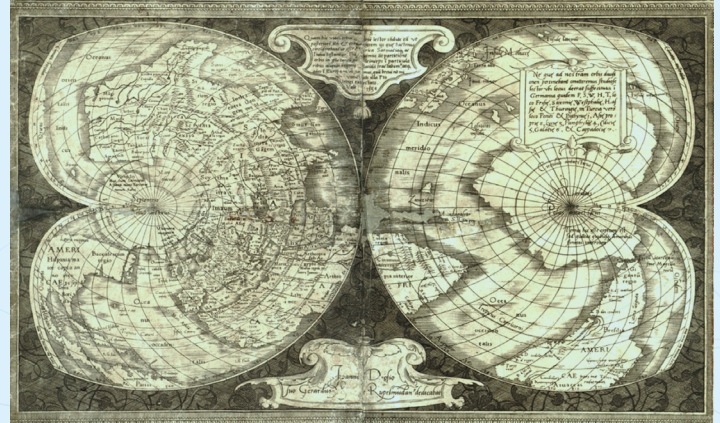
Early maps depicted small areas and were pictorial in nature. They had no rules to how they were oriented and relationship between the features on the maps were often not accurate. The Greeks are credited with map making based on mathematical principles. Using surveying techniques, they measured positions of various objects by calculating the distance and angles between each point. The earliest Greek known to have made a map of the world was Anaximander in 6th Century BC, assuming that the earth was cylindrical.

While Eratosthenes was the first person to assume earth as spherical in shape, Ptolemy (90-168), a Hellenized Egyptian, developed the depiction of the spherical earth on a map by using perspective projection. He suggested precise methods for fixing the position of geographic features on its surface using a coordinate system with parallels of latitude and meridians of longitude. Ptolemy's eight-volume atlas Geographia is a prototype of modern mapping and GIS. For the first time the practice of orienting maps so that north is at the top and east to the right of the map started with Ptolemy, which has become a default standard today.

First World Map

It was 16th century when Gerardus Mercator born as Geert de Kremer (1512-1594) a leading Flemish cartographer

published the first world map in 1538, usually referred to as "Orbis Imago". He used a double-heart-shaped projection which resulted in maps of greatly increased accuracy. Mercator's navigational charts enabled compass bearings to be plotted in straight lines on charts and clarified longitude and latitude measurements. Mercator's world maps flattened the spherical planet with latitude and longitude lines drawn in straight grid, to make it easier to display.



World Map 1538, By Mercator, Image Source Wikipedia.

Thematic Maps

Ability to handle thematic maps / layers have proved to a big differentiator of GIS technology. Interestingly, idea of portraying different layers of data on a series of base maps, and relating things geographically, has been around much longer than computers. Maps of the Battle of Yorktown, 1782 (American Revolution) drawn by Louis-Alexandre Berthier (1753-1815), Minister of War and chief of staff to Napoleon, have used overlays to show troop movements.



Louis-Alexandre Berthier map showing position of the American and French Armies in Kings Ferry, Peak's Hill, Crompond and Hunts Tavern from September 17 to October 20, 1782. Map shows roads, bridges, houses, some industries, creeks, rivers, and relief.

In 1838 "Atlas to Accompany the Second report of the Railway Commissioners, Ireland" by Irish Railway Commission, showed population, traffic flow, geology and topography superimposed on the same base map.

Origin of modern-day thematic representation of map layers can be attributed to Photozincography (sometimes referred

to as heliograph, also known commercially as zinco). First developed by a British army officer, Sir Henry James FRS (1803–1877) in the mid-nineteenth century, this process allowed maps to be split into different thematic layers. While the use of layers much later became one of the main typical features of a contemporary GIS. This method proved invaluable when it was used to create maps by Ordnance Survey of Great Britain in the 1850's.

Positioning (GNSS)

One of the invisible technological components that has made significant contribution to development of GIS applications is precise positioning using Global navigation satellite systems (GNSS). GNSS aids in determination of location, navigation, tracking, mapping, and timing, relying upon real-time satellite signals.

Ground-based radio navigation systems, such as LORAN (1942) and the Decca Navigator (1945), were used during World War II. These learnings were applied to space and The Soviet Union launched Sputnik 1 satellite in 1957. American scientists tracked Sputnik's radio pulses using the Doppler effect, which led to development of Navy Navigation Satellite System, known as "Transit". Transit became the first satellite-based geo-positioning system in 1960 and was used primarily by the US Navy in 1964. For better accuracy, scientists developed accurate time reference for a ranging signal which led to development of the Navstar-Global Positioning System (GPS) by United States (launched in 1973). The Soviet Union developed their own satellite navigation system "Parus" in 1974. While these were initially developed for military uses, they were made accessible to civil applications in 1983. These were followed by many other systems over years including GLONASS (Russia), Galileo (EU), BeiDou (China), QZSS (Japan) and The Indian Regional Navigation Satellite System (IRNSS) operationally known as NavIC. As on 1st September 2021, there are about 150 navigation and positioning satellites in earth's orbit.

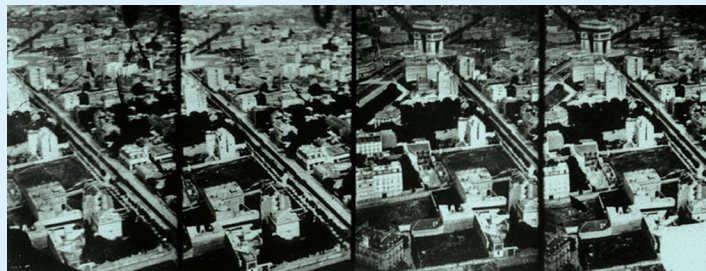
Remote Sensing

With ground-based surveys being time consuming and expensive, remote sensing technologies became a very viable alternative and soon became main source for rapid information acquisition.

Remote Sensing of earth started with aerial photography. Early platforms used for acquisition of aerial photos included balloons, pigeons and kites. The first aerial photograph was taken in 1858 by Felix Tournachon (1820-1910), known as Nadar, from a tethered balloon over the Bièvre Valley in France. Light aircrafts were widely for aerial photography in the first world war during 1914–1918. This was followed by development of new format cameras, development of photogrammetric hardware (analog stereoplotters), digital photogrammetry and use of aerial photographs in non-military applications as time passed.

Satellite remote sensing started in 1960's with meteorological applications being the first ones. In early 70's the first satellite ERTS-1 Earth Resources Technology Satellite (later

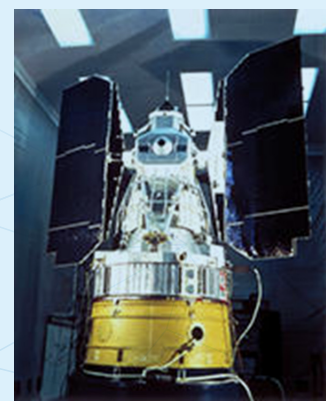
renamed as Landsat in 1975) specifically designed to collect data of the Earth's surface and its resources was developed and launched by United States.



Aerial Photographs of Paris from a balloon by Nadar, 1838, Image Source Wikimedia

Since then, many countries have launched earth observation satellites including India's IRS constellation (IRS-1A was first launched in 1988). Landsat program continues to be operational even today with Landsat 9 being the latest launch in September 2021. As per Union of Concerned Scientists (UCS), there are about 4550 operational satellites currently in earth's orbit, of which 1028 are Earth Observation satellites as on 1st September 2021.

Over the decades, satellite remote sensing has witnessed rapid developments that transformed the GIS application landscape. These include higher spatial/temporal resolutions and stereo pairs providing finer details with improved accuracies suitable for most of the civil applications. Optical and radar systems, hyperspectral sensors, and thermal sensors also came into use to address specific challenges.



Landsat 1 (ERTS 1)

Early Spatial Analysis

Spatial analysis has been the most intriguing and remarkable aspect of GIS critical to solving complex problems. First known instances of spatial analysis are reported from the field of epidemiology. In 1834 French economist, statistician, and demographer Louis-François Benoiston de Châteauneuf (1776-1856), as head of a French commission, issued "Rapport sur la marche et les effets du choléra-morbus dans Paris- Year 1832". This work contained map outlining 48 districts of Paris, using color gradients, to provide a visual representation for the number of reported deaths due to cholera. In 1854, John Snow (1813-1858), an English epidemiologist and physician, determined the source of a cholera outbreak in London using spatial analysis.

As the time progressed ability of GIS to aid in spatial analysis with power to visualize and explore contextual information became widely popular for extracting knowledge and

Cover Story

insights for decision support. In recent times ability of GIS to integrate with non-spatial data and leverage advanced technologies have further amplified the benefits for users.



Original map made by John Snow in 1854. Cholera cases are highlighted in black, showing the clusters of cholera cases (indicated by stacked rectangles) in the London epidemic of 1854. The map was created in order to better understand the pattern of cholera spread in the 1854. Image Source

Birth of Geographic Information System (GIS)

Technological and conceptual advancements in the last half of the twentieth century brought by advent of computers, development of faster mathematical and computational algorithms, and the earth observation satellites contributed to paradigm shift in the way geographic information could be

harnessed.



Dr Roger Tomlinson (1933-2014)
Image Courtesy Wikipedia

Computer hardware development spurred by nuclear weapon research led to general-purpose computer "mapping" applications by the early 1960s. With development of new sources, use of geographic information proliferated and complexities led to automation for better organization, presentation and management of geographic data and information, and thus

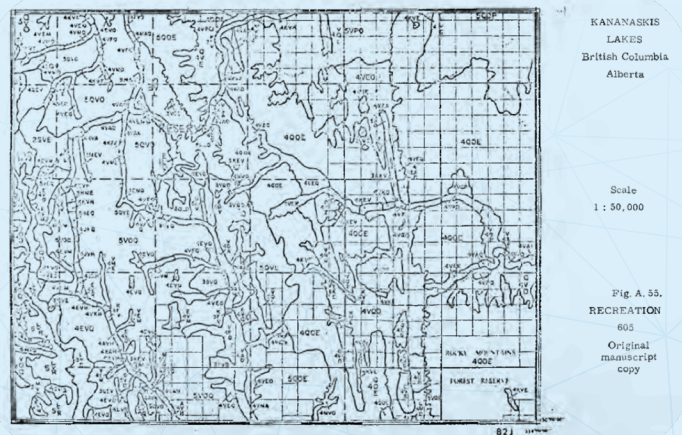
Geographic Information System (GIS) was born.

The first known automated mapping application was produced by Swedish meteorologists and British biologists in 1957. It was in 1963 when the term Geographic Information System (GIS) was coined by Dr Roger Tomlinson (1933-2014) who developed Canada Geographic Information System (CGIS) for Canada Land Inventory.

CGIS was an improvement over "computer mapping" applications as it provided capabilities for overlay, measurement, and digitizing/scanning. It supported a national coordinate system that spanned the continent,

coded lines as arcs having a true embedded topology and it stored the attribute and locational information in separate files. Dr. Tomlinson promoted use of overlays for spatial analysis of convergent geographic data.

Other notable developments in the early days of GIS which have left a significant impact on modern day GIS are development of theoretical aspects of spatial data handling by Howard T Fisher (1903-1979) of Laboratory for Computer Graphics and Spatial Analysis at the Harvard Graduate School of Design in 1964. By the 1970s distributed seminal software code and systems based on these concepts became source for subsequent commercial development of GIS worldwide.



Graphic Output of The Canada Geographic Information System (CGIS) from Dr. Roger Tomlinson's PhD Thesis. Source, UCL <http://discovery.ucl.ac.uk/1563584/>

Introduction of map overlay method by Ian L. McHarg (1920 – 2001), a Scottish landscape architect and writer on regional planning using natural systems in his book "Design By Nature" (1969), highlighted on how to break down a region into its appropriate uses. He also introduced a street network into the US Census Bureau's DIME (Dual Independent Map Encoding) System. The file format developed for storing the DIME-encoded data was known as Geographic Base Files (GBF), which was replaced with Topologically Integrated Geographic Encoding and Referencing (TIGER) in 1990. Waldo Tobler (1930-2018), an American-Swiss geographer and cartographer coined the term analytical cartography in 1975 to reflect the combination of mapping and analysis. He asserted that "everything is related to everything else, but near things are more related than distant things" (1970). Known as Tobler's First Law of Geography, this has proven to be immensely important in the development of geographic information science.

Commercial GIS Software

Encouraged with these developments and recognizing future potential of the technology for civilian applications, late 1960's saw a flurry of activity in commercial GIS software development.

In 1969, Jack Dangermond, then member of the Harvard Lab and his wife Laura founded Environmental Systems Research Institute, Inc. (Esri). Esri applied computer

mapping and spatial analysis to help land use planners and land resource managers make informed decisions. Esri's early work demonstrated the value of GIS for problem solving. Esri's Arc/INFO was first released in 1982 which laid the foundation for today's ArcGIS.



Jack and Laura Dangermond

By the late 1970s two public domain GIS systems (MOSS and GRASS GIS) were also in development and eventually launched in 1979 and 1984 respectively.

In due course of time M&S Computing (later Intergraph and now Hexagon) along with Bentley Systems Incorporated, CARIS (Computer Aided

Resource Information System), MapInfo Corporation (later Pitney Bowes and now Precisely) and ERDAS (Earth Resource Data Analysis System) (Later Leica Geosystems and Now Hexagon) released other notable commercial GIS software incorporating many of the CGIS features, combining the first generation approach to separation of spatial and attribute information with a second generation approach to organizing attribute data into database structures.

By the end of the 20th century, the rapid growth in various systems had been consolidated and standardized on relatively few platforms. Business landscape too changed with mergers and acquisitions in the industry bringing in consolidation of complementary technologies and capabilities. With proliferation of internet and faster networks, "desktop GIS" graduated to "internet GIS" making anywhere, anytime access possible.

Data compression and management technologies paved way for easy and quick access to the geospatial datasets which inherently were large in sizes and were cumbersome to deal with. With cloud taking over in recent times, increasingly geospatial data and mapping applications are switching over to the cloud offering GIS as SaaS (Software as a Service) and PaaS (Platform As a Service) empowering users to leverage the GIS technologies at their convenience.

Present

From 1960's to 2020's, rapid technological advances transformed the way geographic information is being collected, processed, analyzed, and disseminated over times. Cutting across industry verticals, from direct productivity benefits and cost savings, modern GIS technologies are force multipliers for economic growth and play a critical role in sustainable development of resources.

While continuing to be based on the principles of traditional

cartography, modern day GIS allows us to much more than just visualizing maps. Jack refers to GIS in its digital manifestation of geography, going beyond just the science (2015). He says "It provides us a framework and a process for applying geography. It brings together observational science and measurement and integrates it with modeling and prediction, analysis, and interpretation so that we can understand things".

With increasing awareness on benefits of GIS, easy availability of location information has fueled geo-enablement across the sectors. Use of GIS which started with land information management in 1963, today finds an important place in governance, politics, urban development, rural development, agriculture, infrastructure development, natural resource management, disaster management, mining, power, telecom, oil & gas, and water management, planetary sciences, social empowerment and so on.

Diverse technological advances have also played a major role in providing these widespread benefits and adoption. With advanced communication infrastructures faster connectivity and data exchange became easier. Proliferation of location intelligent devices flooded the landscape with "real-time" geoinformation which brought to fore numerous applications for user convenience and decision support. This "real-time" data and "actionable" intelligence are being leveraged by businesses and consumers for informed decisions.

Digital transformation initiatives in recent decades started focusing on establishing linkages to exploit data and insights through interconnections and interdependencies. By integrating diverse data and knowledge, spatially and temporally in a unified environment, organizations are able to harness the "Science of where" better than ever. With their unique ability to integrate data about everything—and provide intuitive understanding through maps, GIS technologies have become an essential tool for organizations.

With cloud technologies and easy to use Platform-as-a Service (PaaS), access to GIS has become much easier, faster, and cheaper. Relieved of expensive computing infrastructure and storage, organizations are now able to churn out enhanced value from their GIS investments from very first hour. With faster computing available at lower costs, by processing and integrating ever increasing volumes of geo-data from satellites, LiDAR, and other IoT sensors, along with crowdsourced data, organizations are now able to rapidly transform data into actionable intelligence for informed decisions.



Governments and businesses are using geographic information to strengthen governance, improve business operations and provide services to citizens and consumers. Geo-information driven experiences like maps, routing apps, location information, etc using mobile phones are transforming consumer landscape rapidly. Consumer behavior and expectations are being reshaped towards personalized experiences based on their location.

Mobile GIS tools now play a vital role in democratizing geo-information and empowering stakeholders with real-time information for informed decisions and risk mitigation.

Continued advancements in data storage and parallel and distributed computing are making solving problems at the intersection of machine learning (ML) and GIS increasingly possible. This focus on innovation empowers users to take advantage of the latest advances in technology and computing, while still focusing on solving problems in a fundamentally spatial way. Advanced GIS capabilities like spatial modelling and predictive analysis using artificial intelligence, machine learning and big data provide enhanced situational awareness for accurate forecast of likely scenarios to mitigate, plan and respond, including the impact of changing economic, demographic, and climatic conditions. Spatially simulated models provide decision-makers with interactive tools for understanding the physical systems and judging how actions on the ground can affect the overall ecosystems.

“Geo-Hub’s” are revolutionizing open access of the authoritative geospatial data, fostering collaboration, and sharing among governments, scientists, NGOs, communities, and other stakeholders for informed decisions through data driven insights. Fostering spatial thinking, “Story Maps” are redefining the way we communicate intuitively and spread awareness to a larger audience.

Today’s GIS gives people the ability to create their own digital map layers to help solve real-world problems. GIS has also evolved into a means for data sharing and collaboration, inspiring a vision that is now rapidly becoming a reality—a continuous, overlapping, and interoperable GIS database of the world, about virtually all subjects. Today, hundreds of thousands of organizations are sharing their work and creating billions of maps every day to tell stories and reveal patterns, trends, and relationships about everything.

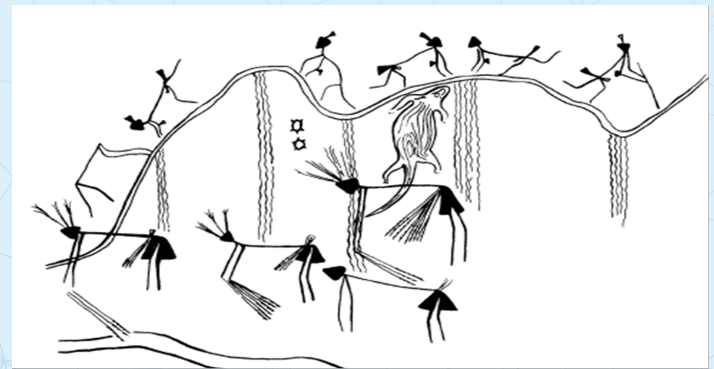
Indian Context

Early cartography in India is known to have used paintings and poetry for description of locations. Cave paintings from Mesolithic sandstone caves in Madhya Pradesh show geometric designs, which could be purely decorative but might also be, in some cases, cartographic elements, symbolic plans of huts, depicted in both ground plan and elevation.

Evidence of modern-map making can be traced to the Brahmand Purana of 500 B.C. to 700 A.D. Sulva Sutra (science of mensuration) and in the Arth Shastra of Chanakya written in the 3rd century B.C refer to the art of surveying and techniques of mensuration.

Bhavabhuti, a 8th century scholar described paintings in his work “Uttara Rama Charita” which minutely describe a habitation and its surroundings. In the 9th century, Islamic geographers under Abbasid Caliph Al-Ma’mun improved on Ptolemy’s work and described the Indian Ocean as an open body of water instead of a land-locked sea. The Iranian geographers Abū Muhammad al-Hasan al-Hamdānī and Habash al-Hasib al-Marwazi set the Prime Meridian of their maps at Ujjain, a centre of Indian astronomy. Revenue maps and land survey systems were known to have started during Mughal emperor Sher Shah Suri’s regime during 1540-45. Shershah (1472-1545) is credited to have introduced systematic survey and measurement of the entire cultivable land of his empire and fix the land-tax on just and fair principles.

Modern cartographic traditions were officially employed by the British Survey of India. Major James Rennell (1742-1830) the first Surveyor General of Bengal (1767-1777) carried out the first

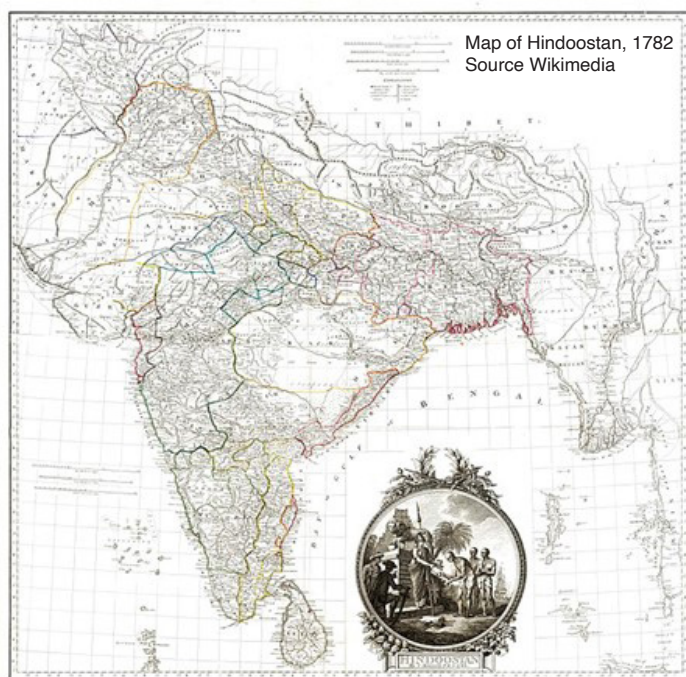


Cave paintings from Mesolithic sandstone caves in Madhya Pradesh - Introduction to South Asian Cartography, Joseph E. Schwartzberg

comprehensive geographical survey of much of India at a greater detail. He is most known for his Bengal Atlas of 1779 and Memoir of a Map of Hindoostan (1782). His survey led to The Great Trigonometrical Survey (GTS) of India which began in 1802 and continued throughout most of the 19th century which is referred to as most advanced mapping carried in the world at that time. Other nations, including Britain, were not mapped to the extent that India was.

First known aerial photography in India was carried out in 1920 when large-scale aerial photographs of Agra city were acquired. In 1923-24 Air Survey Party of the Survey of India took up aerial survey of Irrawaddy Delta forests (now in Myanmar). Post independence aerial photography in the country continued predominantly for military applications.

Like other parts of the world, the modern map making techniques in India, too employed digitization, photographic surveys, and printing. This was followed by use of remote sensing data including aerial photographs and Satellite imageries. IRS-1A, the first of the series of indigenous remote sensing satellites, was launched in 1988. IRS-P5 (CARTOSAT-1) launched in 2005 was equipped with high resolution panchromatic equipment to enable it for cartographic purposes for the first time.



(NUIS), National Spatial Data Infrastructure (NSDI), and other state geospatial infrastructures.

2010's can be termed as decade of mass adoption with use of GIS spreading across the economic activity in the country. There was a surge of GIS deployment in the country for addressing various challenges covering infrastructure, water resource management, rural development, urban development, public safety, healthcare, agriculture, environment and natural resource management and disaster management. This decade also saw strengthening of geospatial infrastructure in terms of Continuously Operating Reference Station (CORS) networks being deployed in the country along with further expansion of GIS based decision support systems and state spatial data infrastructures.

Future

GIS in India

Adoption of GIS in India started in late 1980's with Natural Resources Data Management System (NRDMS), National Natural Resources Management System (NNRMS), and National Natural Resources Management System (NNRMS). This was followed by Urban Mapping Scheme (UMS) which involved base map preparation using aerial photographs for 53 towns as pilot scheme, which was continued under National Urban Information System (NUIS) scheme in tenth five year plan.

1990's saw increase in adoption of GIS by governments in diverse application areas along with private enterprises embracing GIS. Indian Defence, India Census, Integrated Mission for Sustainable Development, National (Natural) Resources Management System (NRIS), adopted GIS during this period. In the private sector CESC and Reliance Infocomm, commenced deployment of electric GIS and Telecom GIS respectively. Satellite imageries were used extensively for generating telecom propagation models for planning by the private telecom industry.

It was 2000's when use of GIS became prominent in governance. Many government schemes were formulated with GIS as integral component of the implementation plan. These include Restructured Accelerated Power Development and Reforms Programme (R-APDRP), The Digital India Land Record Modernization Programme (DILRMP), previously known as the National Land Record Modernization Programme (NLRMP), The Jawaharlal Nehru National Urban Renewal Mission (JNNURM), Integrated Watershed Management Program (IWMP), and many others. This was the decade which also saw massive geospatial infrastructure deployment in the country. These include National Forest Information System (NFIS), BharatMaps-Multi-Layer Geographical Information System (GIS) for Planning - NICMAPS, National Urban Information System

Over last six decades use of geospatial information has grown exponentially. From being a niche technology, GIS is getting subsumed into enterprise architectures. Blurring the lines, with its unmatched capabilities, GIS is becoming integral component of enterprise IT architectures and fueling geo-enablement of digital transformation initiatives.



Changing Business Dynamics

With changing market and consumer dynamics businesses are being challenged constantly to adapt and align themselves to stay ahead. With explosion of data they are also challenged to efficiently and cost effectively mine the data for insights and decision support. Increasingly there is a realization that 80% of data generated today has a context of geographic location attached, which can be effectively harnessed for improving business operations and providing better services to customers. In times when data is being termed as "new oil", this underutilization of location has been one of the major misses of recent digital transformation initiatives. With proliferation of location information and rich experiences they provide, businesses are forced to take

cognizance of the fast changing consumer behavior with a strong desire for location rich personalized experiences. Post first wave of the COVID 19 pandemic, there is also an increased awareness that contextualized data and analytics offer a huge potential to deal with disruptive changes and radical uncertainties in a better way. Along with climate change and sustainability concerns, governments across the world are also faced with increasing population, urbanization and demand for natural resources which need to be addressed on war-footing.

Drivers

With 2000's setting stage for geo-enabled transformations, explosion of location rich data and advanced capabilities of GIS technologies are expected to be primary drivers for future growth. Increasing reliance on data and insights, improved awareness and past experiences are expected to drive governments and organizations to move up the geospatial value chain to realize higher potential from GIS technologies to address the complex challenges they are faced with.

As per the UNGGIM's Future Trends in Geospatial Information Management: The Five to Ten Year Vision, Third Edition, the view of 'everything happens somewhere' will drive many of the changes in the global economy as geospatial enters the mainstream. The next five to ten years will see an unprecedented change in the way in which geospatial information will shape and be shaped by the global economy.

Technology

Technologically, the next frontier in IT services will be driven by the nexus of cloud, edge, 5G, artificial intelligence (AI), the Internet of Things (IoT) and data and analytics, according to Gartner's report "Tech Providers 2025". The report urges leaders to embrace this nexus to enable solutions for emerging use cases such as smart cities, drones, connected and autonomous vehicles, remote healthcare, and smart retail.

Gartner predicts that from "Big Data" the thrust is shifting to "Small Data" and AI solutions around them will be way forward for better agility and resilience. These call for contextualized analytics with deep AI/machine learning (ML) capabilities to deliver location specific experiences. Given how these are closely linked with geographies and cultures, context of location is expected to be a gamechanger in these transformation initiatives. Newer opportunities to capitalize on the geo-information using spatial modeling and analytics, artificial intelligence, machine learning and deep learning are waiting to be exploited.

Blockchain technology is expected to test waters in the geospatial industry in coming years. Leading the efforts, European Space Agency (ESA) has identified priorities relevant to block chain solutions for the EO community. The

outcomes of this program will be eagerly awaited by the geospatial industry.

Applications

Geoinformation driven experiences through mobiles have been transforming geospatial landscape rapidly. Consumer behaviour is being reshaped towards instantly gratifying personalized experiences which are creating demand for new products and services. Consumers are changing the narrative and will expect products that offer dynamic, proactive and even prescriptive, location specific personalized experiences. Be it gaming or navigating, virtual terrains are here to transform the future interactions.

Powered by multiple devices live streaming location, physical "analog" objects are being complemented by intelligent "digital twins". Opportunities for creating "digital cities" and "virtual terrain models" for an immersive experience and their applications throw open new opportunities for businesses to access the metaverse in multiple ways. Once realized, metaverse will be a new way of people interacting with their environment and potentially transform every aspect of business in coming years.

With more and more earth observation sensors such as satellites, UAV's, high altitude, or vehicle-based sensors providing a greater variety and flexibility to acquire application/project specific data at desired spatial resolutions and temporal frequency, customers will be able to make optimized choices for their specific requirements.

Emerging cloud based geospatial data/content management tools and capabilities are expected to revolutionize capture, maintenance, and management, helping organizations to focus on harnessing the geospatial data for their requirements while taking away the burden of managing the infrastructure and associated challenges.

Continued developments in image recognition and feature extraction, coupled with reduced storage costs, are fostering faster data capture and geo-spatial content creation. While offering cost arbitrage these automated capabilities are expected to free up time-consuming and resource-intensive tasks benefitting organizations with faster turnaround times, better operational efficiencies, and enhanced cost savings. As the web-based service infrastructures gain popularity, a new wave of customized GIS tools that can be rapidly configured and deployed by users themselves are likely to emerge. While at the same time, creation and management of virtual geospatial data center's and delivering Data-as-a-Service (DaaS) itself is an opportunity waiting to be exploited. Given the rapidly deteriorating global climate and its impact on the businesses and society, adopting to climate change will be a critical challenge for leading governments and businesses alike. This will be critical for steering economic, environmental, and social progress sustainability. Geospatial information combined with socio-economic and other statistical data will continue to provide critical inputs for addressing the complex challenges of climate change while supporting in policy preparation, monitoring, and evaluation.

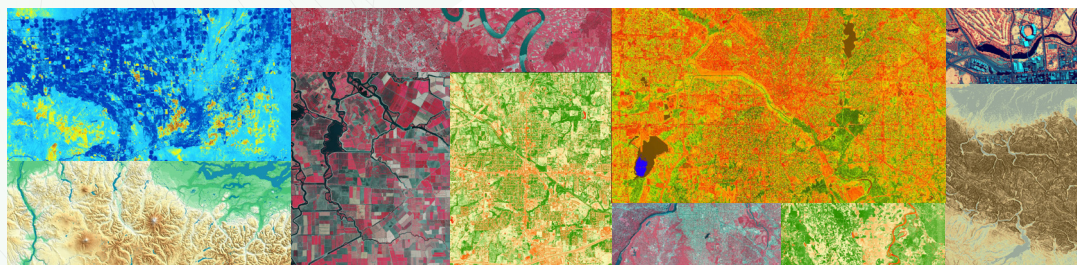


ArcGIS with ready-to-use GIS solutions and data products engineered for India

Indo ArcGIS is the one-stop destination for all your GIS needs. Powered by industry leading ArcGIS technology, the Indo ArcGIS offers out-of-the-box solutions and data products developed by Esri India's engineers to solve some of the most challenging problems the country is facing today.

Contact us to get started
go.esri.in/indo-arcgis

Tel : 1800-102-1918
Email : customercare@esri.in



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Our Customers, Our Inspiration

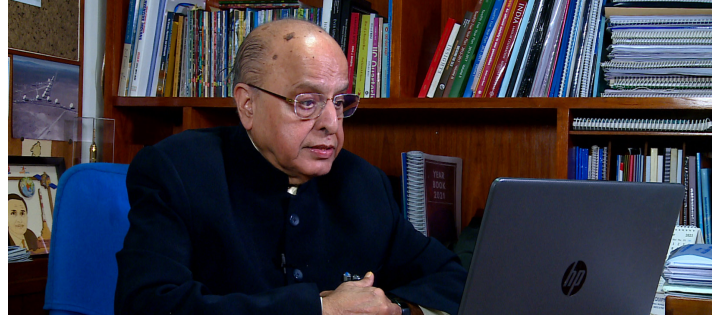
Customers words of encouragement, their constructive and valuable responses motivate us to achieve new milestones.

When it comes to anything geospatial, we at Esri India always believe in providing top-quality solutions to our customers — government organizations, businesses, academia, and non-profits. Nearly 70% of our customers are government organizations. Working with them allows us to be a part of some of the largest development projects in India, such as Smart Cities, Sagarmala, Bharatmala, Namami Gange, Digital India, among many others.

In past 25 years, we have been dedicated towards supporting our customers with the latest end-to-end GIS solutions so that they can better plan and manage their operations and make well-informed decisions. Our mission statement, “We enable our customers to solve social and business challenges using GIS”, clearly indicates that apart from GIS, a customer-centric approach is at the heart of Esri India.

Our customers have always welcomed our ‘open discussion’ approach, which promotes feedback and strengthens our communication with them. We have often been acknowledged for providing personalized services and timely deliveries leading to profitable outcomes for our customers. Here is what a few of them have to say about us:

The national space agency of India, the Indian Space Research Organisation (ISRO), is one of the earliest users of ArcGIS; it started its use way back in the mid-1980s. ISRO initiated remote sensing and GIS applications projects under the National Natural Resource Information System (NNRIS). This effort brought together a team of GIS experts. It paved the way for many seats, central agencies, and academia to get into the GIS platform apart from contributing to the GIS knowledge growth in India. “It gives me great pleasure to congratulate Esri India for having completed 25 years of operations in India and an event full journey laced with tremendous progress of GIS technology applications and policies in the Indian GIS landscape. I do not doubt that Esri and the spatial analytics can play an important role and support many aspects of national economic development



and governors in process in the near future,” says **Dr. K. Kasturirangan, Former Chairman ISRO.**

Survey of India (SOI) is the oldest scientific department of the Government of India. SOI has been the National Mapping Agency of India into survey and map preparation for more than two and a half centuries and has gone through various phases from paper maps to digital maps and now advancing to enterprise GIS systems.



Dr. Prithvish Nag, Former Surveyor General of India, goes into the flashback — his interaction with Esri as an organization initiated when he first met Jack Dangermond in 1986. “There was something different about this organization, his philosophy, his approach in comparison to other technology companies. Esri focuses on the organization, investees, and institutions; it is not only for the sale of software but also to work with them and sorts out their problems. There are very few technology visionary organizations, and Esri is one of them,” he said.



Dr. Devendra Pandey, Former Director General, Forest Survey of India (FSI), also shares the same experience, “I came in contact with Esri, the world leader and pioneer in developing the GIS software in 1998. I was then in the stage of transition and was switching over from visual to digital interpretation. Esri conducted training for our technical staff, which brought a sea change in the skill level as well as the culture of the organization. The FSI and many other state forest departments, later on, switched to the GIS inferred effective management of the forest. Esri has been supporting us since then.”



Dr. Shailesh Nayak, Former Secretary, Ministry of Earth Sciences (MOES), tells us about the importance of Esri ArcGIS in the Tsunami warning system. “The maps which suggest the travel time, the run-up height, and this information is provided to all portions of Indian Ocean rim countries through web GIS. This is one of the essential applications of Esri software and technologies. This system won many international awards for its innovation and in providing location-based services to the entire Indian Ocean rim countries,” he said. The Indian Tsunami warning system set up in 2007 at the Indian National Center for Ocean Information Services (INCOIS) in Hyderabad used Esri’s software tools and technologies in many geospatial applications of this center. The Esri ArcIMS and ArcSDE were used to generate these scenarios, to find out the earthquake source regions, and to create the directivity maps.

National Informatics Centre, Ministry of Electronics and IT has played a pivotal role in E-governance space of the country for more than three decades.



Shri Vishnu Chandra, Deputy Director General & Head of Group (NIC - Geo-Spatial Technology & Services Division and NIC-MohUA, MoEFCC, Power, MNRE & Coal Divisions) shares “In context of Geospatial technology and services, Esri technology and its ArcGIS range of products have really made a difference. NIC’s multilayer GIS Platform Bharatmaps’ deploys Esri products and API based map services extensively for geo enabling various e-governance workflows with very innovative technology solutions. My heartiest congratulations to Esri India for completing 25 years of successful GIS technology solutions services and best wishes for future endeavours.”



Dr. A. Ramanathan, Former Senior Executive Vice President – Projects, Reliance Industries, recalls that in the early 2000s, they started a GIS module for their upcoming Reliance mobile communications project. Realizing the critical role played by GIS and having no expertise and understanding of the technology was a challenging task. However, Reliance’s collaboration with Esri was a saviour. Esri ArcInfo enabled them to develop a world-class system for Reliance. “I must thank Esri India. We were able to leverage the power of location intelligence, successfully developed a cross-country cable-cut identification app, and became the first to develop the Digital Map of India. With the success of this project, we were approached by Maharashtra Police Department, CIDCO, NMMC, Symbiosis institute, Pune, etc., to assist in their respective initiatives. We are proud of the way Reliance & Esri India collaborated to popularize and revolutionize the acceptance of GIS into every conceivable field.”

Our customers are our inspiration. Their words of encouragement and constructive and valuable responses motivate us to achieve new milestones — their needs and challenges prompt us to find and deliver better solutions. Moving forward, we aspire to serve every industry and organization of every size and promote the uptake of GIS technology in India.



REDLEAF Collaborates with Esri Transform Goa Tourism Development

Redleaf Technologies is one of the premier organizations, which has been working with Esri India in providing GIS-based solutions in multiple Government & Industry-led projects. Major business operations of Redleaf Technologies are carried out on a GIS-based platform developed by Esri India. Redleaf Technologies collaborated with Esri India to develop a GIS-based web application, tourism information system, and decision support system using Esri ArcGIS for Goa Tourism Development Corporation (GTDC).

Challenges

GTDC was looking for a solution that matches the expectations and requirements of their customers i.e., tourists and internal stakeholders. In achieving objectives like planning, monitoring, and managing assets and activities, GTDC intended to develop a base map, web-based tourist information system using GIS of Goa State with due linkages to GTDC - Management Information System (MIS) and provide improvised information for decision making on municipal functions including shack locations, encroachments on Goa tourism lands, collection of taxes, development, planning, and management of infrastructures.

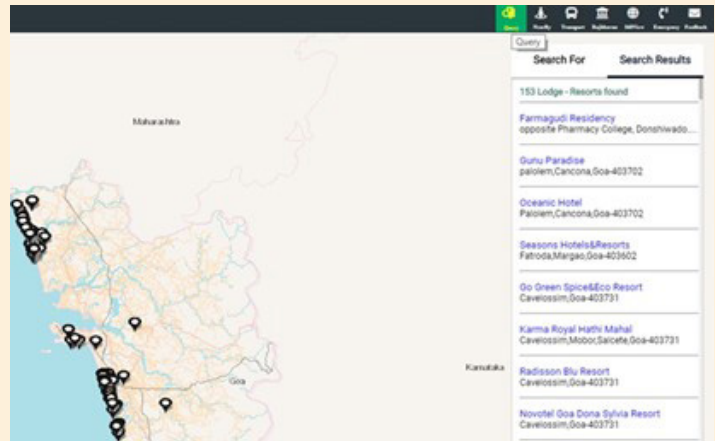
Solution

Redleaf collaborated with Esri India to develop a GIS-based solution based on Esri ArcGIS. The solution included the following:

GIS Web Application

The GIS-based web application has been configured using ArcGIS Enterprise and rendering specific details for the general public and tourists such as beach location, nearby lodges and restaurants, hospitals, ATMs, banks, important tourist locations, among others. Also, details related to shacks their location, size, license, GTDC properties, public amenities for efficient management and administration by GTDC departmental users. In order to feed accurate details, the following web applications were built using the ArcGIS Enterprise platform:

- **Tourist Information System:** A public web portal application for the general public and tourists.
- **Decision Support System:** An administrative web portal application for GTDC internal stakeholders.



Tourism is a major industry and remains an important source of income and employment for every nation. In the era of digital transformation, GIS plays a crucial role in attracting tourists. Goa, a globally acclaimed tourist destination is known for embracing technological transformation in its bid to boost tourism. Goa Tourism Development Corporation (GTDC) is an example of how this organization has leveraged technologies like GIS in the digital transformation of India. Established in March 1982, the Goa Tourism Development Corporation Limited (GTDC) looks after the commercial activities of the Government in the service industry of tourism in the state. The liabilities of the Government in the form of accommodation (hotels), vehicles, tours, boats, and other properties were transferred to Goa Tourism Development Corporation Limited to run and to manage the same with a view to promoting, developing in the state and to carry out business and to manage the welfare of the employees transferred along with the assets of the Government.

India to Digitally ment Corporation

Tourism Information System

Tourist Information System is a public web portal application custom configured and built to provide various tourist-related information like nearby banks, ATMs, lodges, resorts, hospitals, parking areas, etc. It shows detailed information and directions from user's location. Below are the features:

ATMs / Banks Nearby: Allows users to find nearby ATMs / Banks within a buffer distance.

Hospitals / Medicals Nearby: Allows users to find nearby Hospitals / Medical centers within a buffer distance.

Lodge and Resorts Nearby: Allows users to find nearby lodges and resorts within a buffer distance.

Rest Rooms Nearby: Allows users to find nearby rest rooms / washrooms within a buffer distance.

Legend: Displays labels and symbols for layers in the map. It can be set to automatically update when the visibility of a layer or sub layer changes.

Layer List: Provides a list of operational layers and their symbols and allows users to turn individual layers on and off. Each layer in the list has a check box that allows the user to control its visibility.

Base Map Gallery: The Base map Gallery widget presents a gallery of base maps and allows the user to select one from the gallery as the base map.

Measurement: The measurement widget allows the user to measure the area of a polygon or length of a line or find the coordinates of a point in various units.

Query: The query widget allows the user to retrieve information from source map data (Layers in the current Map) by executing a predefined query like query lodges or resorts by various facilities.

GTDC Decision Support System

GTDC Decision Support System is a web-based administrative and facility management application for internal GTDC stakeholders. This application provides in-depth details on various shacks licensed, size, owner, location, GTDC properties details, lodges and resorts

license and rating management, etc. This application has been custom built and configured to manage, obtain details, trace defaulters (in link with other applications), with different tools as per the needs of the departmental users.

Search Shacks: Enables end-users to search shacks on the GTDC application.

Shacks Nearby: Allows user to find nearby shacks within a buffer distance.

Shacks in Permissible limit: GTDC authority can find which are the shacks that are within the permissible limit from area to area for safe recreational purposes.

Bookmark: Stores a collection of map view extents displayed in the app. Allows the user to create and add spatial bookmarks through configuration or at run time after the app starts.

Share: Allows the user to share a GTDC application by posting it to their respective social media account, sending an email with a link, or embedding it in a website or blog.

Swipe Layer: Enables the user to easily compare the content of different layers in a map

Legend: Displays labels and symbols for layers in the map. It can be set to automatically update when the visibility of a layer or sub layer changes.

Layer List: Provides a list of operational layers and their symbols and allows the user to turn individual layers on and off. Each layer in the list has a check box that allows the user to further control its visibility.

Base Map Gallery: The base map gallery widget presents a gallery of base maps and allows you to select one from the gallery as the base map.

Select: The Select widget enables the users to interactively select features on the map and take actions on the selected features. The selected features can be passed on to other widgets as input

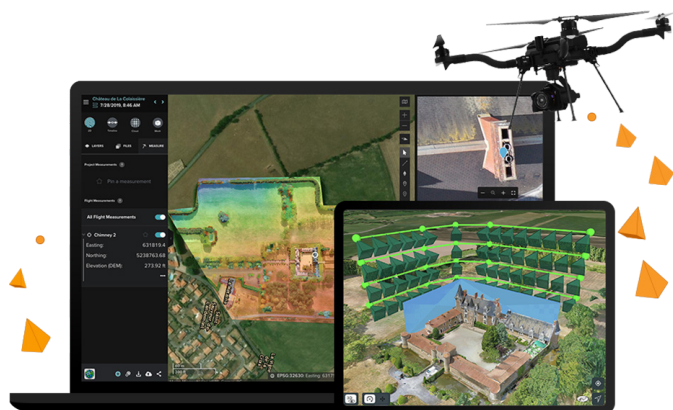
Measurement: The Measurement widget allows the user to measure the area of a polygon or length of a line or find the coordinates of a point in various units.

Draw: The draw widget allows the user to create graphics that display on the map. It can optionally add line distance or polygon area to the feature as text.

Query: The Query widget allows you to retrieve information from source map data (Layers in the current Map) by executing a predefined query. Such as: Query Shacks by Registration Number, Query Shacks by Size and Query Shacks / Lodges and Resorts by Location, etc.



Site Scan for ArcGIS



Site Scan for ArcGIS is the end-to-end cloud-based drone mapping solution. It is a one-stop solution for all the drone data in an organisation. Users can collaborate and plan their missions, execute them, process, and share the data and manage their entire fleet of drones on this platform. The data is stored on a cloud that adheres to MeitY guidelines by government of India for cloud data. The data can be securely processed a scalable cloud environment to create high-quality 2D and 3D imagery products that can be easily downloaded and shared throughout the organization.

With Site Scan, drone operators can achieve the following:

1. Plan missions and capture data with drones

Users can plan their missions from their desks or while on ground. A user can use the Site Scan Flight App which is an iOS application for an iPad and easily connect with a drone. There are different types of flight plans available such as Area (lawn mover pattern), cross-hatch pattern, perimeter and vertical scans, 360 degree panoramic photography and corridor scan. It also has terrain follow capability and enables to view flight plans in 3D. This application helps in managing flight data and in uploading the data to the cloud.



2. Process, Manage and Analyse data on the cloud

Site Scan Manager is a web-application connected to the cloud. With this, a user can process unlimited data on cloud. 2D outputs such as Orthomosaic and Surface Models and 3D outputs such as coloured point cloud and 3D Mesh can be generated from the geo-tagged images from the flight. Users can also create Full Motion Videos (Geo-tagged videos), 3D panoramas and thermal Orthomosaics. It also supports adding overlays in various formats. GCPs can be auto-detected or manually tagged to enhance data accuracy. All the data that is generated can be easily visualized and annotations such as points, distances, heights, areas, volumes, cross-sections can be made. The results can be saved on the cloud.



STEP 1

Plan

Plan the optimal flight path. For enhanced safety and planning accuracy, import layers and 3D models from previous flights.



STEP 2

Execute Autonomous Flight

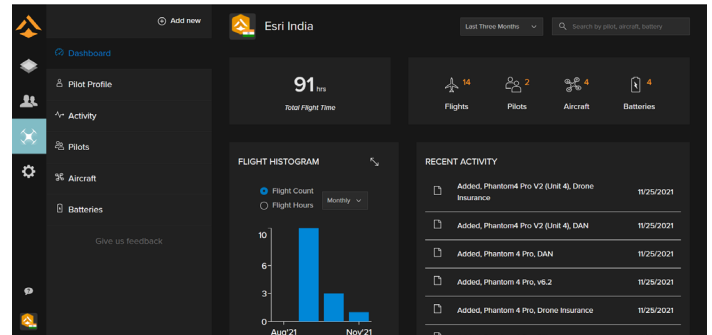
Complete your pre-flight checklist and execute an autonomous drone flight.

3. Disseminate and collaborate with team

All 2D and 3D data and annotations data from the cloud can be viewed by unlimited users. It can be shared as links with other stake holders for download or view-only. This would expedite delivery and decision making process extensively. Stakeholders do not have to rely on expensive hardware for their drone data. Users can share information with other stakeholders in formats they understand whether in a 3D view or as a report or a map. Site Scan can easily be integrated with ArcGIS Enterprise and the data can be published seamlessly. It supports processing files using reality capture technology with Autodesk BIM 360 integration. The data can also be exported in common Autodesk file formats.

4. Drone Fleet Management

Site Scan allows drone program managers to track all their assets and manpower. Managers can assign different projects to different teams and give them Admin, Full Access and Read-Only access depending on their role in the project. Site Scan can be a single window to monitor and track all the drones, sensors and batteries. It keeps a complete track record of all the pilots and their missions with exact date and time stamp. Drone program managers can also create custom pre-flight checklists for their teams and store responses within the cloud. teams and store responses within the cloud.

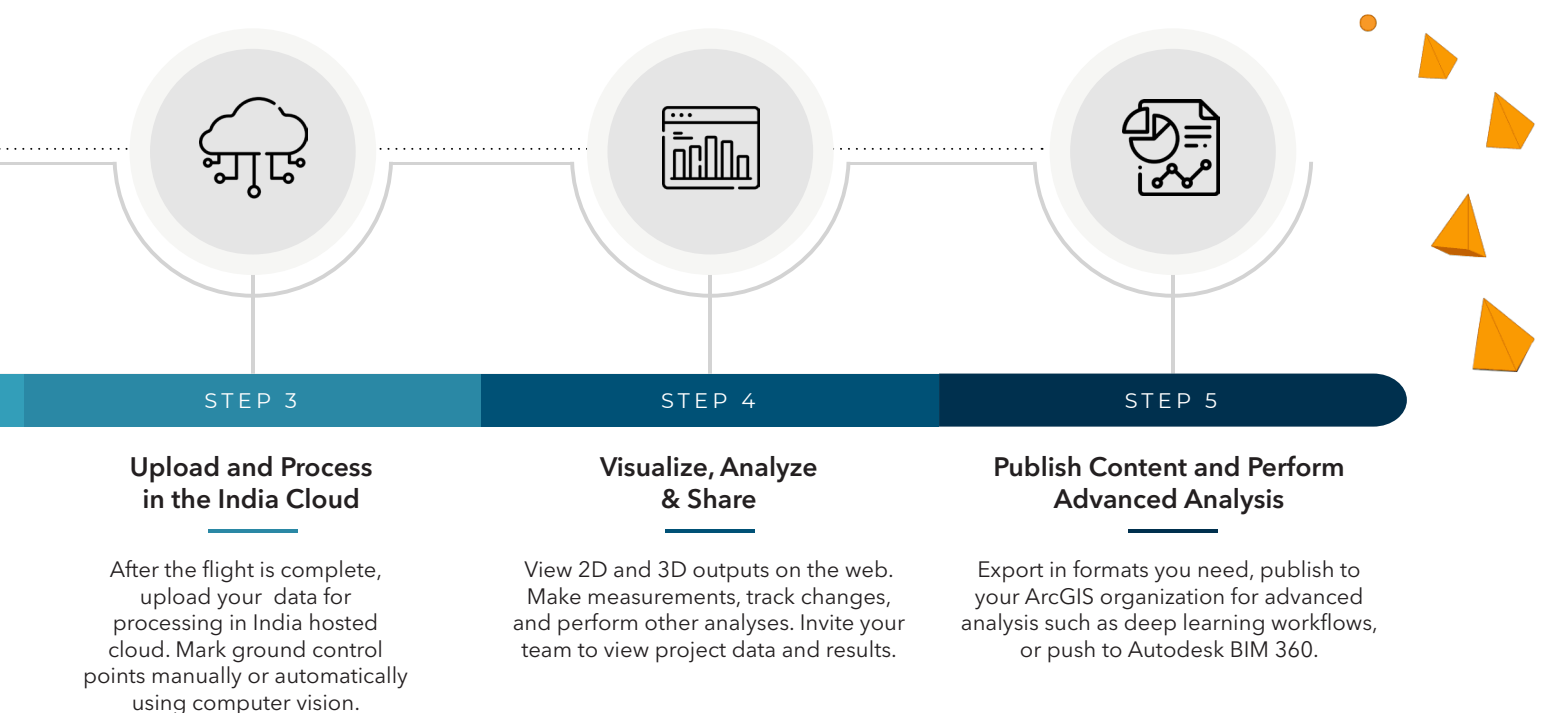


Licensing Roles

There are three types of licenses currently: Read-Only license, Access License, and Operator License with a defined set of privileges assigned to the user.

With Viewer, users can see project data in Site Scan Manager and use the measurement tools but can't make any edits or changes. On the other hand, with the access license type users can use the full functionality but aren't able to fly a drone with Site Scan Flight Planning. Lastly, the Operator license allows in addition to the capabilities of an Access license, these users can fly a drone using Site Scan Flight Planning and upload images for processing.

Hence, Site Scan for ArcGIS is a powerful and a decentralised solution for all your drone related activities.





Deep Learning with ArcGIS Pro



To implement deep learning from scratch, the initial step will be to draw hundreds to thousands of training samples. But with Esri's pre-trained, publicly available deep learning models, we can start identifying features in our imagery with one tool in ArcGIS Pro. There are out-of-the-box models available for building footprint extraction, road extraction, land cover classification, detecting human settlements, and much more. The available models can be viewed and downloaded from the ArcGIS Living Atlas by anyone with an ArcGIS Online subscription.

To use the inferencing tools in ArcGIS Pro, we will work through the following checklist:

- Download a deep learning model package (dlpk)
- Confirm your imagery is suitable for deep learning
- Determine the resolution of your imagery
- Review input parameters for the Detect Objects using Deep Learning geoprocessing tool

Run the Detect Objects using the Deep Learning geoprocessing tool

Download Deep Learning Model Package

A deep learning model package (.dlpk) contains the files and data required to run deep learning inferencing tools for object detection or image classification. The package can be uploaded to your portal as a DLPK item and used as the input to deep learning raster analysis tools.

Deep learning model packages must contain an Esri model definition file (.emd) and a trained model file. The trained model file extension depends on the framework you used to train the model. For example, if you trained your model using TensorFlow, the model file will be a .pb file, while a model trained using Keras will generate a .h5 file. Depending on the model framework and options you used to train your model, you may need to include a Python raster function (.py) or additional files.

You can include multiple trained model files in a single deep learning model package. (Note that a forthcoming blog post in this series will cover how to train your model). The easiest way to find Esri's out-of-the-box models

is through the catalog pane in ArcGIS Pro. A list of publicly available dlps will show in your search results.

Properties include the following information:

Input: The .emd file, trained model file, and any additional files that may be required to run the inferencing tools.

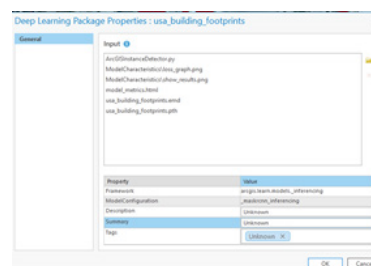
Framework: The deep learning framework used to train the model.

Model Configuration: The type of model training performed (object detection, pixel classification, or feature classification).

Description: A description of the model. This is optional and editable.

Summary: A summary of the model. This is optional and editable.

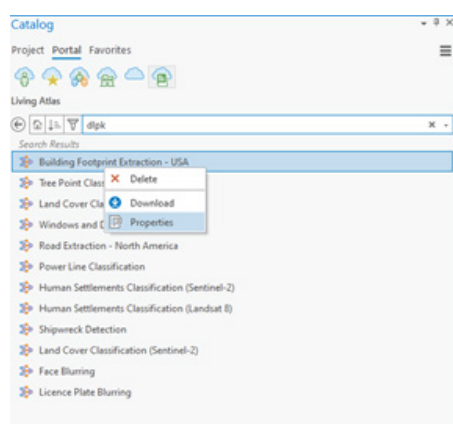
Tags: Any tags used to identify the package. This is useful for .dlpk package items stored on your portal.



Confirm your Imagery is Suitable for Deep Learning

To get the best result from an inferencing workflow, you need to first inspect your imagery visually. Deep learning models are optimized to detect features that you can see with your eyes. In this part of the blog, we will focus on a hot topic in GeoAI: building detection. We will be covering the required imagery resolution for Esri's out-of-the-box Building Footprint Extraction – USA deep learning package, but these tips are relevant to any deep learning model.

First, confirm you can visually locate buildings in your raw imagery. As an example, the image below shows some buildings in Cyprus.



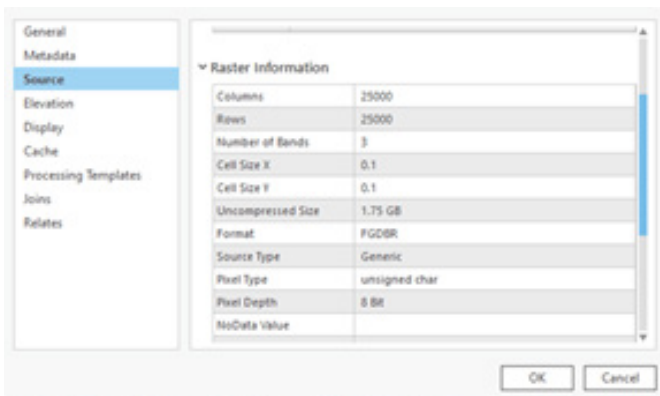


We can distinguish the individual rooftops from each other and the surroundings, so this image is a good candidate for building footprint extraction.



Determine the Resolution of your Imagery

The Building Footprint Extraction – USA deep learning package is designed to work with high-resolution images (10–40 cm). Other dlpks have different recommended resolutions – check the dlpk's item details page for more information. To determine your imagery's resolution, locate Cell Size X and Cell Size Y.



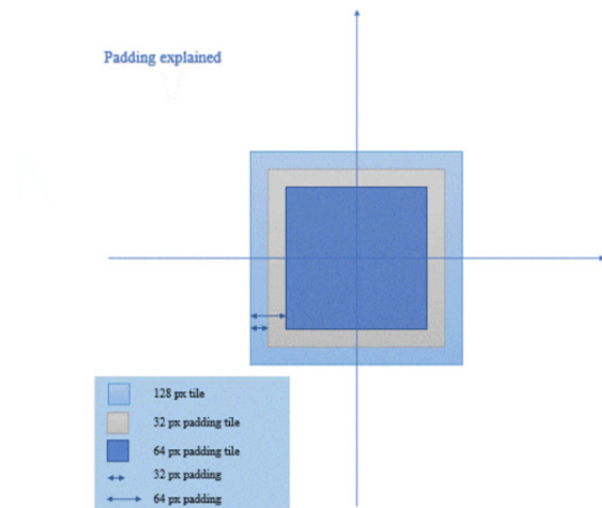
Understand Parameters for Inferencing

With all the prerequisites covered, let us dive into the Detect Objects Using Deep Learning geoprocessing tool parameters. A key element of this process is understanding the different parameters that come with the tool:

- Padding
- Batch size
- Threshold
- Return bounding box

Padding

Padding is the border area from which the model will discard detections, as they tend to be of truncated buildings that span multiple tiles during inferencing. We stride over the padded region where buildings lie at the edge in one pass of the model inferencing. In the second pass of the inferencing the buildings lie at the center of the tiles due to this striding. This means that with the padding parameter adjusted the model will adjust the stride of each tile as it runs the inferencing workflow.



Batch size

Batch size is a term used in machine learning and refers to the number of images tiles the GPU can process at once while inferencing. The images are completely eliminated and converted into tiles during inferencing, and the number of tiles the GPU can inference in one batch is called the batch size. If you run into out-of-memory errors with the tool, you need to reduce the batch size.

Threshold

Prediction models output a level of confidence for each feature (i.e., building) they detect. The threshold parameter sets the minimum level of confidence that will be included in the output.

Return Bounding Box (return_bbox)

The Return bounding box is a Boolean parameter with a True or False input. If True, the Detect Objects Using Deep Learning geoprocessing tool will return a bounding box around the detected feature rather than the feature itself.

Run Detect Objects Using Deep Learning

Now that you are familiar with the parameters for the Detect Objects Using Deep Learning tool, you are ready to start the inferencing process. You can also adjust the parameters to complete inferencing in ArcGIS Pro, you can iterate until you are happy with the output of the model.

ArcGIS 2021



ArcGIS Pro Intelligence

ArcGIS Pro Intelligence is an intelligence analysis software built for intelligence analysts working across military and civilian intelligence agencies, law enforcement, and the private sector. Use link analysis, 2D and 3D maps, timelines, imagery exploitation, and graphs to uncover patterns, trends, and relationships in data to inform decision-making. ArcGIS Pro Intelligence scales to meet your mission whether you need to conduct movement analysis, understand patterns of life, or perform investigative analysis. ArcGIS Pro Intelligence is interoperable and extensible, supporting your data integration strategy across multiple domains is connected, disconnected, and air-gapped networks.

How does ArcGIS Pro intelligence Work?

Integrate Data from Multiple Sources

Integrate data from many sources to conduct multidimensional visualization, advanced analysis, and intelligence production in one desktop environment.

Visualize your Data

See your data in maps, link charts, graphs, timelines, and tables. Manage multiple simultaneous views in a single project-based workflow.

Analyze your Data

Perform spatial, temporal, and relational data analysis to answer questions and forecast events for investigations and to support operations.

Share Actionable Intelligence

Share final assessments with stakeholders for informed decision-making.

Streamline your Work

Leverage a robust library of community-vetted symbols with layer templates and styles.

Symbology sets include the following:

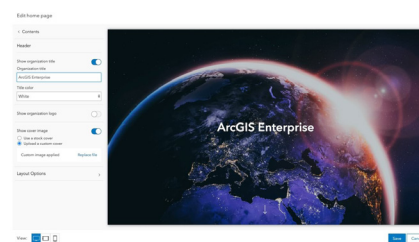
- Entities
- Drugs
- Weapons
- Pattern of Life
- Dignitary Protection
- Law Enforcement
- Critical Infrastructure
- Damage Assessment



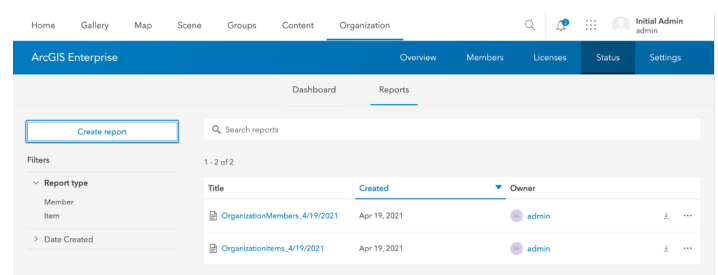
ArcGIS Enterprise

One of the most valuable updates at this release is two-way sync using distributed collaboration. With two-way sync, the enterprise customers can copy feature layers to another Enterprise organization or to ArcGIS Online and sync data edits back and forth. This allows organizations to work closely to maintain up-to-date datasets.

Here are a few other new features and capabilities of interest:



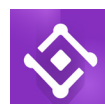
A new home page editor helps you customize your home pages using a flexible set of components that is responsive on desktop and mobile devices.



New administrative reports let administrators export inventories of items and members for a better picture of content and users in their organization.



ArcGIS Enterprise on Kubernetes is now available. To find out more about this new cloud-native offering, check out this blog or reach out to your Esri representative.



ArcGIS Mission

The latest release of ArcGIS Mission enhances the functionality in the ArcGIS Mission Manager web app, extends peer-to-peer capabilities in the ArcGIS Mission Responder mobile app, and introduces an API for automating missions with ArcGIS Mission Server.



ArcGIS Excalibur

The ArcGIS Q2 2021 release of ArcGIS Excalibur delivers a wide range of exciting new capabilities that enhance observation management workflows, including a new, interactive tabular view of observation and context features, and a way to quickly navigate to a location on an image or map.



ArcGIS Business Analyst

Two big updates have arrived for ArcGIS Business Analyst in the ArcGIS 2021 Q2 release. With this release of ArcGIS Business Analyst Web and Mobile Apps, we've been focused on making it even easier to share your analysis with your teams. Updates include a new ArcGIS Dashboards workflow, improved Custom Data Setup, curating content, exporting data to Microsoft Excel from infographics, dark mode in Business Analyst Mobile App, and data updates. For ArcGIS Business Analyst Pro, the team focused on improving performance and productivity. Updates include the addition of a popular AcMap extension to Business Analyst Pro, a new integration with Business Analyst Web App, new scenario planning tools in territory design, and more.



ArcGIS Earth

A new release of ArcGIS Earth is now available to download. This is a major release for ArcGIS Earth on desktop, bringing users more capabilities for sharing data as well as configuration settings—from mobile to desktop, to the organization portal. A new release of the ArcGIS Earth mobile app is also available now with minor enhancements.



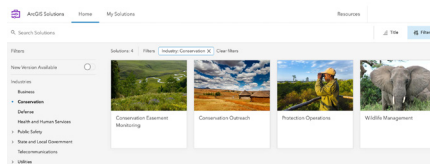
ArcGIS LocateXT

Get an overview of how to use ArcGIS LocateXT, a powerful extension for ArcGIS Enterprise that closes the gap between big data and geographic analysis. Users can drag and drop entire folders of data, including PDFs, text files, PPTs, spreadsheets, geotagged images, and even social media posts, which ArcGIS LocateXT will scan for any location information and plot it on a map, saving hundreds of work hours in manual analysis.



ArcGIS Field Maps

ArcGIS Field Maps is a new mobile app solution that allows you to streamline field workflows and take maps anywhere. You can use Field Maps to explore the maps you make in ArcGIS, collect and update your authoritative data, and record where you've gone, all within a single location-aware app. Field Maps includes a companion web app that is embedded with ArcGIS Enterprise 10.9 and later. The web app allows you to configure the maps mobile workers use in the field.



ArcGIS Solutions

ArcGIS Solutions are currently available in ArcGIS Online and will soon be available in ArcGIS Enterprise 10.9. ArcGIS Solutions is a collection of focused maps and apps that directly address challenges in your organization. They leverage your authoritative data to improve operations, provide meaningful insight, and enhance the services you provide. Built for many industries, these out-of-the-box solutions will save you time and effort in deploying, configuring, and delivering success using ArcGIS in your organization or company.



ArcGIS Pro

As part of the ArcGIS 2021 Q2 release, ArcGIS Pro enables users to expand their GIS abilities with all-new capabilities, performance, and productivity improvements. You can now export layouts as accessible .pdf files and export layouts as accessible .pdf files.



ArcGIS Dashboards

New Selectors - A big part of interactive dashboards are selectors. Adding selectors to your dashboard is a great way to allow users to interact with the data and trigger actions on other elements. In the latest release of Dashboards, selectors have been redesigned and have a fresh new look.



Improved Header Design - As an extension of the new selectors update the header element has gotten an update as well. The dashboard header element still has two distinct sizes, small and large, however, you will no longer see an option for choosing the size. Instead, the size of the header is automatically determined by its contents.

Spatio-Temporal Distribution of Aerosol Absorption Index Over the Northern Region of Indian Subcontinent

By: -

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Maya Kumari, Assistant Professor, Amity University

Abstract

Aerosols can cause a change in climate patterns by scattering sunlight and altering Earth's reflectivity. Indo-Asian aerosols have an impact on radiative forcing that causes negative forcing (cooling) at the surface and positive effect (warming) at top of the atmosphere. Satellite data have been proved to impart information about air quality. Aerosol optical depth derived from various satellites has been used extensively for more than a decade to monitor and study aerosols distribution and its effects. In the present study, an effort has been made to study the same using Aerosol Absorption Index (AAI) obtained from the Tropospheric Monitoring Instrument (TROPOMI) of Sentinel-5P. Monthly average AAI has been used to investigate aerosol distribution in the Spatio-temporal domain over the northern region of the Indian subcontinent from June 2018 to May 2019. Results showed that the AAI values are unusually high over the Delhi-Kanpur region during winters especially, during October and November, due to crop residue burning in Punjab and Haryana. Low AAI values were observed over the study area during the monsoon season corresponding to the normal rainfall. AAI is found to be increasing rapidly in the summer season especially, in June, probably due to dust storms which is a matter of serious concern as it may cause damage to the crops and also to human health.

Introduction

With the rapid increase in India's Industrialization process and rapid urban sprawl in Northern India, atmospheric aerosol concentration has gradually increased in the lower atmosphere and has become one of the major atmospheric pollutants [1-4] and research on India's atmospheric

contamination continues to increase. In the past decade, air pollution has adversely affected people's health and daily lives. Although Aerosols play a vital role in the atmosphere, they also have been a major concern for the social science community due to their adverse impacts when present in abundant quantities. The use of Remote Sensing and GIS techniques for studies and research on climate change and other related problems has increased in the recent past. The reason for the increased popularity of Remote Sensing and GIS techniques is due to the reason that they are convenient, accurate, and help in quick analysis of various meteorological, atmospheric, and lithospheric parameters.

The Aerosol Absorption Index (AAI) is one of the most basic and recently developed optical properties of aerosols as it indicates the presence of elevated sunlight absorbing aerosols in Earth's atmosphere, which denotes the reduction effect of aerosols on sunlight. The TROPOMI AAI is a kind of aerosol concentration data with wide coverage and more accuracy as compared to other sources of currently available aerosol data and is also a key factor used to determine the degree of atmospheric pollution and to evaluate the aerosol climate effects [6-11]. It is often put in use in the studies of aerosol change characteristics and local climatic effects. As in recent years, domestic and foreign scholars across the globe conducted a lot of study and research on the spatial and temporal distribution and variation characteristics of Aerosol Optical Depth [5,12-17], atmospheric environmental pollution monitoring [18], climate change impact [2,13], and other aspects of this subject and have made considerable progress. Hence in this study, the newly devised parameter AAI has been employed to observe the aerosol concentration over the Northern part of the Indian subcontinent. The study area included 5

major North Indian regions viz, Punjab, Haryana, Chandigarh, Delhi, and Uttar Pradesh.

Methodology:

• Data Acquisition:

The data for this study was acquired from the Copernicus Sentinel-5P satellite, which is the result of collaboration between ESA, European Commission, Netherlands Space Office, Industry, Data users, and Scientists. The mission consists of one satellite carrying the Tropospheric Monitoring Instrument (TROPOMI) instrument, with a spatial resolution of 7 km×3.5 km (along-track × across-track). The TROPOMI instrument was co-funded by ESA and the Netherlands. Among the two data products (Level 1 and Level 2) associated with the three levels of TROPOMI processing, the geolocated cloud and aerosol information (e.g., absorbing aerosol index and aerosol layer height) come under Level-2 products.

• Data Processing:

The processing of data involved in this study mainly involved the acquisition of aerosol absorption data, projection definition, image subsetting, data aggregation, and mean calculations to study the spatial and temporal distribution and variation characteristics of AAI. In this paper, first, the format of the acquired AAI data was converted from NetCDF to GeoTIFF format. Later, the AAI data was subjected to WGS 1984 projection, and then the image of the study area was extracted using the boundaries of the major Northern states of India in ArcGIS. Finally, the AAI data were aggregated and averaged.

The obtained aerosol data were first screened to ensure its accuracy before the calculation of AAI, and the valid data (data were considered valid if the percentage of valid pixels in the image data was greater than 50%) were retained. Then, the seasonal, monthly aggregation, and mean values of the aerosol product data were calculated using ArcGIS. The monthly average AAI of the study area analysed in this paper was obtained by accumulating the daily AAI and then averaging. The seasonal average AAI and monthly average AAI were obtained by accumulating the monthly average AAI and daily AAI respectively. The quarterly/seasonal divisions used were, Monsoon from July to October, Winter from November to February, and Summer from March to June.

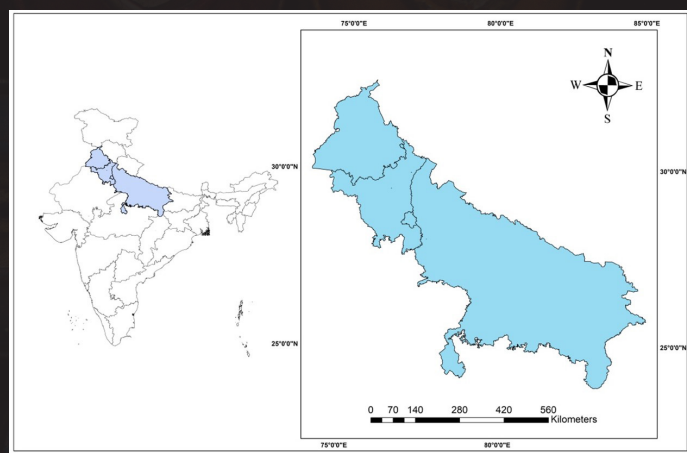


Fig: 1 – Study Area

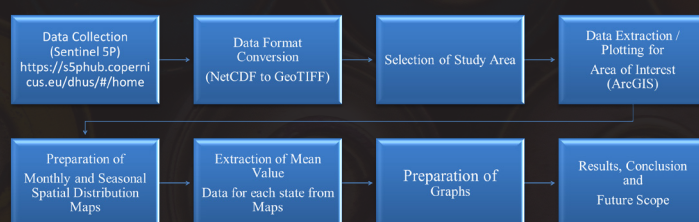
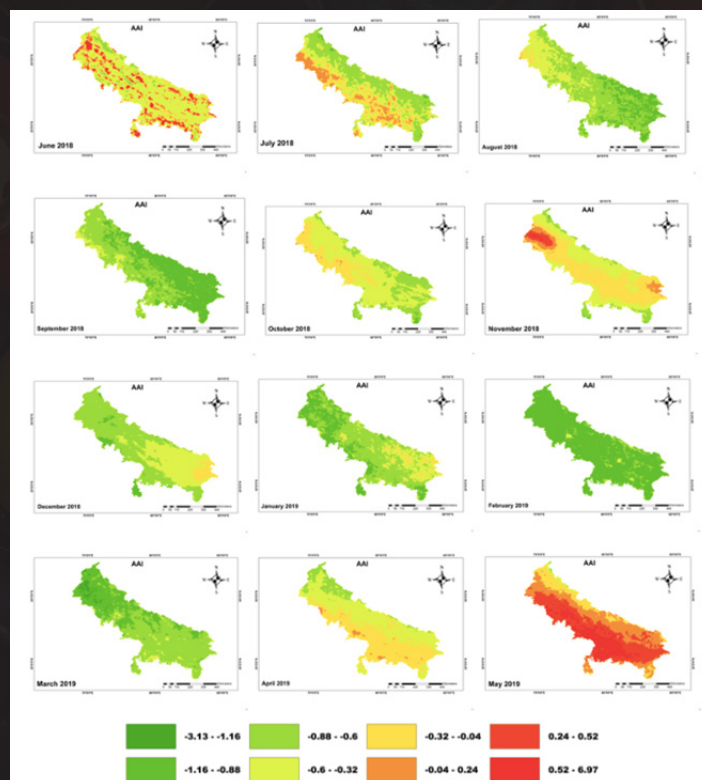


Fig: 2 – Research Process

Results:

• Monthly Average Distribution and Variation of AAI:



It can be observed from the Maps that the values of AAI are high over Punjab, Haryana, Delhi, and Kanpur region during October and November. Comparatively lower AAI values were observed over the study area during August, September, February, and March. The Absorption Aerosol Index is found to be increasing rapidly in May and June. The graph given below gives a comparative variation of AAI for all the months over one year, from June 2018 to May 2019.

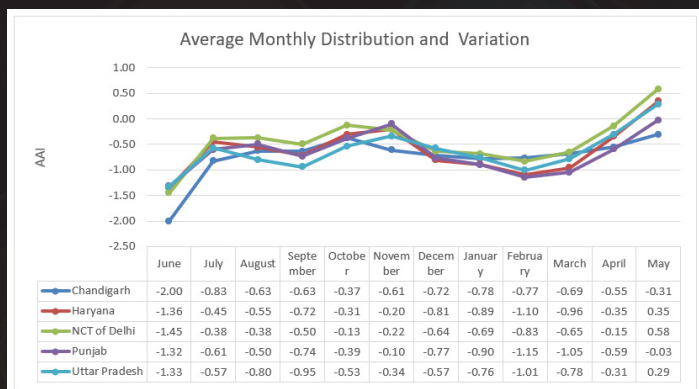
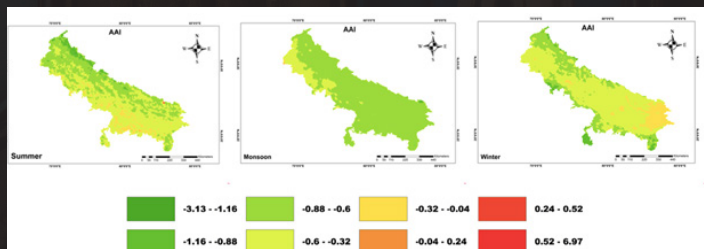


Fig: 4 – Graphical Monthly Average AAI Variation

(ii) Seasonal Average Distribution and Variation of AAI:



As can be ascertained from the Images given above, the average AAI values are higher during the winter and summer seasons. As compared to the winters and summer season, the AAI values over the study area for monsoon were observed to be relatively low. Uttar Pradesh recorded the highest values of AAI for both the summer and winter seasons. Chandigarh was observed to have lower AAI values during the whole year. A detailed comparison of AAI values for all the seasons is given below in the graph.

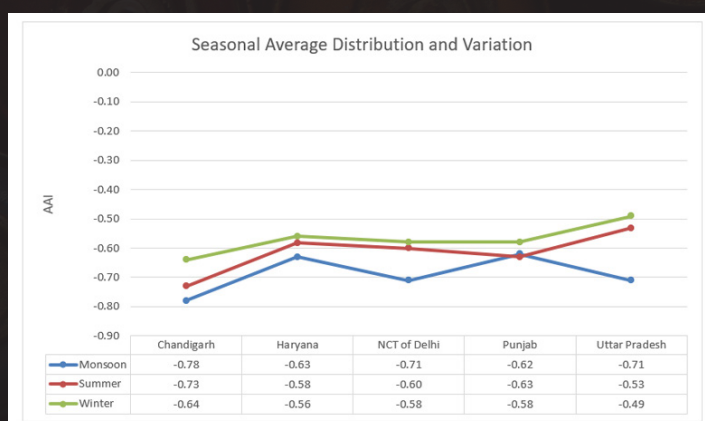


Fig: 6 – Graphical Seasonal Average AAI Variation

Conclusion:

Results from the study showed that the AAI values are quite high over the whole Delhi-Kanpur region during winters especially during October and November, due to crop residue burning in Punjab and Haryana which causes a huge impact on the climate equilibrium directly by scattering and absorbing sunlight radiations and indirectly by influencing cloud forming properties. AAI values were observed to be comparatively low over the study area during the monsoon season, corresponding to the rainfall. Absorption Aerosol Index was found to be increasing rapidly in the summer season especially in May and June, probably due to the dust storms coming from the North-Western region. All such increased levels of Aerosol over Northern India have serious implications to the crops and human health as well.

The excessive loading of aerosols in the atmosphere can be a combined effect of both anthropogenic as well as natural activities, both amplifying the overall adversity on living beings. It is however the next step of this study to ascertain the major contributors of the overall aerosol emission, which further need to be mitigated. The major hotspots for high Aerosol generation in the winter season as per this study are Haryana and Punjab, which subsequently causes elevation of aerosols across neighboring states as well. This research can be used as a platform for further study over the North Indian part to look out for the probable solutions to curtail increasing Aerosol concentration in the areas generating huge amounts of Aerosol every year. This research can also be taken as a reference on the implementation of AAI from Sentinel 5P TROPOMI, as a tool to study the Aerosol Pollution as compared to the conventional use of AOD for the same. Validation of the same can be done in the next step of this study.

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