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COVER STORY

GIS for Land Use & Land Administration

CASE STUDY
MahaBHUMI Geo-Portal

ARTICLE
Geospatial for Land Management

PRODUCT REVIEW: ArcGIS BUSINESS ANALYST
ArcGIS Business Analyst is a powerful tool for anyone involved in business analysis, market research, or location-based decision-making.

ESRI INDIA LOCATIONS

DELHI NCR

Noida (Corp. Office)
10th Floor, Max Tower, Sector - 16B
Noida - 201301, Uttar Pradesh

Jasola (Regd. Office)
Plot no. 8, Elegance Tower, 5th Floor,
Unit No.505 & 506, Pocket - 1, Jasola Vihar,
New Delhi - 110025, Delhi

BENGALURU
IndiQube Gradeur 14, Walton Rd,
Shanthala Nagar, Ashok Nagar,
Bengaluru - 560001, Karnataka

HYDERABAD
Apeejay Business Center, Tresorie,
1st Floor, The PARK, 22, Raj bhavan Road,
Hyderabad - 500082, Telangana

KOLKATA
Urbanwrk Private Limited, 8th Floor, Technopolis
Building, BP Block, Sector V, Bidhannagar,
Kolkata - 700091, West Bengal

MUMBAI
AWFIS Space Solutions Private Limited,
Auram Qparc, Building Q2, 8th Floor, TTC,
Thane-Belapur Road, Ghansoli,
Navi Mumbai - 400710, Maharashtra

PANCHKULA
3rd Floor, Plot No 16, IT Park, Sector - 22,
Panchkula - 134109

1st Floor, Plot No - 1, South Block, IT Park, Sector - 22,
Panchkula - 134109

esri India

Esri India Technologies Pvt. Ltd.

10th Floor, Max Towers, Sector 16B, Noida - 201301, Uttar Pradesh (India)

1800 102 1918 info@esri.in esri.in

@esriindia

Scan to visit esri.in

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MD'S DESK

Agendra Kumar
Managing Director, Esri India

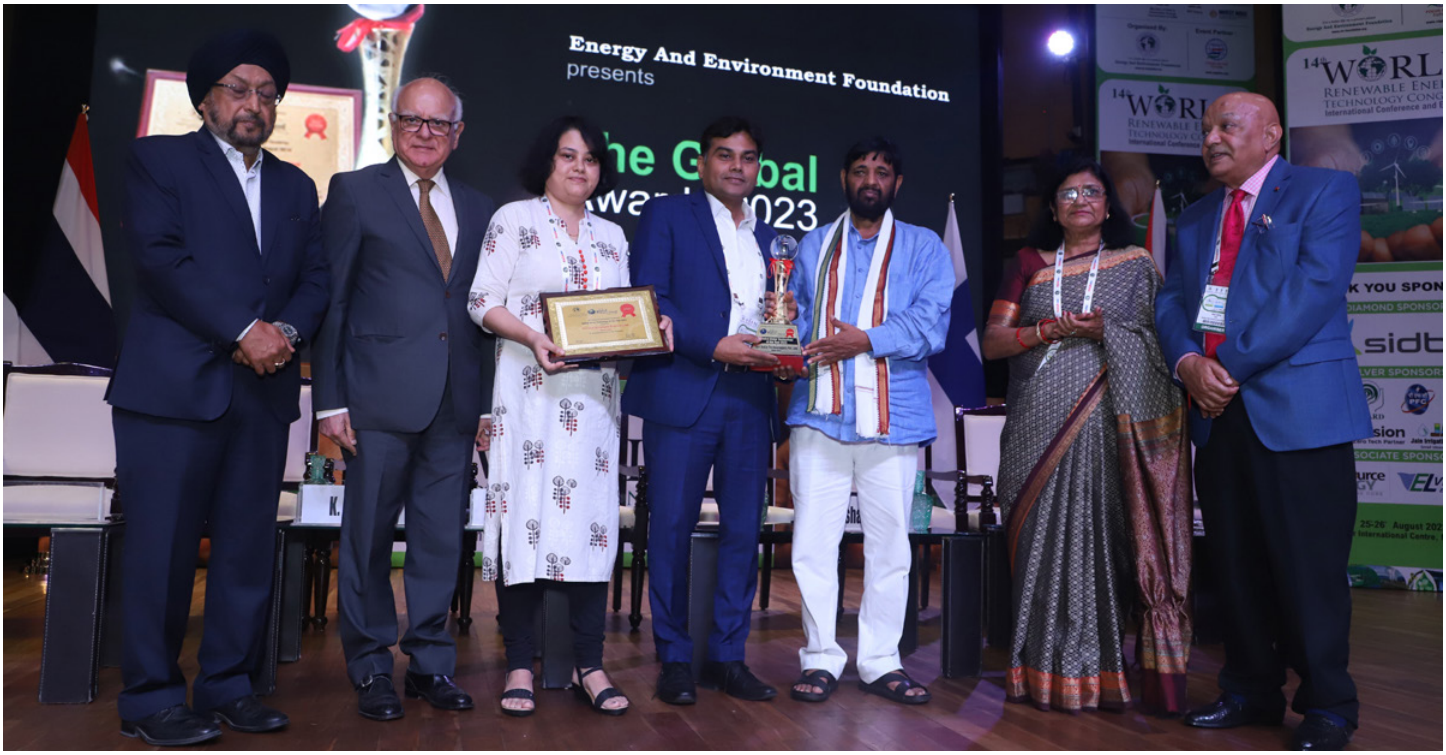
Land is a valuable economic asset. It serves as a critical and fundamental source of livelihood for many, especially in the rural areas. 60.3% of India's arable land employs close to 60% of the Indian labor force. For many individuals and families, owning land represents a long-term investment and a means of building financial stability and security. In such a case, it becomes all the more important for us to not only adopt sustainable land management practices but also develop sustained solutions for solving granular problems such as establishing clear land ownership titles.

Ambiguity in land ownership often leads to a range of problems, affecting individuals, communities, and even the broader economy. Ambiguous land titles often result in legal disputes, leading to prolonged litigation. Unclear land ownership also deters potential investors from entering the market, as they may be reluctant to invest in properties with uncertain legal status. This, in turn, hinders infrastructure and development projects. According to Land Conflict Watch, a data research agency, land disputes in India currently impact roughly 8.2 million people and affect approx. INR 2.9 trillion in investments.

The ambiguities often get aggravated by outdated or inadequate land records, making it difficult to establish and verify ownership. To address these challenges, the Government is making huge efforts to improve land governance and streamline the process of land transfer and mutation using technologies like GIS. GIS integrates various data sources, such as survey data, satellite imagery, and cadastral information, to create comprehensive and accurate maps of land parcels. GIS systems can be linked to databases containing information on land titles and ownership. This facilitates quick and efficient verification of land ownership by spatially locating and cross-referencing ownership information with map data. GIS can also be used for historical analysis of land ownership changes, helping authorities track the evolution of land ownership patterns over time. By allowing the comparison of historical land records and maps, GIS assists in determining the legitimacy of land claims.

ArcGIS Parcel Fabric allows organizations to effectively manage 2D, 3D, and 4D parcel data, including strata and subsurface information, ownership records, and agricultural and natural resource rights. This next-generation solution provides a comprehensive framework for managing, editing, and sharing parcel data in both multiuser and single-user environments. With its advanced capabilities, Parcel Fabric enables efficient parcel mapping, improving communication and collaboration within land record organizations. The Parcel Fabric preserves historic and parent parcels, thus helping in tracking parcel lineage. By leveraging this advanced GIS technology, land record organizations, government agencies, real estate developers, and utility companies can improve their operations, decision-making, and long-term success.

We are working with various State Governments to help them optimally manage all aspects of land information management including land tenure, value, management, and use. As the Government takes more concrete steps to improvise the land administration processes, we aim to function as a strong collaborator. The integration of GIS into land administration fosters informed decision-making at all levels, paving the way for inclusive and equitable growth.



Esri India wins EEF Global Water Award

The Energy and Environment Foundation Global Water Awards recognize the most important achievements in the international water industry within several categories to honor and reward those initiatives in the water, wastewater, and desalination sectors from world over to focus on innovation, technology, conservation, and sustainable finance. The Awards encourage and celebrate the responsible business movement across the globe.

Esri India won The Energy and Environment Foundation Global Water Technology of the Year Award 2023 for the India-WRIS project.

India WRIS is a one-of-its-kind comprehensive Water Resources Information System (WRIS) that provides authoritative, and consistent data and information on India's water resources and allied themes. This information enables the stakeholders to achieve highly effective outcomes in the planning, development, and management of water resources in the country. India-WRIS is a national-level decision support system used for informed decision-making and strengthening the capacity of targeted water resources professionals and management institutions in India.

The Award was presented during a 2-day international conference on renewable energy, water, and waste-to-wealth management, held in New Delhi. The event witnessed the participation of many esteemed public and private organizations.

Esri India Master's Scholarships in GIS – 2023 Winners Announced

Scholarships worth 10 Lakhs Awarded

In November 2022, Esri India announced a 'Master's Scholarships in GIS Program,' to award INR 1 lakh each as Scholarship to 10 deserving students at the post-graduate level, every year. The Program, which is intended to run for 10 years, is designed for Indian students who are beginning the 2nd year of their post-graduate course in GIS, Geoinformatics, or a similar subject at an institute/university in India. The aim of the Scholarship Program is to recognize and support outstanding students who have demonstrated exceptional academic achievement, and a commitment to making a positive impact using GIS.

The first year of the Program was recently concluded with the selection of 10 recipients of the Scholarship. The selection followed a rigorous process that involved submitting a Statement of Purpose, a Project Synopsis, and a Presentation and Interview with an esteemed Jury. Apart from the Scholarship, the students will also get Esri's ArcGIS software for their personal use.

Commenting on the Program, **Agendra Kumar, Managing Director, Esri India** said, "We launched the Master's Scholarships in GIS

Program to encourage students to gain higher competence and make significant contributions in the field of GIS. We were delighted to receive such an overwhelming response to this initiative. Selected students demonstrated clarity of thought, drive to innovate, and make a difference to society. We are extremely happy to announce 10 winners for this year's scholarship. I wish a promising career to them where they use GIS in solving some of the pressing social and business problems."

Esri India received more than 200 applications for the Scholarship Program from students pursuing diverse courses such as Soil Science, Water Resource Engineering, Geology, Geoinformatics, and more at varied prestigious institutes/universities across the country. After thorough rounds of assessment, the following 10 students were selected for the prestigious Scholarship:

Mahreen Zahra	Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir
Jay kumar Singh Chauhan	Indian Institute of Technology, Kharagpur
Bhavya Anand	TERI School of Advanced Studies, New Delhi
Boddepalli Navjoth	Indian Institute of Technology, Kharagpur
Deepak Meena	Indian Institute of Technology, Delhi
Shrabani Kar	Vidyasagar University, Midnapore
Ananthu P S	Centre for Environmental Planning and Technology University, Ahmedabad
Raghavendra SP	Visvesvaraya Technological University, Belagavi
Vimarsh Kumar	Symbiosis Institute of Geoinformatics, Pune
Baby Sonal	Birla Institute of Technology, Mesra


Mahreen Zahra


Jay kumar Singh Chauhan


Bhavya Anand


Boddepalli Navjoth


Deepak Meena


Shrabani Kar


Ananthu P S


Raghavendra SP


Vimarsh Kumar


Baby Sonal

Esri India's Customers Win Geospatial Excellence Awards

Geospatial World recognizes outstanding examples of innovation and excellence in the geospatial sector each year with the Indian Geospatial Excellence Awards. These awards are awarded to projects that showcase exemplary usage of geospatial tools at GeoSmart India, Geospatial World's flagship annual geospatial event in India.

This year, Esri India's customers, **The National Water Informatics Centre (NWIC)** and **Sterlite Power** were awarded the Geospatial Excellence Awards for their projects "India Water Resource Information System (India-WRIS)" and "An integrated GIS ecosystem for powerline route planning and finalization" at GeoSmart India.

Centre for Knowledge Sovereignty and Esri India Join Hands to Launch Program in Geospatial Skilling

Leading Indian Public Policy Think Tank Centre for Knowledge Sovereignty (CKS) and Esri India have joined hands to launch the **'Master Mentors Geo-Enabling Indian Scholars' (MMGEIS) program** in the country. The program targets students from 8th grade to undergraduate levels and aims to make India a global skilling and innovation hub for geospatial technology. The program will also work towards fostering a strong IP framework to enable more patents from India in its journey towards becoming a global geospatial innovation hub.

With the aim of enabling up to 1 lakh students per year, the program is designed to spread geospatial awareness at the school and college levels and set the stage for next-generation geospatial research and innovation by mentoring promising students under the guidance of leading scientists and innovators like Shri Kiran Kumar, former Chairman of ISRO, Dr K J Ramesh, former Director General of IMD and Shri Girish Kumar, former Surveyor General of India. The program will tap pan-India talent through a comprehensive process and will provide students with vision talks and interaction with Master Mentors, one-on-one mentoring by experts, and interactive activities.

Vinit Goenka, Secretary, Centre for Knowledge Sovereignty, highlighted, "A skilled mentor has the power to significantly enhance a student's life. When we conceived MMGEIS, our intention was to extend this idea and offer students a platform to develop skills that would shape them into thought leaders. Through MMGEIS, we aim to nurture the personal growth of students by fostering curiosity, critical thinking, and problem-solving skills. Ultimately, our goal is to establish a robust foundation that inspires our children to become innovators and make meaningful contributions to the development of our nation."

Agendra Kumar, Managing Director, Esri India, stated, "We're delighted to join hands with the Centre for Knowledge Sovereignty on this significant initiative. GIS technologies are poised to play a critical role in India's development trajectory with applications across sectors like Urban Planning, Natural Resource Management, Agriculture and Land Records, Disaster Management and others to improve the lives of citizens. The MMGEIS program reflects our shared vision to empower school and college students to think spatially, innovate and create intellectual property in the geospatial space. This will play a crucial role in achieving our goal of making India a developed country by 2047 and enhancing India's presence on the world stage."

AS Kiran Kumar, Member, Space Commission and Former Chairman, Indian Space Research Organization (ISRO), shared his views, "The introduction of the Master Mentor Geo-Enabling program marks a significant step in India's journey towards becoming a leading innovator. We anticipate this initiative will lead to a surge in patents filed by young Indians, showcasing their creativity and the program's effectiveness. These patents, expected to cover a range of fields from environmental solutions to technological advancements, will highlight India's growing stature in the global arena."

The MMGEIS program is designed to nurture students' spatial thinking from an early age to enable them to develop the capacity to analyze and interpret spatial data, ultimately leading to the generation of innovative solutions and the creation of new intellectual property.

GIS for Land Use and Land Administration

India with only 2.4% of the total land area of the world is supporting 18% of the global population. Naturally, the pressure on the land is much beyond its actual carrying capacity. An unavoidable outcome of this scenario is the land's constant degradation and the fast conversion of productive lands into wastelands. Mapping of degraded lands in the country by ISRO's Space Applications Centre has indicated that an area of 97.85 million hectares, which accounts for about 29.77% of the country's total geographic area, is under degradation as of 2018-19.

Land provides the foundation for shelter, supports agriculture and natural resources, contributes to cultural identity, fosters economic development, and plays a crucial role in environmental health. As the global population continues to grow, sustainable land management becomes increasingly important to ensure the well-being of present and future generations.

Inequality arising due to ambiguity in land ownership is also a great cause of concern. Land ownership is often linked to various aspects of social, economic, and political inequality. Ambiguity or lack of clear land ownership leads to unequal distribution of land resources. In many cases, a small percentage of the population holds a large proportion of the land, while a significant number of people have limited or no access to land.

Disparities in land ownership also contribute to rural poverty. Small and marginalized farmers may struggle to access land, leading to economic hardships and perpetuating a cycle of poverty. Land-related disputes and lack of clarity in ownership also often lead to conflicts.

Intelligent Land Information Systems can help solve these problems. Land parcel data (also known as cadastral data) provide geographically referenced information about the rights, interests, and ownership of land. The data can be used by governments to make informed decisions about land titles, land development, property tax management, law enforcement, and more. Accurate measurement of land parcels also helps the government to assess property taxes more accurately and earn more revenue.

Intelligent Land Information Systems

The three necessary systems that comprise an Intelligent Land Information System are the **"System of Record" (parcel data), the "System of Insight" (valuation), and the "System of Engagement" (stakeholder and public engagement).** GIS efficiently delivers all three on a single platform.

Additionally, as land administration increasingly moves towards adopting the "Sensor to Software" approach, GIS can offer a cost-effective, efficient, and safe way to monitor land, analyze data, and make informed decisions about land management. With the help of drones, urban planners are able to collect large amounts of up-to-date data in a short period of time. They are able to reach areas, otherwise difficult for people to reach and do manual surveys. The images collected by drones allow planners to examine the existing social and environmental conditions of the sites and take into account the impact of different scenarios. Aerial images taken by drones accelerate and simplify topographic surveys, necessary for land management and planning. For the purpose of land management, it is necessary to process the data collected by drones effectively. GIS enables the production of high-accuracy cadastral maps, high-resolution orthomosaics, and detailed 3D models from drone data quickly and easily, even in complex environments. Using GIS, surveyors can extract features from the images, such as signs, curbs, road markers, fire hydrants, and drains, leading to highly efficient land use planning and management. Esri's ArcGIS is an effective platform that enables users to exploit, manage, and share the data captured by any UAV.

GIS as a System of Record: Parcel Data Management

Parcel data is a complex web of ownership, boundaries, and historical data. Managing these efficiently and accurately can be daunting, but thanks to tools like Esri's ArcGIS Pro and ArcGIS Enterprise, authorities can achieve streamlined land administration. As a System of Record, GIS provides crucial information about land ownership, land use, and various property-related transactions. This information is maintained by government authorities at the local, regional, or national level and serves as a crucial component of a well-functioning land administration system.

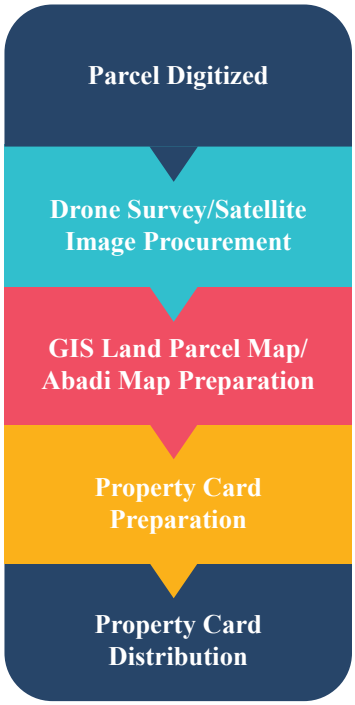


Figure 1: GIS Workflow in Parcel Data Management

Indo ArcGIS is a unique product, developed by Esri India to solve some of the most pressing social and business challenges the country is facing today. Indo ArcGIS includes solutions and data products for achieving

excellence in land records management, property tax management, urban and regional planning, etc. These solutions are supported by 800+ layers of Indian datasets available through the Indian edition of ArcGIS Living Atlas.

A comprehensive GIS Solution for parcel management helps in achieving efficient workflows, improved field operations, higher accuracy, aggregated parcel data, better visualization, and more informed decisions.

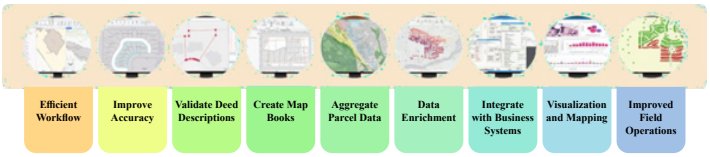


Figure 2: Comprehensive GIS Solution for Parcel Data Management

Accurate land records verification and management systems help in establishing and verifying property rights, supporting land transactions, and ensuring transparency and legal compliance in land-related matters. Improved analytical systems bring more power to the citizens, allowing them to use their land as a financial asset as well.

Accurate land parcel data management also helps in the process of mutation or transfer of land. In case of rural land many times, historical data about the ownership of the land is not available, and this creates a risk of litigation. GIS-based Land Information Systems, by enabling mapping and registration of lands, play an important role in land dispute resolutions. The risk of litigation also comes down due to the availability of historical data about land ownership.

GIS also helps in the accurate valuation of a piece of land based on its location. For instance, if a land is nearer to a river, a highway, or a road, the value of the land is typically higher than the land that is located inside. Once this kind of valuation is recorded, the accurate stamp duty charging at the time of registration can also be easily achieved. Accurate valuation of land also helps in matters of transferring land as part of inheritance.

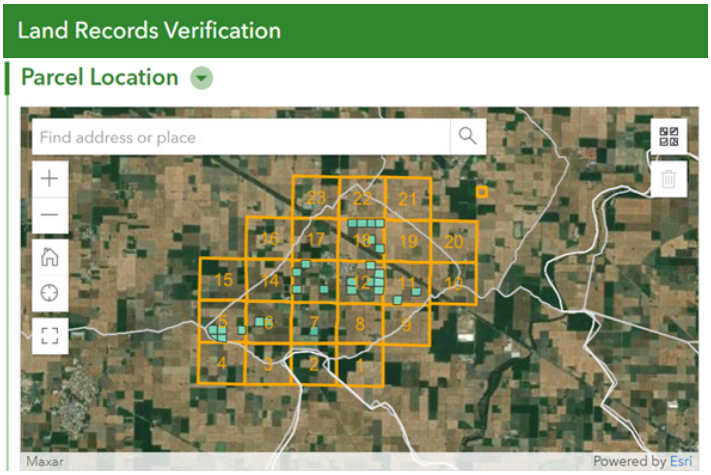


Figure 3: Land Records Verification Powered by Indo ArcGIS

GIS as a System of Insight: Valuation Modelling

Assessors are often looking for information to analyze how well their assessments are performing at various levels of the spatial hierarchy—in certain market or submarket areas or neighborhoods. Assessment inequity, or dissimilarities among assessments of similar properties, can be caused by many factors, such as field appraisers miscoding a property's features. This can bring errors in defining assessment models and drawing market areas.

When authorities map and analyze property values with GIS, they achieve significant improvement in property value assessments. Location analytics enables them to enrich their data and visualize the results to uncover trends and patterns. With the help of GIS, they can quickly detect errors and outliers, refine valuation models, and deliver more accurate data to the stakeholders and taxpayers. GIS also allows quick mapping of price per square foot, comparable properties, and sales ratios to improve efficiency and property analysis.

Using GIS as a System of Insight, assessors can visualize sales ratio studies at different levels of aggregation—by the market, submarket, or neighborhood level, for instance. This information helps them to see where they are performing well and where assessments may need to be shored up or reevaluated.

GIS dashboards also allow assessors to select property data and drag it onto a card to visualize it as a map, chart, or table. The cards can be linked, making digging deeper into the data quick and easy. To concentrate on one data selection, such as market area or quality of construction, a user can pick that row in a table to automatically change the maps, charts, and graphs. Esri's ArcGIS offers a variety of tools that can provide invaluable insights to officials for better management. Indo ArcGIS' solutions for Land Records Management can enable the Revenue Department to collect data from the field, assess it, and make more informed decisions.

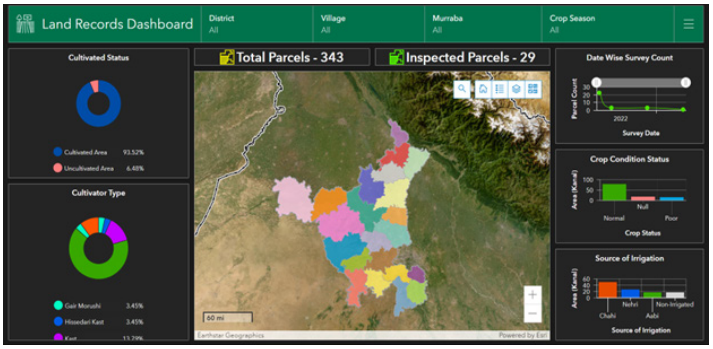


Figure 4: Land Records Dashboard

Local government organizations are always in need of quick, cost-effective ways that can help them get more insight out of their data. GIS-powered dashboards serve as a great tool for presenting operational, analytical, and other types of data. These dashboards allow local government officials to easily visualize and analyze the data they have collected, helping them to make informed decisions.

For example, the following Green Cover Dashboard powered by ArcGIS enables the Brihanmumbai Municipal Corporation (BMC) to assess the green cover for the years 2002, 2012, and 2022 providing a representation of the changing landscape over the past two decades. Users can easily compare and analyze the declination of green cover, highlighting significant alterations in land use and environmental trends. This tool offers valuable insights into the shifting dynamics of vegetation and urban development over time.

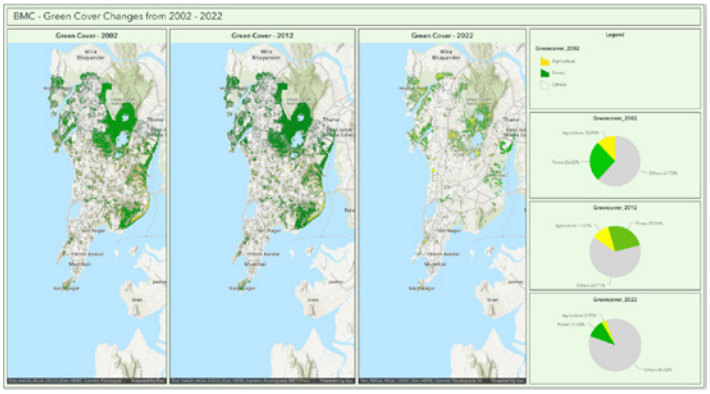


Figure 5: BMC Green Cover Dashboard

Also, ArcGIS powered MahaBHUMI Geo-Portal used by the Maharashtra Remote Sensing Centre (MRSAC) allows GIS to serve as an effective System of Insight by providing the users the ability to query and access geospatial data in various domains including transport, urban planning, topography, land use & land cover. It serves as a valuable resource for government agencies to access and analyze geospatial data for informed decision-making and planning.

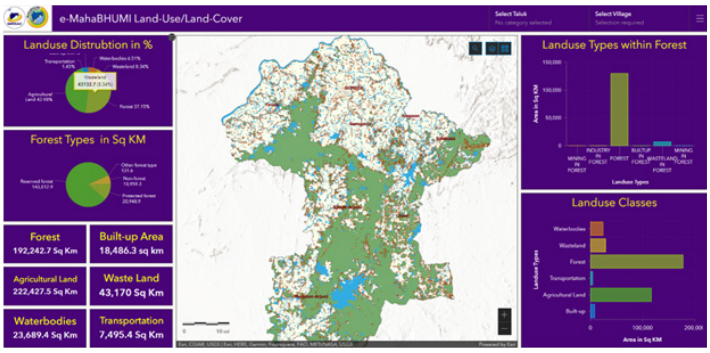


Figure 6: MahaBHUMI Land use/Landcover Theme Sample Dashboard – for Gondia District

GIS as a System of Engagement: Collaborative Decision-Making

GIS enables authorities to improve transparency and stakeholder engagement. It is vital for land authorities to maintain public trust and confidence. In the past, sharing data and property information internally and with the public involved property cards, folios, and paper maps. Today, citizens, taxpayers, and the public expect property information to be easy to find, quick to understand, and available on any device. GIS as a System of Engagement allows the agencies to share property information with web maps, apps, open data, hubs, and services. Additionally, sharing authoritative data internally with services allows systems to connect to each other eliminating duplicate data and duplicated work.

Figure 7: Indo ArcGIS Solutions enable the Public to Gather Details about their Properties

GIS-powered dashboards keep organizations and the public in the know with a vast amount of valuable information daily. GIS delivers transformational technology to assessors. GIS-based land information management systems can be used to inform taxpayers of critical timelines in the assessment process, allow the public to access property data at any time and on any device with modern, easy-to-use maps and apps, and enable easy sharing of data among the stakeholders.

For example, a Geospatial Hub powered by ArcGIS enables BMC to provide access to a wide range of geospatial data and tools to the public. By making various geospatial datasets and applications publicly available, the application allows BMC to gain higher engagement with the citizens. It is user-friendly and can be used in a collaborative manner across different domains.

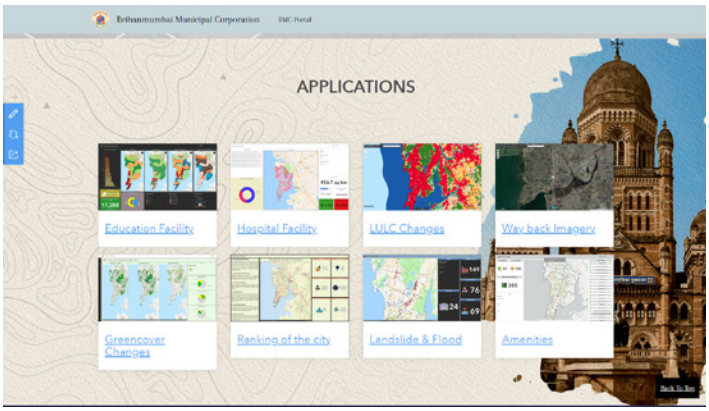


Figure 8: BMC Geospatial Hub Fostering Higher Citizen Engagement

In Summary

GIS qualifies as an effective tool for accurate large-scale spatial data management, data integration, mapping, analysis, modeling, and decision-making. It streamlines workflows, thereby helping authorities avoid duplication of effort and problems with data accuracy. By linking maps and legal descriptions to land ownership records, GIS provides an efficient method for record-keeping as well as identifying errors in land records. A GIS-based workflow that uses topology tools helps eliminate errors resulting from overlapping boundaries, incomplete parcel descriptions, and other discrepancies in land records. Additionally, advances in Web GIS make parcel information and maps readily available to the public, businesses, and other agencies, and that saves time and money.

GIS technology easily accommodates multiple users, parcel history maintenance, and data security. Its capabilities for data sharing and documentation enable organizations to build and share information more widely, and a GIS facilitates the creation of data of known quality, making it the preferred means to distribute public geospatial data.

With its focus on data, GIS technology can manage large amounts of information covering a wide geographic extent in a single, seamless spatial database. GIS has the capability to store real-world features accurately and effectively. GIS features are stored as elements in spatial databases, and data structures manage the connectivity of linear features into linear or polygon networks. Boundaries can be made of simple or complex linear features. GIS technology uses the concept of layering for segregating different kinds of information into more easily managed units.

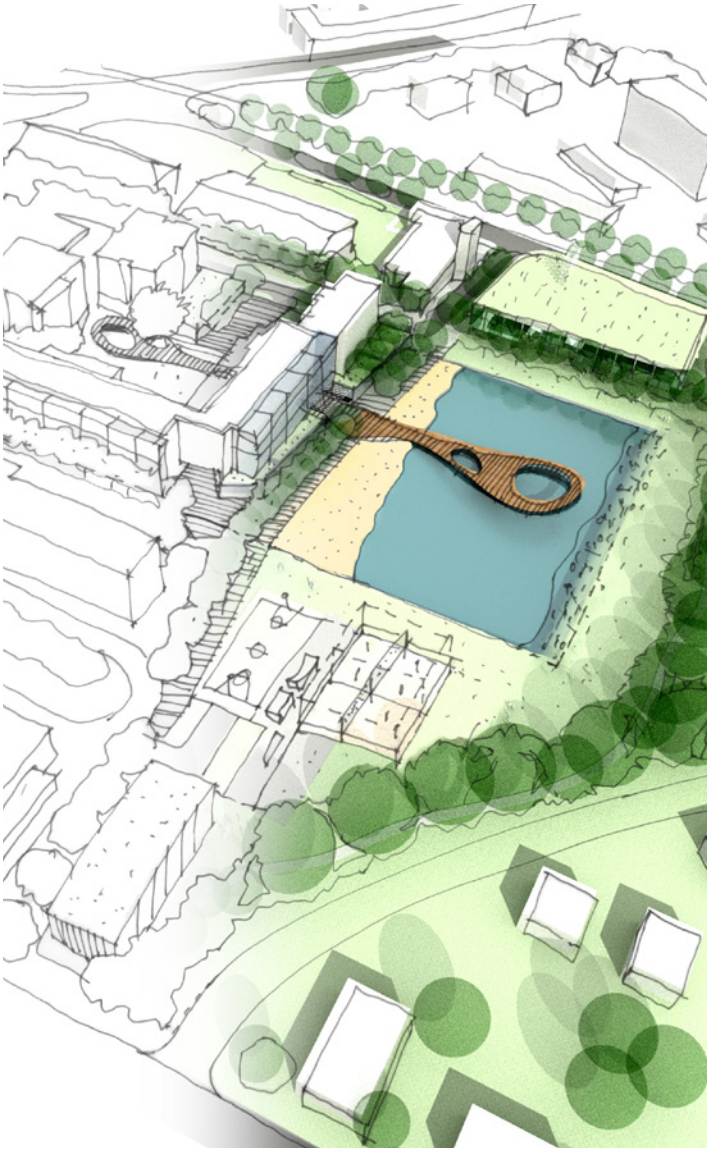
The interoperability tools of GIS overcome the usual problems associated with file conversion. Users can perform data migration or support map distribution according to their specific needs. They can use the appropriate tool for the job while ensuring the flow of information across the enterprise. Local governments generally are concerned with the issues related to a single, common geography, which points to the need for a centrally managed and shared GIS. An enterprise GIS enables users from different departments in an organization to use common data for their specific tasks. Adopting an enterprise geodatabase is more widespread because it helps organizations be more accountable and efficient. GIS enables stakeholders to respond to requests for information faster, serve clients better, and respond to governmental issues, all while reducing costs.

ArcGIS is a valuable tool in the field of land administration, offering a comprehensive set of capabilities for managing and analyzing spatial data related to land resources. It enhances the efficiency, transparency, and effectiveness of land administration processes. ArcGIS Parcel Fabric allows organizations to effectively manage 2D, 3D, and 4D parcel data, including strata and subsurface information, ownership records, and agricultural and natural resource rights.

A GIS-powered Land Information Management System helps authorities overcome the challenges usually associated with land administration such as incomplete cadastre, moving from paper to digital, ensuring data is up to date and accurate, quality improvement, and delivering new products and land information services. A GIS-powered Land Information Management System aids in effective land administration by supporting the land administration trends of automated workflows, digital submission, connected workers, systems consolidation, 3D cadastre, cadastre as basis for national SDI, standards compliance, open data & transparency, “fit for purpose” cadastre, etc.

Figure 9: ArcGIS enabling Land Administration

Integration of GIS in land administration practices enables government agencies, landowners, and stakeholders to make informed decisions, reduce errors, and achieve excellence in land governance and administration.



MahaBHUMI: GIS Based Digital Basemap on 1:4k for Integrated Planning - Maharashtra State

Industry
Government

Organization Profile
Maharashtra Remote Sensing Application Centre (MRSAC) was established in January 1988, as an autonomous body under the Department of Planning, Govt. of Maharashtra. It is a premier institution, dedicatedly involved in serving the state of Maharashtra through use of geospatial technology like remote sensing, geographic information system (GIS), global positioning system (GPS), mobile technology, photogrammetry, drone (UAV) and LiDAR for 3-D mapping.

Solution
MahaBHUMI Geo-Portal.

Highlights
The aim of designing an integrated information system - MahaBHUMI Geo-Portal is multi-fold:

- To develop a system that shall depict the basemaps prepared from very high resolution satellite data on 1:4k with details of transport system, water resources, irrigation, urban areas and landuse. The Contours generated under the MahaBHUMI project are at 2m interval and are also shown in the topomaps collated at 1:10K scale.
- To integrate data generated in MRSAC from high resolution satellite images & geotagged information on water supply schemes, forest boundaries (upto beat level), orchards, mining lease boundaries, historical monuments, etc. with topomaps.
- To create a central repository of departmental data & assets in GIS.
- To create Web services of various databases so that these could be consumed by various departments in their own applications.

Website
https://mrsac.gov.in/MRSAC/

Project Summary

In order to make effective use of the very high-resolution satellite database and to achieve the e-governance objective of Maharashtra State, MRSAC has designed an integrated information system/unified geo-portal called MahaBHUMI. The aim of designing MahaBHUMI Geo-Portal is to acquire high-resolution satellite data and provide as services, the value-added processed satellite image data, under a common base of coordinate and projection system. The value-added base maps are generated by the process of abstraction of the visible features distributed into various base themes. The integration of the base themes generates the base map with various assets and topographic information. This can aid in creating a central repository of base information in a GIS environment. The project employs database standards with a standard schema for the generation of base geodatabase using very high-resolution ortho-corrected satellite data.

Challenges

For any kind of planning, a strong and robust database forms the backbone. This is the first of its kind in the country and therefore involved setting new benchmark in satellite data ortho-rectification to designing Geodatabse standards to meet the large scale mapping needs of different departments involved. The present initiative of standardization and feature extraction from very high-resolution satellite imagery, for planning, implementing, monitoring, and management of various government schemes is therefore taken up. The aim of such standardization is to enable individual state level partner institutions (Line Departments) to create, update, and carry out capacity building and disseminate the information up to grassroot (Gram Panchayat) level. In other words, the whole effort is for designing, creating, updating and disseminating the resource information under the ownership of individual stakeholder departments. The outcome of creating and organizing information is to establish and enable the information system comprising spatial natural resources and non-spatial data (MIS) towards supporting the decentralized planning at various levels in the Govt. The GIS database is customized to meet the requirements of the Government departments based on their problems/priority/developmental programs at the Cadastral/ Village/Block/Taluka/District level.

Solution

The base maps and the geo-portal that are generated under the MahaBHUMI project would lay the foundation for efficient infrastructure planning, monitoring

and management. Monitoring is a continuous process that involves data collection and analysis. The findings from monitoring and evaluation form the basis for establishing key goals and targets, adjusting strategies and making them effective and efficient. The information generated under MahaBHUMI will help in the integration and coordination of various databases in all state and local agencies involved in ensuring the success of the implementation of the various state development programs. MRSAC's systematic approach for base map preparation ensures accuracy and precision which can be effectively utilized for any/all planning purposes of various line departments of Maharashtra.

Objectives

1. Feature extraction and interpretation on 1:4K scale using high-resolution ortho-rectified and geocoded stereo satellite data of 50 cm resolution. The activity is carried out for the following base layer themes based on the standard document and schema provided:

   URBAN Bag containing settlement, buildings, habitation, industries, mining areas, historical monuments, etc.

   TRANSPORT Bag containing all transportation layers including roads, railways, airports, helipads, waterways, metros, mono rails, road land use, etc.

   WATER Bag Water Resources layers and irrigation layers with canals, hydro structures, etc.

   LUSE MASK Bag: Creation of land use/land cover integrated mask using the features extracted from the above-defined three themes along with FOREST, WASTELAND, and AGRICULTURE base themes. Reserved/Protected Forest boundaries for the state are used as a reference for Reserved Forest interpretation.

2. The activity is processed on 10K sheet based on the NSF OSM grid.

3. The database is generated as per the ArcGIS geodatabase scheme.

4. Integration is performed to generate a seamless mosaic of all theme data with respect to the adjacent grid data.

Methodology

Spatial distribution of Earth's surface features, both natural and man-made, represented in the form of a map is the best tool available to catalogue and view the arrangement and distribution. For the preparation of thematic maps, the base map becomes a pre-requisite, and many times this base map itself serves as an excellent tool for various application purposes- both for planning and implementation. With the very high spatial resolution satellite images available these days, it is possible to prepare a very accurate base map on a larger than 1:2000 scale. The base layers generated should be so accurate to lay the foundation for efficient infrastructure planning, monitoring, and management of natural and man-made resources of Maharashtra. MRSAC employed a very systematic approach for base map preparation under the MahaBHUMI project. The stereo and tri stereo data of World view-2 and Pleiades data on 50 and 30 cm was used to generate orthomosaic using dedicated DGPS points classified as Iconic, Primary and Secondary. The data so prepared is used for the generation of DEM and 2 m contour. A comprehensive schema and data standard is prepared for the project with proper nomenclature, domains and data types.

The following base layers are generated under MahaBHUMI with full theme details along with their attribute information. A complete metadata standard is generated along with the data using the metadata software generated by MRSAC. The base layers are contained in the following Data "BAGs":

Directory Nomenclature
MBIMAGEBAG (MahaBHUMI Satellite Images Bag)
MBGRIDBAG (MahaBHUMI OSM GRID Layers Bag)
MBTOPOBAG (MahaBHUMI topographic Layers Bag)
MBURBANBAG (MahaBHUMI Settlement/Urban Layers Bag)
MBTRANSBAG (MahaBHUMI Transport Layers Bag)
MBWATERBAG (MahaBHUMI Water Resource Layers Bag)
MBMASKBAG (MahaBHUMI Land Use/Land Cover Bag)

Thematic interpretation is done using very high-resolution ortho-rectified and geocoded satellite data of 50 cm resolution. The data is generated on 10K sheet wise with scale of interpretation of 1:2000. The various theme features, which need to be abstracted/interpreted, are based on Geodatabase Standard which facilitates generating the databases, organizing them, and integrating them in a better way to achieve various goals of the MahaBHUMI project. The features that need to be abstracted/interpreted in each bag are described separately in separate sections of the Standard document. The description is comprehensive information about the minimum content of the base data, and in the future other information can be generated and augmented to these data through attribute object tables.

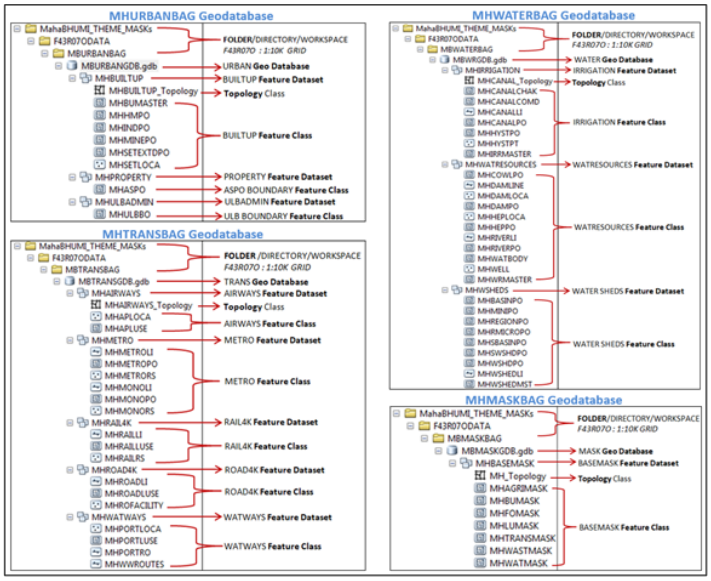


Figure 1: MahaBHUMI Database Schema

Output

Interpretation under various themes is being done for 11,109 grids of 10K of SOI for Maharashtra State. Feature extraction for the 10K SHEET is done using high-resolution ortho-rectified and geocoded satellite data of 50 cm resolution stored in the IMAGEBAG for URBAN (Settlement, Habitation & other urban layers), TRANSPORT (Transportation layers), WATER (Water Resources & Irrigation layers) and MASK themes as per the Geo-Database Standards . In the MBMASKGDB, the MASK feature class is initially interpreted for three classes only viz. FOREST, WASTELAND, and AGRICULTURE level-1 base themes. For interpreting the Forest theme, under MASKBAG, Reserved/Protected Forest boundaries generated using HR satellite data are used as reference. Data interpretation is carried out for all the Point, Line and Polygon features designed for the specified themes under the GDBs in their respective feature datasets (FD) and feature classes (FC). Topology is created in the individual FDs for each theme. The interpreted/abstracted polygon master database of URBAN, TRANSPORT, and WATER is integrated with the MASK using union command for final integrated LUMASK.

The project is intended to enable user departments with necessary applications using the data created under MahaBHUMI to be served on internet. Sample applications are configured for one district for the feasibility of applications and workflows for the project implementation. The details can be seen in Figure 2 covering the area of Gondia Municipal Council. An example of one 10K grid interpreted using the STANDARDS is presented in Figure 3.

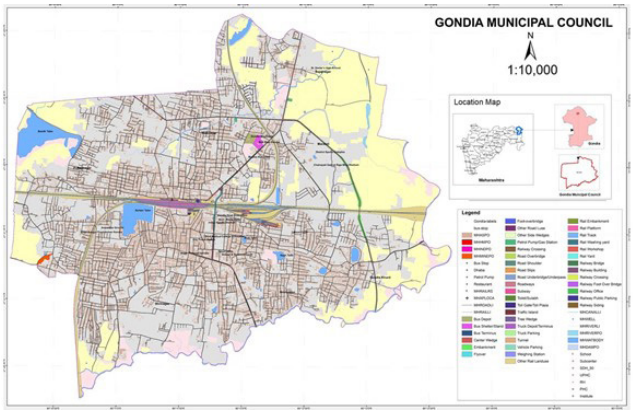


Figure: 2: Gondia Municipal Council Map as per MahaBHUMI Standards

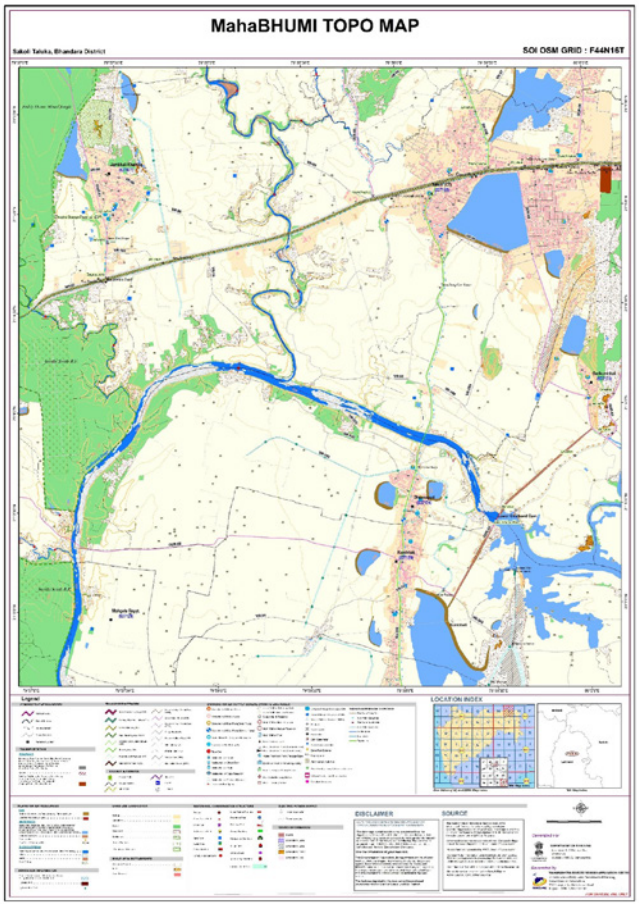


Figure 3: MahaBHUMI 1:10K TOPOMAP

The Sample applications can be seen in Figure 4 to 8 for Gondia district covering dashboards and geoportal.

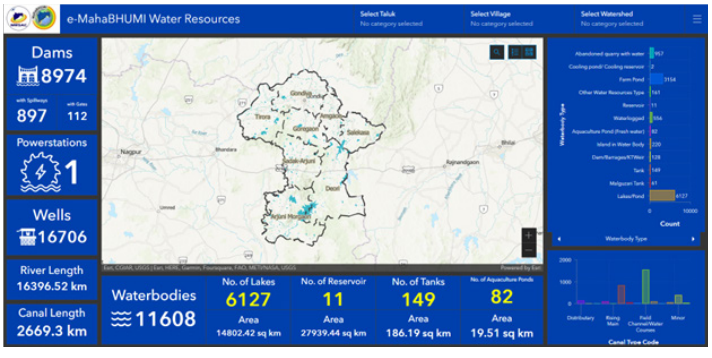


Figure 4: MahaBHUMI Water Resources Sample Dashboard – for Gondia District

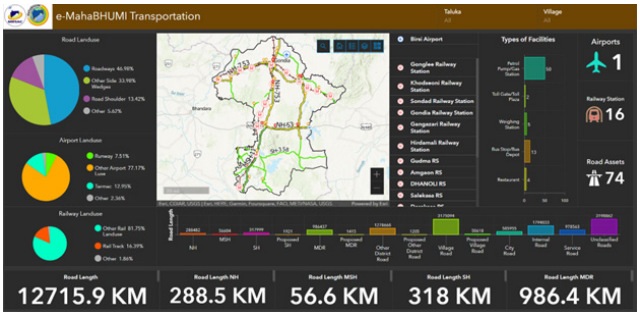


Figure 5: MahaBHUMI Transportation Theme Sample Dashboard – for Gondia District

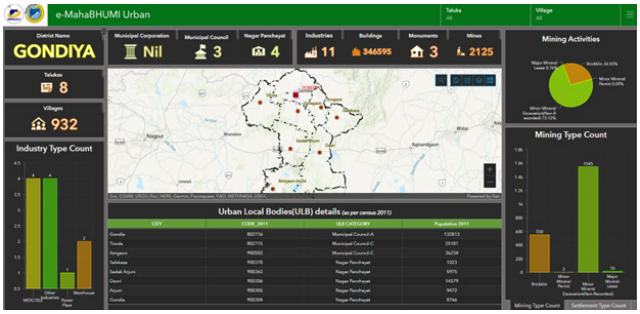


Figure 6: MahaBHUMI Urban Theme Sample Dashboard – for Gondia District

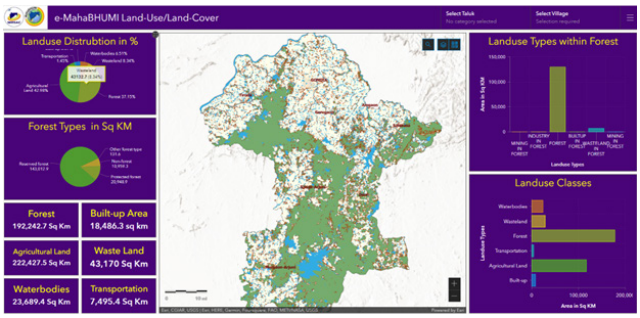


Figure 7: MahaBHUMI Land use/Landcover Theme Sample Dashboard – for Gondia District

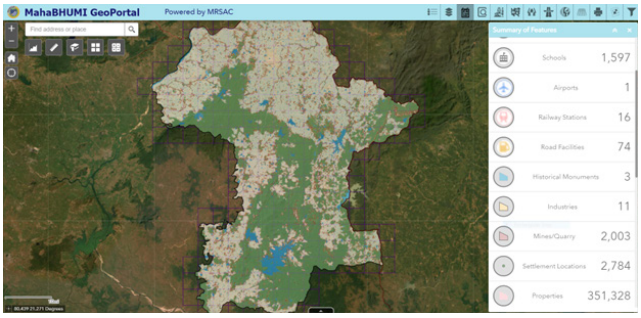


Figure 8: MahaBHUMI Sample Geoportal – for Gondia District

About MRSAC

MRSAC has carved a niche in the e-governance program of the Government with its small but highly dedicated team of Domain Expert Scientists called as 'Guardian Scientists' who help and guide the various line departments in understanding how their data or MIS can be integrated with the geospatial technologies for transparent, reliable, timely decision support along with 'ease of doing their regular activities'. MRSAC has an indigenous geospatially trained team who generate the standardised data and a software team responsible for customised mobile applications and geoportals for the display, query, report generation of the geospatial data so created. The branch offices of MRSAC at Mumbai and Pune cater to the needs of Mantralaya and the various department headquarters for liaisoning between the various departments for the use of geospatial technology. MRSAC is governed by a governing body consisting of Secretaries of various departments headed by Chief Secretary to Govt. of Maharashtra as Chairman and Director, MRSAC as Member Secretary.

> "Base maps generated under MAHABHUMI Project on 1:4K scale and its integration with Cadastral maps, MIS data of various Govt Depts and also the data from location based services shall change the way planning, implementation and monitoring are carried out for citizen centric services in the state. Geospatial services of this data through decision support system for each department will be a game changer in the state, setting a new benchmark in the e-Governance."
>
> **- Dr Ashok Kumar Joshi, Director, MRSAC**

Dr. Ashok Kumar Joshi (Director, MRSAC, Nagpur) - Technical and Administrative Support, Overall Guidance, Management and Monitoring of the Project.

Shri. D. M. Kolte, (Former Director, MRSAC) and Senior Resources Scientist for Overall Monitoring and Management of the project.

PROJECT TEAM

Dr. Tutu Sengupta, Associate Scientist & Project Manager-MahaBHUMI Basemap & Project Coordinator- Water Resources, MRSAC, Nagpur

Mrs. Sapna Deotale, Head, MRSAC Mumbai Branch Office & Associate Scientist (Former Project Coordinator-Urban Team)

Dr. Sanjeev Verma, Associate Scientist (Project Coordinator- Transport, Industries)

Mrs. Archana Kolhe, Scientific Associate (Project Coordinator-Land use, Database & Archival)

Shri. Sanjay Balamwar, Associate Scientist (Project Coordinator-Ortho-Image & Urban)

Dr. Indal Ramteke, Scientific Associate (Project Coordinator-Urban)

TEAM MEMBERS

A) DATABASE MEMBERS

Dr. Ajay Deshpande, Associate Scientist (Project In-charge -Mining and Historical Monument)

Dr. Vivek Kale, Scientific Associate (Land Use-Wasteland)

B) HARDWARE/ SOFTWARE MEMBERS

Mrs. Sangita Rajankar, Associate Scientist (Software Development)

Shri. Srinivas Khandare, Associate Scientist (Hardware)

Shri. Rajkumar Fulzele, Technical Assistant (Hardware & Software)

DATABASE AND ARCHIVAL COORDINATOR

Dr. G.S. Rao, Scientific Associate (Coordinator- Database & Archival)

FORMER PROJECT MEMBERS

Mrs. Neelima Shrivastava, Associate Scientist (Retd.) and Former Manager-MBBM

Dr. Arvind Hadap, Documentation Officer (Retd.) and Coordinator- Database & Archival

Project team extends gratitude to Dr. S. N. Das (Former Director, MRSAC, Nagpur) for conceptualization and formulation along with Senior Scientists of MRSAC, Nagpur

NeoGeo & Esri India Collaborate to Facilitate Land Records Management in Assam

Land is an essential resource that supports nearly every aspect of our social and economic well-being. As a finite resource, it is necessary to govern and manage land effectively for social stability, sustainable economic development, and equitable taxation. GIS technology helps in managing all aspects of land information and land records including land tenure, value, management, and use. With all land information in a GIS-based comprehensive land administration system, governments are able to improve land information management, property valuation and analysis, and communication with the public.

With this intent in mind, NeoGeoInfo and Esri India collaborated with the Directorate of Land Records and Surveys, Government of Assam, under 'Mission Basundhara' to set up a GIS Lab at Guwahati.

Assam GIS Lab – Unlocking the Potential of Geospatial Technology

The GIS Lab serves as a centralized platform or system that leverages GIS technology to manage, analyze, and share geographic and land-related data.

It aims to help the Land Records Department in the following ways:

1. **Centralized Data Management:** The GIS Lab could serve as a central repository for all land-related data, including property boundaries, ownership information, land use classifications, and more. This consolidation can streamline data management and reduce duplication of efforts.

2. **Data Visualization:** GIS technology enables the visualization of land data on maps, making it easier for land officials to understand spatial relationships, identify trends, and make informed decisions. This can help in better understanding land usage patterns, potential conflicts, and planning for development.

3. **Spatial Analysis:** GIS allows for advanced spatial analysis. The Land Records Department could use spatial analysis tools to assess factors such as proximity to infrastructure, environmental considerations, flood zones, and more when making decisions about land usage or development permits.

4. **Efficient Land Administration:** With the help of the GIS Lab, land records can be updated more efficiently and accurately. Changes in land ownership, boundaries, and other attributes can be recorded and reflected on maps in real-time, reducing errors and administrative overhead.

5. **Public Access to Information:** Depending on the level of accessibility, the GIS Lab can provide a platform for citizens, businesses, and other stakeholders to access land-related information online. This promotes transparency and can reduce the need for people to physically visit the Land Records Department.

6. **Planning and Zoning:** The GIS Lab can assist in comprehensive planning and zoning activities. By overlaying different datasets (e.g., land ownership, zoning regulations, utilities), authorities can make informed decisions about land use, development regulations, and infrastructure planning.

7. **Disaster Management:** GIS technology can be crucial in disaster management. Authorities can use GIS to identify vulnerable areas during disasters, plan evacuation routes, allocate resources effectively, and assess post-disaster damages.

8. **Decision Support:** The GIS Lab can provide decision-makers with tools and information to evaluate different scenarios, such as the impact of proposed developments on the surrounding area, environmental consequences, and socioeconomic implications.

9. **Data Sharing and Collaboration:** Different departments and agencies can benefit from a centralized GIS Lab by sharing relevant land data, leading to better collaboration and coordinated decision-making across various government bodies.

10. **Long-Term Record Keeping:** The GIS Lab can serve as a digital archive for historical land-related data. This can be valuable for analyzing trends, understanding land use changes over time, and ensuring accurate records for legal and administrative purposes.

NeoGeoInfo is committed to unlocking the potential of geospatial technology and the data that exists with government bodies. As part of this endeavor, NeoGeoInfo has embarked on the journey of building the mission-critical infrastructure for geospatial technology, and Assam GIS Lab is one such effort.

Geospatial for Land Management

In classical economics, land is one of the three major factors of production along with labor and capital. Growing population and economic development demand an increase in food production, an expansion of infrastructure, and a higher consumption of natural resources. But this comes at a cost. The conversion of agricultural land and forests to urban development reduces the land available for food production. Urbanization and industrialization challenge farmers on the fringes with a risk of collapse of the local agricultural economy. As a host to water resources, land degradation deteriorates the quantity and quality of both surface and groundwater resources. Loss of vegetation exacerbates climate change events, which in turn, are causing even greater degradation triggering negative impacts across the ecosystems.

Land resource assets have a heavy bearing on the economic growth and future of the nation. With limited availability and increasing pressure, land use change is inevitable for development and social progress. While there is a need for expanding infrastructure to improve the living conditions of a growing population, there is a parallel need to satisfy shifting consumption patterns and limit negative environmental impacts. And while there is also a need for industrialization and agricultural intensification, there is a parallel need to combat climate change and ensure future food and water security. The need for improving crop yields and restoring wastelands in a sustainable manner co-exists with the need to minimize land degradation/desertification and conserve biodiversity. Managing land resources efficiently and sustainably is the only option we are left with. It is time for us to harness 'spatial intelligence' and move beyond land record management and land use planning to an Integrated Sustainable Land Management (ISLM).

Geospatial technology and its applications

Land resources are unique and diverse in their characteristics while being a single physical unit. The suitability of land for a specific purpose varies for rural, urban, industrial, mining, ecological, and environmental applications, and each of these has its own challenges. To address the complex challenges posed, there is a compelling need to understand the interconnections within the land ecosystem and analyze them spatially and temporally to negotiate the right balance.

Geographic Information System (GIS) technology plays a central role in bringing together all related factors to aid with a comprehensive land intelligence on the local conditions facilitating sustainable land management. GIS based land information systems play a major role in the judicious use of land resources and strengthening land governance. Image processing capabilities aid in rapid monitoring and assessment of land-use/land-cover changes, which are critical for taking timely action and decision support. Land being a common resource, sharing and collaboration of land intelligence between central, state, district administrations, financial institutions, NGOs, and other stakeholders becomes critical.

With the threats of global warming and climate change looming large, advanced GIS capabilities like spatial modelling and predictive analysis using artificial intelligence, machine learning and big data can provide enhanced situational analysis with an accurate assessment of the situations and likely scenarios to mitigate, plan and monitor the land use and land cover changes.

Geospatial Value Impact

The use of GIS technologies has yielded positive results at regional and local levels in land use planning, productivity assessment, conservation, restoration, etc. This clubbed with the economic value offered by geospatial technologies in supporting sustainable land management practices, makes a significant impact on the overall economy. Geospatial Value Impact (GVI) on the land resource sector is as under:

Operational Benefits	**Consumer Benefits**
Improving planning, utilization and productivity, enhanced and decision support, cost savings and cost avoidance	Improving transparency, enhanced convenience, reduced commodity prices and better quality of life
Social Benefits	**Employment Generation**
Sustainable natural resource management, environmental, ecological and biodiversity conversation, preparing, mitigating, and responding better to disasters (manmade and natural) and community development	Enployment generation for geospatial information management including allied services and indirect employment

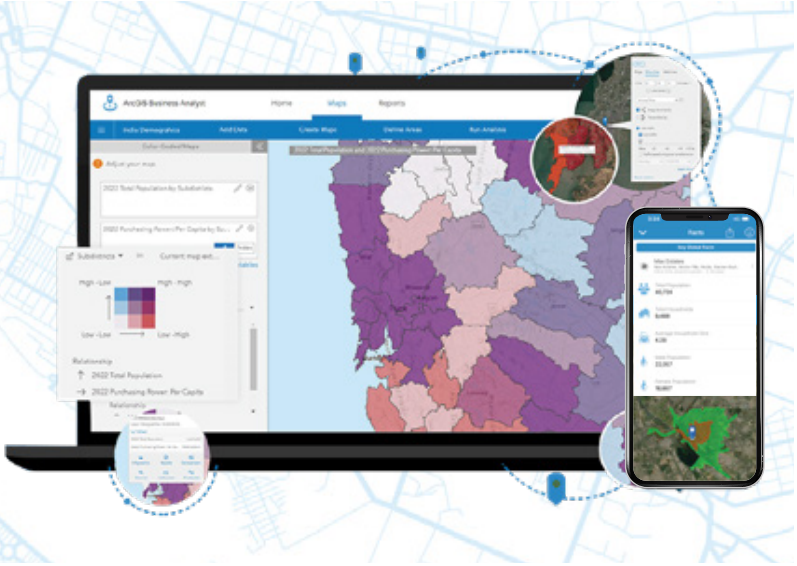
Conclusion

Land is a scarce resource and is already under severe stress. GIS technologies will be vital for harmonizing the complementary goals of providing environmental, economic, and social opportunities for the benefit of present and future generations while preserving long-term socio-economic and ecological functions of the land. Actionable spatial intelligence from geo-enabled platforms can provide evidence-based insights for policy advocacy and strengthening of the regulatory framework to further the land reforms in the country.

Geospatial Value Impact – Land Management (www.geospatialworld.net/article/geospatial-value-impact-land-management/)

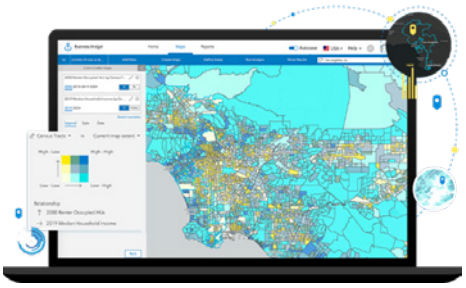
ArcGIS® Business Analyst™

Location-Based Market Intelligence



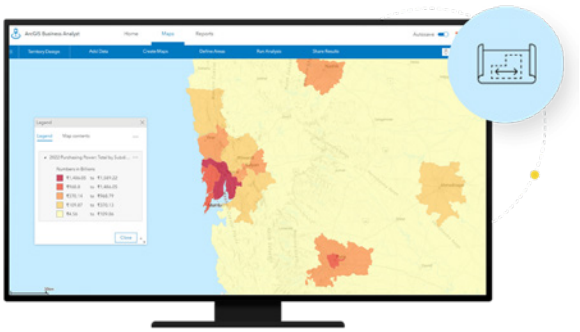
ArcGIS Business Analyst

ArcGIS Business Analyst is a solution that applies GIS technology to extensive demographic, consumer spending, and business data to deliver on-demand analysis, presentation-ready reports and maps. It is a comprehensive and powerful tool for anyone involved in business analysis, market research, or location-based decision-making.



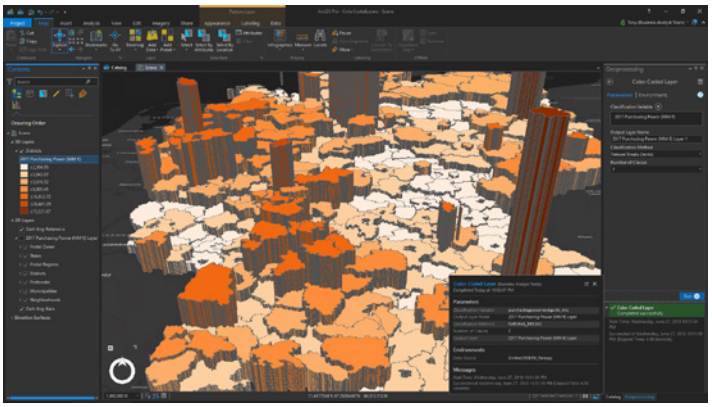
User-Friendly Interface:

One of the standout features of ArcGIS Business Analyst is its user-friendly interface. It caters to users of all skill levels, from beginners to advanced GIS professionals. The intuitive layout and easy-to-navigate menus make it accessible to those who may not have a deep background in Geographic Information Systems (GIS).



Mapping and Visualization:

ArcGIS Business Analyst excels in mapping and data visualization. It allows you to create detailed, interactive maps with ease. The ability to overlay multiple datasets, customize symbology, and conduct spatial analysis makes it a powerful tool for visually representing complex business data.



Data Sources:

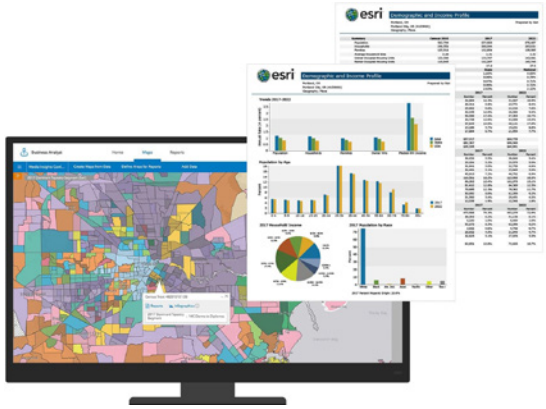
The software offers access to a vast array of data sources, including demographic, socioeconomic, consumer behavior, and market data. This wealth of information is crucial for understanding market trends, customer segments, and target demographics. The ability to integrate your own data or third-party data sources enhances its versatility.

Advanced Analytics:

ArcGIS Business Analyst provides advanced analytical tools to support data-driven decision-making. You can perform spatial analysis, site selection, suitability modeling, and more. These features are indispensable for businesses looking to optimize their operations and marketing strategies.

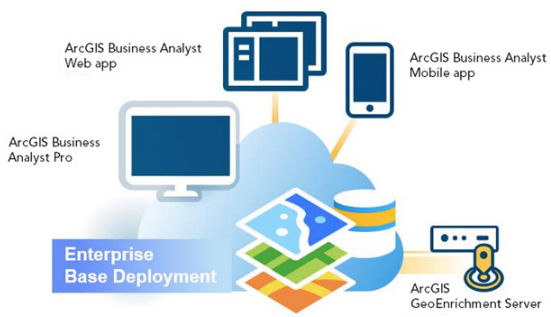
Custom Reporting:

Creating custom reports is a breeze with ArcGIS Business Analyst. You can generate comprehensive reports that include maps, charts, and tables to communicate your findings effectively. This feature is particularly useful for sharing insights with stakeholders and colleagues.



Integration and Compatibility:

The software seamlessly integrates with other ArcGIS products and can also be integrated with various third-party applications. This compatibility allows users to leverage the full capabilities of the ArcGIS ecosystem and expand their analytical capabilities.



Scalability:

ArcGIS Business Analyst offers scalability to meet the needs of businesses of all sizes. Whether you're a small business owner or part of a large enterprise, you can select the subscription level that suits your organization's requirements and budget.

In conclusion, ArcGIS Business Analyst is a top-tier solution for businesses and professionals looking to harness the power of spatial analysis and geographic data. Its user-friendly interface, robust mapping and visualization tools, access to diverse data sources, and advanced analytics capabilities make it an indispensable asset for market research, site selection, and strategic planning. While the cost may be a consideration for some, the benefits it offers in terms of informed decision-making and competitive advantage far outweigh the investment. If you're serious about optimizing your business strategies and understanding your target market, ArcGIS Business Analyst is a valuable tool that delivers results.

ArcGIS Business Analyst for India includes a variety of location-based datasets, such as points of interest, road network, accurate boundaries at various levels like village, PIN codes, district, state, etc., socio-economic and demographic data, and data available from Esri's Living Atlas. Live road traffic information is also available. The solution can help in the identification of new markets, new sites for stores or outlets, understanding customers' preferences better, and getting better visibility about competitors.

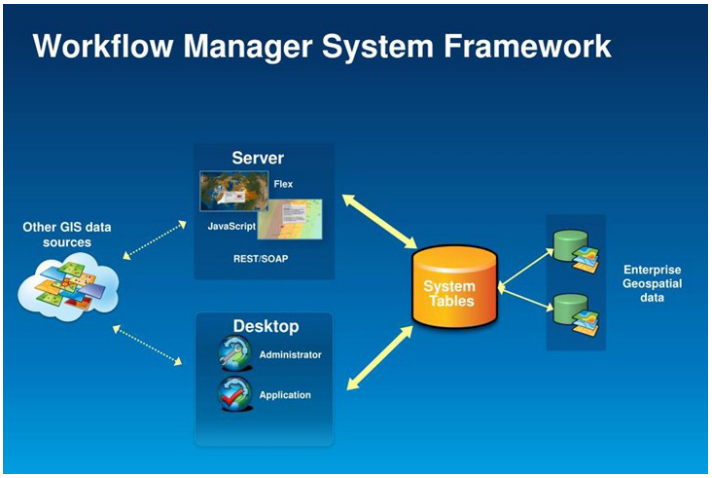
ArcGIS Workflow Manager

ArcGIS Workflow Manager is a scalable workflow management system that automates and simplifies many aspects of performing and managing GIS and non-GIS work in an organization. It optimizes GIS operations by providing real-time tools for managing people, processes, and products required to complete work. It drives improvements in production efficiency by maintaining standardized, centralized, and repeatable workflows across your organization to reduce errors and inefficiencies and save time.

The most common workflow that Workflow Manager supports is a basic data editing workflow. An example use case is an editor updating spatial or attribute information for a location. A GIS specialist updates a map based on the captured information. Their work is then validated by a quality control (QC) specialist, and if there are any issues, it's sent back to the GIS specialist. This use case illustrates the basic functionality of Workflow Manager. The series of steps needed to complete the task in this scenario is called a workflow, and one instance of a workflow is called a job. Jobs can be associated with specific properties and can be assigned to multiple members or groups in an organization. Steps can perform various tasks, such as opening a map for a GIS specialist or prompting a user to answer a question to route the job in different directions.

Workflow Manager can then extend this type of workflow by sending email notifications at key points of the workflow, managing and cleaning up spatial data versions, running geoprocessing tools to assist in initial site selection, and so on.

Workflow Manager is flexible in how it manages where a workflow occurs and can seamlessly handle all interaction points. For example, work can be performed in the field in a mobile app, data editing can be performed in ArcGIS Pro, and quality control can be performed in the Workflow Manager web app.



Functionality:

Workflow Manager can be configured to support many types of workflows depending on your organization's needs. The following are examples of some of the many workflows you can create:

- **Web-based, user-driven workflows:** These types of workflows allow users with a Workflow Manager user type extension to interact with jobs in the Workflow Manager web app.

- **Desktop-based, user-driven workflows:** These types of workflows allow users with a Workflow Manager extension license to interact with jobs in ArcGIS Pro.

- **Semi-automated workflows:** These types of workflows allow you to automate portions of your workflows, such as running a geoprocessing service, and are included with a Workflow Manager user type extension. These capabilities are meant to compliment user-driven workflows and help automate repetitive work.

- **Automated workflows:** These types of workflows are available with a Workflow Manager user type extension and an optional ArcGIS Workflow Manager Server Advanced role. This optional

role provides improved performance, scalability, and advanced functionality to help you streamline and automate your workflows.

Workflow Manager components

In Workflow Manager, several components make up a job. Depending on your duties in your organization, you may only need to use a subset of these components.

Workflow items

Workflow items are single instances of Workflow Manager that allow groups in your organization to perform different types of work. When you use multiple workflow items to separate your organization's various groups, the unique requirements and work done by one group won't interfere with the other groups.

Step templates

Step templates are preconfigured steps designed to perform various types of actions when a job is run, such as opening a map, running a tool, asking a question, and so on. Each step template contains a preconfigured name and default values for step properties, options, and styling. When a step template is added to a workflow diagram, it becomes a unique step in the workflow and its default values can be customized as necessary.

Workflow diagrams

A workflow diagram is a visual representation of a business process and consists of individual steps and paths. In Workflow Manager, this is more than a simple flowchart, as each step can be configured with its own type, properties, options, and style, and paths can be configured to perform specific actions after a step is run. For example, a question step prompts you to answer a question, and a mapping step opens a specific map. When a path is followed, it can change the status of the job or change the person to whom a step is assigned. By designing a workflow with different types of steps and paths, an organization can model end-to-end work that crosses multiple departments, locations, and software products.

Job templates

All jobs are created from a job template that is associated with a workflow diagram. The job template contains the default job properties assigned to a job when it's first created, such as the first person to whom it is assigned; the priority and due date; and any additional job properties that were added by your organization.

Jobs

A job is a single unit of work in the Workflow Manager system. In some organizations, a job may be known as a work order or a task. It can be assigned to a person, many people, or a group, and scheduled for completion by a certain date. It includes the workflow steps to complete and the job's details, outlining its scope. It can also contain additional help for completing steps, attachments, the job's location, and associations to spatial data. Many jobs of the same type can be created in the system.

Job locations

Workflow Manager allows work to be associated with a geographic location that can assist with managing and automating your jobs. The job's location can be defined as a point, line, polygon, or as multipart lines and polygons. You can also use a job's location to streamline jobs as follows:

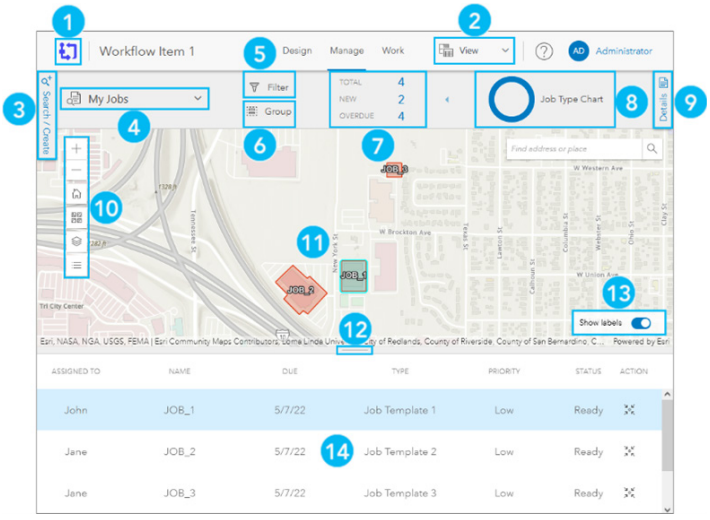
- Visualize jobs on a map and change the color of the locations based on attribute values defined in shared charts to create a visual job status dashboard.
- Use the boundary of a job's location as an input for a tool, model, or script that runs as a step in a workflow.
- Zoom to a job's location when a map is opened in the Workflow Manager web app.
- Share a job's location with web or mobile apps.

Workflow Manager user interface

The main parts of the Workflow Manager user interface (UI) are the pages, panels, and workflow canvas. Depending on your duties in your organization, you may only need to use a subset of these elements. The Visibility and functionality of the UI are controlled by user groups, roles and privileges.

Manage page

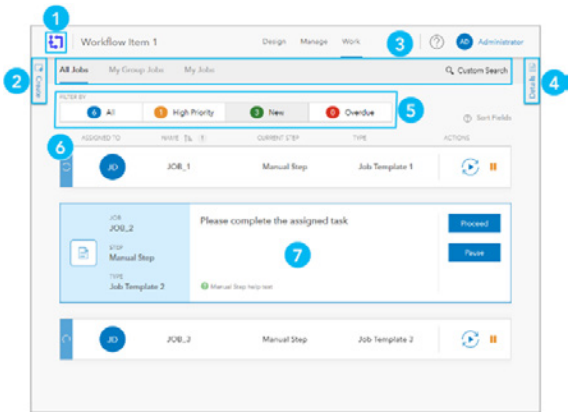
The Manage page is used by production managers to create work, monitor and update existing work, and review completed work. It allows organizations to continually monitor and review the status of work.



Work page

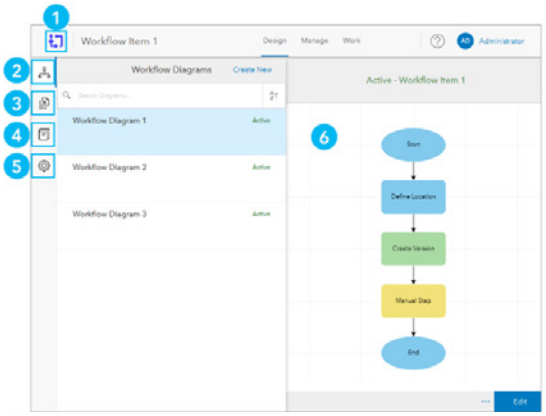
On the Work page, you can search for and complete work on jobs. The following are some common tasks that can also be done on the Work page:

- Jobs can be created by individuals inside and outside of the organization.
- Web apps can be opened to edit or review edits made to web maps.
- Job properties can be managed, and jobs can be approved by a workflow administrator.
- Attachments, such as construction drawings, can be added to jobs.



Design page

The Design page is used by workflow item administrators to create and manage workflow diagrams and job templates and to configure system settings.



When you click on **Create New** in the **Workflow Diagrams panel** or a workflow diagram's **Edit button** on the Design page, the workflow diagram editing page appears and contains the following elements:

What can Users Do with ArcGIS Workflow Manager?

ArcGIS Workflow Manager provides step-by-step guidance and tightly integrates with Esri technology to create seamless end-to-end experiences that result in efficient, predictable, and repeatable workflows.

1. Automate workflows

Create a dynamic production system with the powerful automation tools in ArcGIS Workflow Manager to streamline processes such as data ingestion, analysis, and aggregation.

2. Work in real-time in ArcGIS

ArcGIS Workflow Manager unifies Esri technology to drive consistent workflows across desktop and web applications. Collaborate and coordinate work across teams, platforms, and locations with synchronized data to drive efficiency improvements. Monitor the status of work in real-time to facilitate informed decision-making.

3. Increase reliability and accountability

Standardize and centralize data and project information to ensure the consistency, accuracy, and quality of data at all stages of a project. Increase process efficiency and transparency to help build accountability and trust between your organization and your customers.

4. Transform the way you work

Capture best practices and configure complex business processes in just a few clicks with a clean, modern user interface. Automate repetitive manual tasks such as data preparation and cleanup to help your workforce stay focused on important tasks. Deliver tools, applications, and data without limitations to get new employees up to speed quickly.

5. Promote successful communications

The integrated communication tools in ArcGIS Workflow Manager boost productivity and efficiency, reduce downtime, and help cut operational expenses. Track actions in real-time to quickly communicate progress, resource allocation, and status to stakeholders through reports and dashboards.

Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST-Kashmir)

Enabling students and professionals to harness geospatial technologies for sustainable and efficient agricultural practices.

Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST) is a multi-campus university. It was established in the year 1982 through an Act of the J&K Assembly, with its headquarters at Shalimar, Srinagar. In the year 1998-99, the University was renamed as Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-Kashmir), and its territorial jurisdiction was redefined to Kashmir and Ladakh regions.

In a conversation with **Dr. Shabir Bangroo, Assistant Professor, Remote Sensing & Geoinformatics Lab (RSGL), SKUAST-Kashmir**, Esri India discovers how the University is helping in building a geospatially skilled workforce for the country.

Please tell us about SKUAST, Kashmir in brief.

Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir is one of the leading mountain agricultural universities that cater to the research needs of the western Himalayan Kashmir valley and Ladakh. It is one of the fastest-growing state farm universities in the country that has moved to be the 4th best SAU and has been awarded the Band excellent category in the Atal Innovation ranking. Based on its strong institutional performance indicators in the last 5 years, it has emerged as an institution with the promise that has taken innovative reforms in reshaping higher education in agriculture. It is the first SAU to implement NEP-2020 and promote innovation and entrepreneurship as means of improving faculty and student output towards translational research for developing science-based solutions to farm sector challenges based on new frontiers of science such as AI, ML, robotics, and decision support system.

The Remote Sensing and Geoinformatics Lab at SKUAST – How is it helping in building a Geospatially skilled workforce that can effectively address some of the most pressing challenges faced by modern agriculture?

The Remote Sensing and Geoinformatics lab (RSGL) at SKUAST-K is relentlessly training and shaping individuals in the Remote Sensing and GIS domain. We are mainly focusing on agriculture applications such that our trained professionals can effectively address pressing challenges faced by modern agriculture. We provide hands-on training, technological expertise, and practical experience, enabling professionals to harness geospatial technologies for sustainable and efficient agricultural practices. RSGL provides technical proficiency in using specialized software, remote sensing imagery, and spatial data analysis tools. We at RSGL focus on research and innovation and encourage our students to develop models/methodologies that synergize the use of geoinformatics in modern agriculture. Our research at RSGL round about the application of geoinformations in precision agriculture, data-driven decision making, crop monitoring and management, climate resilient agriculture, agro-ecosystem services and crop health mapping. In summary, RSGL has taken the initiative to transform agriculture into a data-driven, sustainable, and resilient industry by providing practical training, fostering innovation, and equipping professionals with GIS and Remote sensing knowledge and expertise.

How is Esri India helping you in your endeavours?

Esri India is acting as an enabler, providing tools and resources that empower SKUAST-K to reshape the future of agriculture technology. Here are some ways Esri India contributes to our goal achievements.

- **Advanced Infrastructure:** Hardware, software (High-performance computing HPC), and networking solutions (servers, cloud services, and networking equipment) that provide SKUAST-K with the necessary infrastructure for teaching, research, and administrative tasks.
- **Educational Tools and Platforms:** Learning management systems (LMS), e-learning platforms, virtual classrooms, and other educational technologies that enhance the university's teaching methods and support remote learning.
- **Research Support:** Access to research tools, data analysis software, and computing resources that aid faculty and researchers in conducting cutting-edge research.
- **Collaboration Solutions:** Collaboration tools, such as video conferencing, document sharing, and virtual collaboration platforms that help connect faculty, students, and researchers across various locations.
- **Training and Support:** Training sessions and support services to help faculty, staff, and students effectively use technology tools and platforms, enhancing their proficiency and productivity.
- **Innovation and Partnerships:** In research collaborations with SKUAST-K, fostering innovation and providing opportunities for students to work on real-world projects. Further, SKUAST-K and Esri India can partner through research partnerships, grant programs, and funding opportunities. These collaborations can support university research initiatives and promote innovation.
- **Career Services and Networking:** Career services platforms that connect students with potential employers, internships, and job opportunities. These platforms enhance students' career prospects and strengthen the SKUAST-K alumni network.

Why is it important to focus on sustainable agriculture and natural resource management?

In recent times we have significant variations in global dynamics. These variations are evident in terms of climate change and environmental degradation. These changes are the accord of our poor natural resource management, which in turn are observed due to human's ever-growing demands and accelerating population growth. The aftermaths of this negative intervention can be seen on a local to global scale. As such, the concept of sustainability and natural resource management is the need of the hour and one of the vital methods to cater the negative environmental variations. The concept of sustainability touches every realm of the co-existence of man and nature. This holistic approach is crucial for maintaining a harmonious balance between human needs and the health of our planet. We need to inculcate environmentally friendly practices that ensure the conservation of vital resources, ensuring food security and sustainable agriculture. By embracing practices that safeguard ecosystems, conserve resources, and ensure food security, we pave the way for a prosperous future for ourselves and generations to come. The synergistic relationship between environmental health, economic stability, and social equity underscores the significance of these approaches.

How the use of technologies like Remote Sensing and GIS can help in achieving more productive outcomes in these areas?

Remote sensing and Geographic Information Systems (GIS) are integral tools for effective natural resource management. Remote sensing involves the collection of data from satellite imagery, drones, and other sources, allowing us to monitor land cover changes, vegetation health, water resources, and more. GIS, on the other hand, enables the integration, analysis, and visualization of this geospatial data. By combining information from various sources and creating infographic maps, GIS helps decision-makers assess environmental trends, plan resource allocation, and develop strategies to safeguard our natural resources. These technologies revolutionize our ability to understand, monitor, and manage the complex interactions between human activities and the environment, contributing to sustainable and informed decision-making for the optimal utilization and conservation of natural resources.

A competent skilled workforce is a necessity to bring ideas to fruition. What role agricultural universities like yours are playing in creating technologically competent agriculture professionals?

SKUAST-K is actively nurturing technologically competent agriculture professionals who can address the evolving challenges of modern agriculture. By integrating technology into education, research, and practical training, we are equipping students with the skills to drive innovation, enhance productivity, and contribute to sustainable agricultural development. We provide specialized education and training that equips students with the skills and knowledge needed to harness technology for sustainable and efficient agricultural practices. At the core, SKUAST-K incorporates technology-focused courses into their curricula, covering subjects such as precision agriculture, remote sensing, GIS, agricultural automation, and data analytics, ensuring student's exposure to cutting-edge technologies from the very beginning. In parallel to this, SKUAST-K organizes hands-on training in modern agricultural machinery, sensors, and software with a focus on research and innovation in advanced agriculture. Further, SKUAST-K has collaborated with technology companies and industry experts to offer workshops, seminars, and internships. Such partnerships expose students to the latest tools and practices in agriculture technology and foster connections for future career opportunities. In addition to this, SKUAST-K does handholding for entrepreneurship programs to develop entrepreneurial skills by offering programs that support the creation of agritech start-ups.

Geospatial Mapping of Hotspots for Implementation of Cool Roofs for Achieving Urban Resilience in Extremely Hot Climates

Priyam Tewari[1], Akshay Jeevan[1], Surya Srinivas Chavali[2], Suman Dasgupta[3], Shashank Vyas[1]

[1]Consultant, Energy & Utilities, Infosys Limited | [2]Senior Industry Principal, Energy & Utilities, Infosys Limited

[3]Industry Principal, Energy & Utilities, Infosys Limited

Introduction

Heatwaves have become a persistent challenge, and the intensity & frequency of heatwave events are expected to rise with climate change events becoming more common. India witnessed over 6500 deaths 2010 onwards from heatwaves and related events[1]. The primary reason for heatwaves is associated with the increase in GHG emissions where urbanization is a major contributor. With the scale of rapid urbanization in India, it tags along the phenomenon of Urban Heat Island's (UHI's) because of tightly spaced and tall buildings, industries, fewer green areas and other impermeable infrastructure that absorbs the incoming solar radiation and radiate it back to warm the atmosphere. UHI's primarily result in the increase of Land surface temperature (LST) which will in-turn result in heat stress among the public in the absence of access to cooling systems. India's per capita consumption for space cooling stands at mere 69 kWh which is 75% lesser compared to the global average of 272 kWh[2]. This indicates lower accessibility to space cooling among the Indian population and gives a picture of the extent of vulnerability of the Indian population to heat stress. India, like other rapidly developing countries, is placed such that it needs to strike a balance between its economic growth while also dealing with climate change and related threats. This rising demand for cooling needs is to be noted at a time when, Intergovernmental Panel on Climate Change's (IPCC) 6th working group report reaffirms the need for limiting global temperature rise within 1.5-degree C. All these put together necessitates the apt identification for classification of Heat Vulnerable areas and mapping of the most stressed urban areas requiring immediate heat mitigation. Early identification enables an opportunity for introduction of faster counter measures in restricting the temperature rise and then also in ensuring the faster deployment of heat mitigation strategy for socio-economic progress and prosperity as a nation through increased wellbeing and urban resilience.

Among various heat mitigation strategies, cool roof technology is one which can play a significant role as this technology is sustainable, green and low cost at the same time. Cool roofing helps significantly in improving the reflectance coefficient of the roof (albedo) and thereby reducing the heat absorbed by the roofing surface. A field experiment carried out in composite climate of Nagpur city showed that daily average cooling energy savings of ~0.15 kWh/m2/day was observed in summer season[3]. Cool Roofs can play a significant aiding role in reducing the global cooling demand. Cool roof deployment strategy should also take into consideration the prioritization based on heat vulnerability index scores and UHI. This paper aims to develop a methodological framework for identification and mapping of most suitable sites for implementation of cool roof deployment in the heat vulnerable areas by using remote sensing and geo-spatial techniques.

Methodology

Increasing frequency, intensity and duration of heat waves has resulted in massive deaths in India. Heat-related deaths are preventable provided a vigorous preparedness & prevention plan is in place and heat mitigation strategies are centric to them. Authors have presented a methodological framework to identify the potential cool roof sites for heat mitigation in the most heat vulnerable regions of the country.

Key considerations for cool roof implementation:

1. Climate and Surrounding Environment (to avoid winter penalty)
2. Moisture Control in case humidity is high
3. Building type and Roof slope
4. Right cool roofing products that offer high solar thermal reflectance and high emittance
5. Overall cost and benefit analysis
6. Impact of weathering on cool roof product

Approach

There can be several potential sites in a city or a region where cool roof technology can be implemented. This site-suitability analysis can be carried out at a geo-spatial level in a GIS framework to optimally arrive at the best among the suitable candidate sites. The methodology using Analytical Hierarchy Process (AHP) associated with GIS will be followed to rank the suitable sites. Various criteria for scoring the sites would be land surface temperature, land use and land cover pattern, availability of roof top area, slope & elevation, etc. used to rank the sites. The relative weights assigned to each of the important parameters can be used in the GIS optimization framework so that the actual geographical co-ordinates can be identified after the optimization problem has been solved considering the constraints and the decision variables (both having weights assigned). The result of the GIS analysis is a rank assigned for each site which is obtained based on a site-suitability score. The site-suitability score is generally arrived at based on the degree of match with the desired constraints such as – high population densities, high roof top space availability, etc.

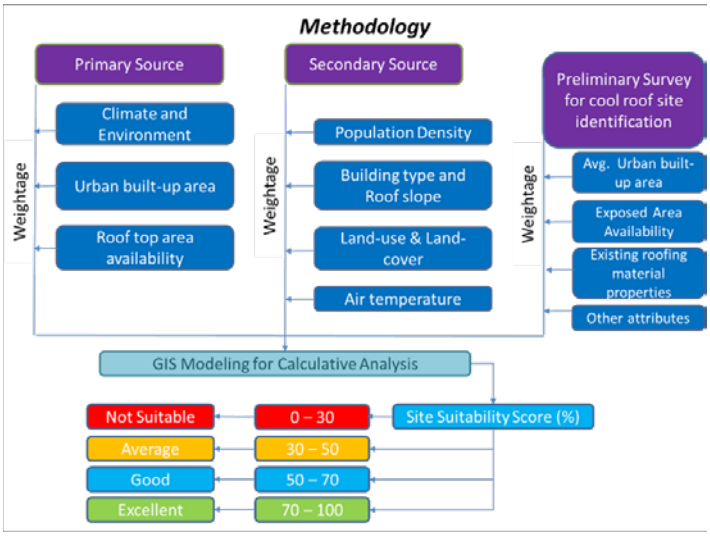
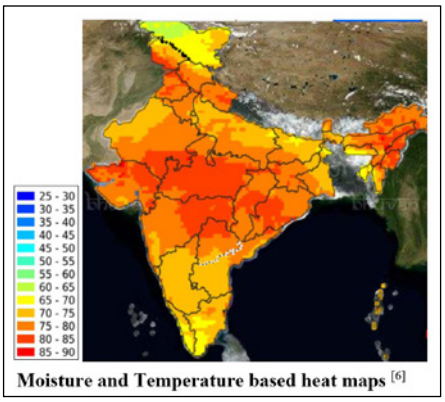


Figure 1: Approach for Site-suitability analysis

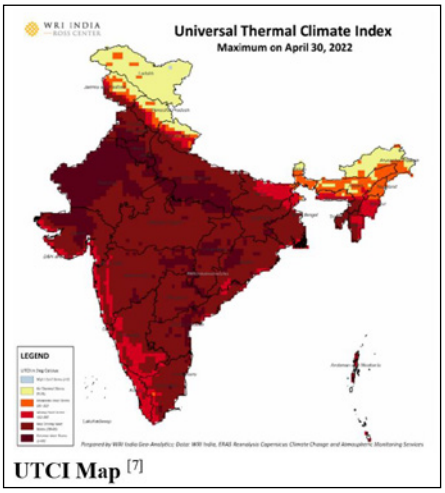
Methodological framework has been divided into three steps as described below:

STEP 1: Identify hotspots at PAN-India level

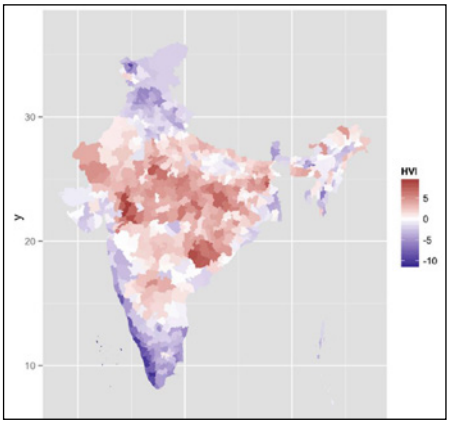
As a first step of this study authors will utilize secondary research methods to map the most vulnerable states in India which are exposed to highest degree of heat and urbanization by considering different parameters such as population densities[4], heat vulnerability index (HVI)[5], etc. This step will be substantiated by mapping the heat wave events and mortality rates. Climatology related online web resources such as Hot weather outlook on Indian Geo-Platform of ISRO[6], WRI report[7] and other relevant secondary resources will be analyzed to understand the heat related statistics at PAN-India level. Moisture and Temperature-based Heat (MTBH) map presented in Figure 2 is extracted through Hot weather outlook and indicates areas with potential for extreme heat conditions through daily maximum temperatures computed from the past 3 decades (1980 – 2010) of data[6]. Maximum air temperatures have been the most common basis for reporting heat in India. In the summer season of the year 2022, a study reported that around 82 crore people faced 40 degrees C, and 99 crore people faced 38 degrees C on the single day of April 30 alone[7]. The vulnerability of humans to heat and resulting discomfort has been measured through an index called the universal thermal climate index (UTCI). UTCI maps presented in one of the studies are analyzed to detect the hot spots for heat vulnerability and thermal discomfort. Heat Vulnerability Index (HVI) map of India is another important resource that provides relative ranking of heat wave vulnerability for all districts in India. Based on data analysis techniques and geospatial comparison of the various relevant resources such as UTCI map, HVI map, MTBH map and LST map following states are identified as most vulnerable to heat stress: *Madhya Pradesh, Chhattisgarh, Gujarat, Rajasthan, and Odisha.*

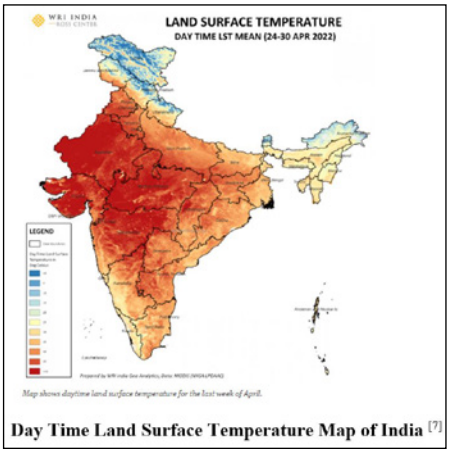


Moisture and Temperature based heat maps [6]



UTCI Map [7]





Day Time Land Surface Temperature Map of India [7]

Figure 2: Visual excerpts related to heat vulnerability in India

STEP-2: Locating Urban heat Islands (UHI) in identified vulnerable states

In the second step, authors further analyze the identified states (most heat vulnerable states) to locate the most urbanized regions to locate the urban heat islands (UHI) requiring immediate heat mitigation. Six factors that can affect urban heat islands: volume of the tree canopy, the height of the tree canopy, ground level vegetation, volume of buildings, difference in building height, and color of the buildings. Thematic maps[8] in the identified states were referred for understanding the urban land cover and land use in most heat vulnerable states identified in Step 1. To map UHI hot spots factors such as Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) are widely used as input parameters for scoring purpose in geospatial analysis tools such as ArcGIS. Landsat satellite imagery were pre-processed to extract the data. Referring to the methods specified in the Landsat 8 (L8) Users Handbook[9] NDVI and LST can be extracted.

Mapping the Land Surface Temperature

1. Converting digital numbers to spectral radiance
2. Converting Spectral radiance to temperature in Kelvin scale equation
3. Converting temperature to Celsius scale

LULC Classification

NDVI values can be used to classify land-cover classes[10] into following types: a. water (NDVI values between -1 and -0.2), bare land (NDVI values between -0.2 and -0.1), built-up area (NDVI values between -0.1 and +0.1), low density vegetation (NDVI values between +0.1 and +0.3), and medium density vegetation (NDVI values between +0.3 and +1)

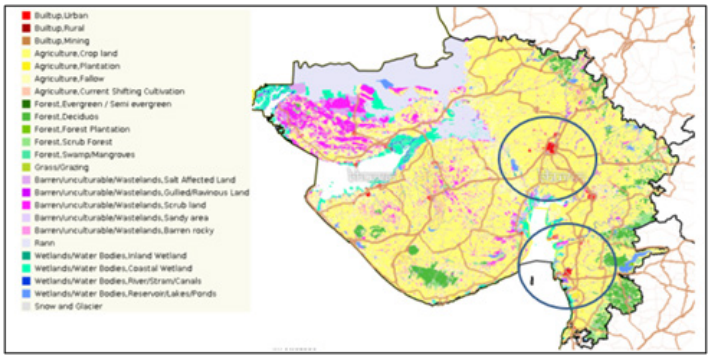


Figure 3: Sample BHUVAN Thematic map for LULC in Gujarat (Black circles present the areas having maximum urban built-up areas)

STEP 3: Identification of Potential Cool Roof Sites: Site-suitability analysis

LST distribution revealed in step 2 can is used to identify most heat vulnerable urban areas requiring immediate attention for cool roof implementation. Now next step is to locate the most suitable sites for cool roof siting. Landsat 8 imageries and various thematic maps developed by BHUVAN digital map can be referred for locating the built up and roof areas as multiple datasets in the geospatial domain can be extracted from these resources. The various data layers that can be extracted from such a digital map include LULC, Points of Interest, Roads, and Building Footprints. Prominent roof characteristics including roof colors, paints, etc. can be produced using Census 2011 data for the study region. Image reclassification of LULC imagery can be done to develop the roof color map. Transformed Divergence Separability Index (TDSI) values can be employed to distinguish the LULC and roof color categories using spectral signature[11]. Ultimately the spatial overlay and statistical analysis of the roof maps and LST map can expose most suitable sites using multi-criteria decision making on GIS tools.

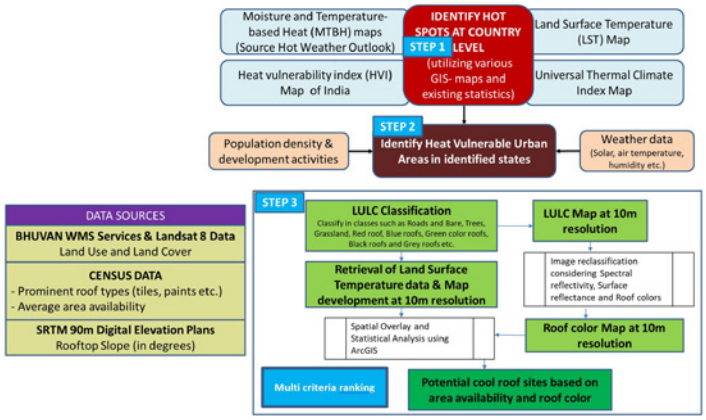


Figure 4: Proposed methodological framework

Discussion and Way Forward

This study presents a methodological framework to identify suitable sites for the implementation of a sustainable and cost-effective heat mitigation strategy "cool roofs" at heat stressed areas of the country. For identification of vulnerable areas in India authors have proposed to undertake assessment of demographic, geographic and climatological parameters including population densities, heat related mortalities, climate change related events, land surface temperature, land use and land cover patters, typical construction characteristics etc. at national, sub-national, city and neighborhood level considering past, present and future trends. As some of the cities are already positioned as most vulnerable to heat stress it is of utmost important to locate hot spots of urban heat island and prioritize the implementation of heat mitigation strategies at these locations. Authors have found that states located in central India (Madhya Pradesh, Jharkhand, Chhattisgarh) and Northwestern India (Gujrat, Rajasthan) are most vulnerable to heat stress. Urbanized built-up area in Gujrat, Rajasthan and Madhya Pradesh requires immediate attention as large population resides in this area. At national level Government of India has introduced the cool roof technology in its action plan (India cooling action plan) and Energy Conservation Building Code (ECBC). However, at state level the implementation of cool roofs has been limited as not all states have mandated the adoption of ECBC and its scope is limited to commercial buildings only. Recently there has been a deliberate focus on reducing UHI and thus some states have now introduced initiative for cool roof implementation. To name a few Ahmedabad, Telangana, Gujrat, and Madhya Pradesh appear as front runners. Green building rating systems

such as LEED, GRIHA, IGBC etc. mandate the implementation of different cool roof products and provide certified green products under their label. However, implementation of cool roofs has only be seen from the lens of higher ambient temperatures and other weathering attributes such as humidity, precipitation, moisture, wind etc. are usually ignored. Consideration should be provided to these ignored attributes in order to maximize the benefit cool roofs have for the reduction of UHI, LST and ultimately on cooling energy. All the prevention and preparedness plans for heat stress must prioritize the implementation of cool roof technology as heat mitigation strategy immediately for sustainable thermal comfort and overall livability in vulnerable areas.

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Rwanda Improves Land Management Processes with GIS Technology

The Rwanda Land Management and Use Authority's (RLMUA) latest release of the Land Administration Information System (LAIS) is transforming the way the country manages, develops, and maps its land.

Begun in 2008, Rwanda's land registration reform has fostered incremental improvements in the Rwanda land administration processes. The first version of LAIS helped to support the initial collection and management of large amounts of land administration and legal data for the development of land-use plans at the national and district levels.

In collaboration with Kadaster International, RLMUA used the Esri ArcGIS to develop and deploy LAIS version 4.0, which is improving the current process of titling and certification of land throughout the country.

Meeting the Challenge of Land Governance

The land authority is responsible for implementing the National Land Tenure Reform Program, as provided by the National Land Policy and the law governing the land in Rwanda.

Over the last two decades, Rwanda has invested considerably in land administration. Most recently, the successful deployment of LAIS version 4.0 in 2019 and the adoption of Esri's Land Administration Modernization Program (LAMP) have provided the country with advanced geographic information system (GIS) technology and support to meet the evolving challenge of comprehensive land governance.

Esri's LAMP is a grant program that allows resource-constrained countries and their cadastral agencies access to the Esri enterprise platform, supporting the upgrade to LAIS version 4.0 and mapping work. "RLMUA got multiple benefits from implementing LAMP, such as providing better and [speedier] service delivery to the population, more consistent data; eliminated errors in land titles; and [provided] a better protection of the land titles [and] web map services, among others," said Espérance Mukamana, Director General and Chief Registrar of Land Titles, RLMUA.

The new system overcame technical challenges encountered in the previous LAIS versions by combining previously separated textual and GIS components into one system and better aligning with the current IT system's security procedures. The new system also ensures alignment with the ISO 19152:2012 Land Administration Domain Model (LADM), which supports standardization and integration of land data.

LAIS version 4.0 now provides users with web access to up-to-date spatial data through mapping services, which can be shared seamlessly. It also integrates interactive national land data visualization that shares real-time statistics on land use through charts available on a central dashboard.

Additionally, the new system is enhancing transparency and providing users with the spatial tools and data they need to perform land-use analysis for their own land and collectively to better plan for the sustainable development of the country.

A Lighthouse for Africa

RLMUA has gained remarkable experience and results by using GIS for land management services, according to Mukamana, who says the technology has "led to a better understanding and implementation of the land management system and helped RLMUA achieve its targets efficiently."

LAIS version 4.0 places Rwanda among the few countries on the continent with the level of advanced geospatial technology that can operationalize land administration and use capabilities while also enabling real-time monitoring of land rights and use for potential investments in the country. The entire system has proven to be a vital tool that informs decision-makers on any changes made to land-related transactions.

"This project represents a lighthouse for Africa," said Sohail Elabd, Esri Global Business Development general manager, Middle East and Africa region. ""Many governments are looking at ways to increase revenue through registration of land. Esri technology, provisioned through the LAMP, provides a set of out-of-the box tools to do so. We are excited to be working with RLMUA to make this happen."

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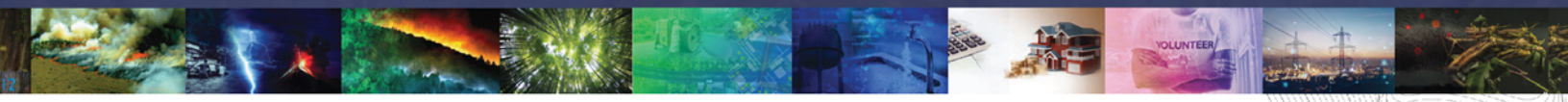

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*Online support on My Esri portal is enabled for Esri products only. Support for partner products e.g ENVI and ArcFM is available via email and telephone.

esri India

Esri India Technologies Private Limited

10th Floor, Max Towers, Sector - 16B, Noida - 201301, Uttar Pradesh (India)
Toll Free No. 1800 102 1918 | Email : info@esri.in | Web : esri.in