esri India
THE SCIENCE OF WHERE

Vol. 12, Issue 2

ArcIndia News

Cover Story

GIS for sustainable living

Case Study
GIS implementation in Municipal Corporation of Greater Mumbai

Interview/Customer Speak
Power reliability with GIS

Technology Update
What's new in ArcGIS API 4.9 for JavaScript

Partner Showcase
Optimizing solar energy generation using AI

esri India
THE SCIENCE OF WHERE

Creating smart & engaged cities with GIS

Geospatial technology gives you the location-based intelligence and spatial analysis you need to build and maintain a Smart City. With its 'Geospatial Analytics Tools & Platforms', Esri provides pre-emptive strategies and remedies that act as strong pillars of a Smart City.

Start your journey today at

esriindia.com/smart-cities

Agendra Kumar | President, Esri India

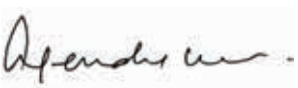
The 17 Sustainable Development Goals (SDGs) were adopted by the United Nations Conference in September 2015. The objective was to produce a set of universally applicable goals that balances the three dimensions of sustainable development: environmental, social, and economic. India is marching ahead in its roadmap towards achieving the Sustainable Development Goals. For implementing the SDG agenda, the Government of India has launched several programs including Smart Cities, AMRUT, Swachh Bharat, Namami Gange and Digital India. Across all these programs, GIS remains a core underlying technology for the implementation of all these programs.

GIS and spatial analytics offer a fundamental platform for integrating earth observations with people & processes by managing and analysing geographic information. It enables us to develop a "digital twin" of our planet and understand how our planet works, how things are interconnected, access the impacts of various actions and make informed decisions. GIS also provides a platform for collective problem-solving, decision-making, and perhaps most critical of all, collaboration.

The integration of GIS with emerging technologies like Big Data, AI and IoT, offers a great opportunity for GIS users to play an extremely critical role in the way we manage and analyse data, and most importantly use it for achieving sustainable development. This is the need of the hour. During recently held Esri India user Conference 2018, users from different government departments presented their work in the areas like Water resource management, Forest cover management, Initiatives for ecological balance, Urban Development, Smart traffic management etc. and shared how GIS is contributing in India's efforts in meeting sustainable development goals.

As we step into 2019, let us all resolve to apply GIS technology across widespread applications to achieve our sustainability goals.

Stay Inspired!



Agendra Kumar

CONTENT

Esri India launched GIS Academy Program for skill development

Esri India recently launched "Esri India GIS Academy Program" (EIGAP) for teaching, learning, and research purposes.

Conscious of the skills gap in the GIS space, Esri India is making strategic investments to train talent by making the technology accessible and affordable. The EIGAP program will bring a transformation by not only skilling the students with latest GIS technologies, but also promoting its adoption in India.

According to Agendra Kumar, President, Esri India, "There is a considerable demand of high quality and well trained GIS professionals across industries and sectors in the country. We are committed to building a strong GIS ecosystem in the country through academia and industry. Our program will help in bridging the skill gap and enable the university students acquire best of GIS knowledge".

The program is available to all Universities and colleges who plan to, or are already teaching GIS in their curriculum. The program includes access to software, curriculum and training resources to equip the institutions to impart best of the GIS skills to their students in various disciplines. Esri India has been supporting the academia through training the resources and equipping them with the GIS know-how through other programs like GIS Academia Council and mApp Your Way.

Elsevier integrates Geofacets into Esri ArcGIS

Elsevier, the information analytics business special- izing in science and health, has announced integration of Geofacets, its information solution for exploration and development, with ArcGIS, the flagship product of Esri. The new plug-in functionality, called Geofacets for ArcGIS gives geoscientists ability to make more informed exploration decisions and reduce risk, without having to leave the application to search. This has become possible through Geofacets' 1.9m maps, figures and tables. The integration delivers a smooth and intuitive user experience, enabling users to go from hypothesis to validation to analysis, faster than ever.

Geofacets for ArcGIS provides users with one primary information solution that combines the mapping and analysis capabilities of ArcGIS, with the information and data discovery solutions of Geofacets. This facilitates increased user focus, and efficient knowledge management and collaboration, and means that users can spend more time analyzing and acting on information instead of searching for it. The single interface means those companies which rely on data from ArcGIS to support their decision making can optimise operations, decrease risk and increase geoscientists' productivity by allowing them to spatially search for validated maps, figures and tables all in one place.

"We're delighted that Geofacets has been elegantly integrated with ArcGIS Desktop and ArcGIS Pro. The easy-to-use interface is a huge increase in usability for the geoscientist using the ArcGIS platform," said Paul Hartwell, Natural Resources Partner Executive, Esri. "We're delighted to not only be integrating Geofacets with ArcGIS, but also to be a Silver Tier partner in the Esri Partner Network." said Sumita Singh, Managing Director, Reference Solutions, Elsevier.

Field Squared and Esri collaborates to Integrate ArcGIS with Field Squared's unified field service platform

Field Squared, Inc., the industry's first Field Service Management Process Automation Platform, has partnered with Esri to integrate Esri ArcGIS within Field Squared's unified field service platform and mobile application.

Accurate geospatial asset management and visibility of fixed and mobile assets is a challenge for field service organizations. By integrating with Esri's ArcGIS software, Esri customers will now be able to synchronize Esri's Feature Services into Field Squared's asset management module. Using the Field Squared Mobile Application, field technicians will have the ability to visualize assets over Esri's ArcGIS base maps and overlays as well as redline asset updates from their mobile device in the field—online or offline. Field updates can be part of an approval workflow before they are synced back to the ArcGIS database.

"Partnering with Esri combines two powerful solutions—Esri's ArcGIS with Field Squared's unified field service management software—to better manage assets in the field from a single pane of glass," said Christopher James Camut, Director, President, and CEO at Field Squared.

"As leading field service management software provider, and one that understands the importance of geospatial asset management, Field Squared was a natural choice to partner with on this effort," said Matt Piper, Global Director Industry Solutions, and Industry Manager Electric and Gas.

Explorer for Esri ArcGIS app now listed in FirstNet App Catalog

Esri's Explorer for ArcGIS app is now listed in the FirstNet App Catalog. The App Catalog allows FirstNet subscribers to discover and access technology that's been specifically reviewed for use on FirstNet. Esri is also providing access to location-based APIs, SDKs, and configurable user apps for developers to support the integration of geospatial capabilities into solutions tailored for the needs of public safety. Explorer for ArcGIS is an industry-standard mobile application for Android and iOS that brings maps into the field on first responders' mobile devices.

"Esri is excited to be included in FirstNet App Catalog, targeted to public safety community," said Mike King, Global 911/FirstNet Manager, Esri.

Combined with Esri's software as a service, ArcGIS Online, Explorer for ArcGIS allows first responders to access their agency's authoritative maps in the field on mobile devices for better situational awareness. Explorer's search capabilities allow responders to search and find places and features, such as assets or areas of interest. Responders can also stay productive in remote locations or in areas with limited connectivity by downloading their maps for offline access. Markup tools make it simple for responders to add notations directly onto maps that help communicate operational needs with other users. Explorer for ArcGIS can also be bundled with other apps in the FirstNet App Catalog – like AT&T Enhanced Push-to-Talk – to further give first responders more situational awareness of the incident.

"We're pleased that Explorer is now Listed in the FirstNet App Catalog," said Bob Sloan, Chief Operating Officer, FirstNet, AT&T.

Esri signs MoU with UAE Statistics Authority

The Federal Competitiveness and Statistics Authority (FCSA), the national statistics body for the United Arab Emirates (UAE) and Esri has entered into an agreement to geoenable FCSA's work. The resultant collaboration will include the creation of an innovative road map to further enhance the geospatial capabilities of FCSA, further integrate location intelligence technology with statistics data and provide subject and technical expertise to the UAE.

"FCSA has already shown its commitment to the United Nations' (UN) Sustainable Development Goals (SDGs) with the launch of its national portal and this agreement will build on that and broaden support of all FCSA's functions."

"This agreement with Esri will allow FCSA to maximize the benefits of utilizing geospatial information in our important work," said Mohammad Hassan, Executive Director, The National Statistics and Data Sector, FCSA. "Our innovation to date and planned road map for the future will help us deliver our vision with the help of technology and new ways of thinking. It will anchor and sustain the valuable effort in place to ensure its success and viability."

FCSA's commitment to further the integration of geospatial and statistical data is in line with and guided by the Global Statistical Geospatial Framework, as agreed by UN Global Geospatial Information Management Expert Group on the Integration of Geospatial and Statistical information (GGIM EG-IGSI), as well as the United Nations Statistics Division project on the Federated Information System for the SDGs (FISSDG).

Esri partners with Ocean Health Index team to release new ocean health data

Esri has announced partnership with Ocean Health Index (OHI), the first program to comprehensively assess ocean health. OHI is a joint project of Conservation International and the National Center for Ecological Analysis and Synthesis. Together, the organisations have integrated OHI scores as a data layer in Esri's ArcGIS Living Atlas of the World and will launch Ocean Health Hubs, which are online tools that enable ocean managers to explore data to better understand regional ocean health.

Dealing with ocean health data is complex. OHI assesses ocean health by looking at the social, ecological, and economic benefits that oceans provide to people. There are over 100 global datasets that power OHI's annual assessments, and they will serve as the foundation for Ocean Health Hubs. Developed with the help of ArcGIS Hub, Esri's citizen engagement platform, Ocean Health Hubs will display these global datasets with local data and allow faster progress on establishing ocean policies and setting priorities.

"Ocean Health Hubs will streamline data management, target setting, and communication into one tool that can be easily accessed and updated by multiple collaborators," said Eva Schemmel, Director and Conservation International Science Adviser, OHI. "Citizens, scientists, managers, nonprofits, and governmental agencies can use the hubs together, making engagement more efficient and effective."

Ocean Health Hubs can be used as the first step in regional OHI assessments or on their own to track ocean conservation investments and sustainable ocean management within a region. Esri's mapping and analytics software will bring this data to life, allowing users to visualise ocean health through Living Atlas and explore open-source datasets for a specific region through hubs.

"Esri is happy to partner with OHI to further unlock data and lower the barriers for ocean managers and policy makers," said Dawn Wright, Chief Scientist, Esri. "These newly accessible datasets will allow users to better understand their regional ocean health and make sustainable ocean management decisions. Our involvement is part of Esri's broader support of initiatives within Conservation International and is in concert with the National Center for Ecological Analysis and Synthesis."

Independent research firm recognizes Esri as a leader in location intelligence platforms

Market research firm, Forrester has recognized Esri as a leader in location intelligence platforms in The Forrester Wave™: Location Intelligence Platforms, Q4 2018 Evaluation. The report acknowledges Esri's leadership in location intelligence technology and highlights the company's long-term commitment to innovation in its market-leading geospatial cloud.

The Forrester report notes, "Esri's vision for location intelligence is to help organisations understand why things happen where and when they happen, with the goal of gaining business advantage through better understanding. By continuing to evolve [its] ArcGIS [platform], Esri is pushing beyond the traditional GIS markets that it has long dominated into the location intelligence market."

"While ArcGIS has long been recognized as a comprehensive system for spatial data analytics and visualisation in the public sector, we think Forrester's recognition reinforces that it is also the go-to enterprise system for the private sector," said Jack Dangermond, Founder and President, Esri.

In the report, authored by James McCormick, Emily Miller, Gene Leganza, and Robert Perdoni, Esri received the highest ranking in the "Strategy" and "Market Presence" categories. Esri also received the highest score among all evaluated vendors in the spatial visualisation and analytics criterion.

"Serving a wide range of users has always been important to us, and we believe having the strongest ecosystem in geospatial cloud solutions allows us to achieve that," said Cindy Elliott, Head, Commercial Industry Strategy, Esri. "Esri's lightweight supporting services are easily embedded to provide location awareness for everything from retail loyalty programs to supply chain optimization."

ArcGIS Indoors

Enabling the Science of Where, Indoors

When it comes to putting spatial data analytics to use, Esri's products remain unmatched in terms of innovation and capabilities. With the launch of their new product ArcGIS Indoors, Esri has made another such conscious effort.

While outdoors are getting heavily mapped, Esri makes a novel attempt to ensure that buildings/campuses don't look like black holes in the GIS world. ArcGIS Indoors is a product offering a complete system that brings location intelligence to empower smart workplaces.

A workplace could have an enormous amount of stratified information about its facilities, assets and spaces. With ArcGIS Indoors, Esri offers a product that meets the large demand for real-time indoor location solutions. Examples of indoor locations that require real-time mapping solutions include corporate facilities, retail and commercial locations, airports, hospitals, event venues and universities.

ArcGIS Indoors makes life easier for employees, customers, travelers and visitors by allowing them to see and share where assets, rooms, departure gates and offices are located. This information, combined with navigation, scheduling and analytic capabilities allows buildings to operate at an increased level of efficiency and safety.

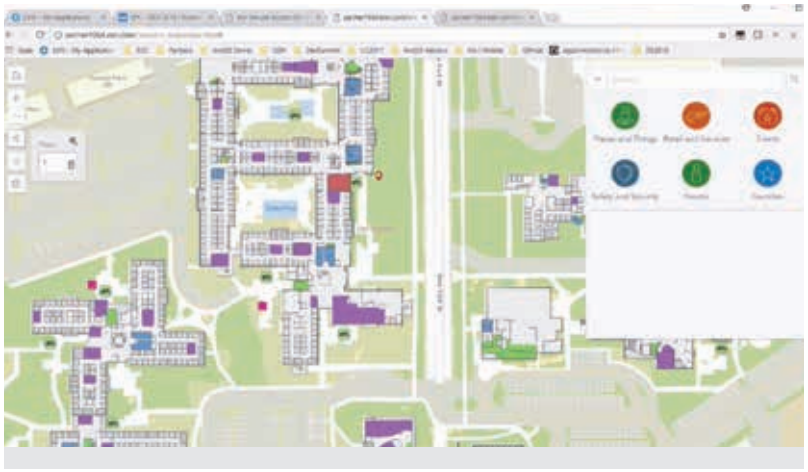
A beta version of ArcGIS Indoors was released at Esri User Conference 2018, held on July 9–13 at the San Diego Convention Center in San Diego, California. It was an exciting time for the participants as they got a glimpse into the working of the product; routing, scheduling and locating functionality was demonstrated. Visitors could schedule sessions and receive walking directions based on their current location inside the venue of the event. Locating functionality like nearest fire exits, conference rooms and cafes was showcased. Combined with scheduling functionality, the system could tell you where your next meeting is and how much time it will take to get there the fastest possible way.

Main Components of ArcGIS Indoors

- **Indoor desktop** - An add-in for ArcGIS Pro to create & edit indoor. 2D and 3D indoor maps can be prepared.

- **ArcGIS Indoor Information Model (AIIM)** – A schema specifically prepared for indoor mapping as 2D and 3D. In this model, a building has hierarchical layer information like Site, Facilities, Levels, Details Lines, Units

ArcGIS Indoors makes life easier for employees, customers, travelers and visitors by allowing them to see and share where assets, rooms, departure gates and offices are located. This information, combined with navigation, scheduling and analytic capabilities allows buildings to operate at an increased level of efficiency and safety.



and Occupants/POIs/Schedules/Events etc.

- **Point of Interests (POI)** - This is the essential information in the system, anything for which a user will use ArcGIS Indoors to find. For example, Places & Things, Services, Safety & Security, Events, Employees, Departments etc.

- **Transportation Network** - A lattice network that covers every walkable space in a building based on the available location data. This network is 3D network dataset of the building.

- **Vector Base Maps** – Contrary to the aged long raster base maps, ArcGIS Indoors will use small in size, easy to transfer vector scale data Base Maps.

- **Data Types / Data Source** – Floor plans can be prepared using IMDF /CAD Drawings and BIM Model and Blueprints.

- **For sharing** - Indoor maps can be pushed to ArcGIS Online as a mobile package or Web Maps and Web Scene to be accessible in ArcGIS Indoors Mobile Application and Browser based Application, respectively.

- **Collaborative** – Esri products like operations Dashboard, Survey123 can configure with ArcGIS Indoors browser based or mobile applications.

ArcGIS Indoors Mobile App

The native mobile app for ArcGIS Indoors will be released on both iOS and Android platforms with support for indoor positioning feeds like beacons, WiFi and smart lighting. It would work in non-connected environments as well and support all common workflows. The solution also includes desktop and enterprise tools for assembling, managing and sharing information.

This app has access to a mobile map package that is hosted on ArcGIS Online and that contains all the indoor location information relevant to the building at hand, such as CAD/BIM Data, POIs and transportation network. Routing, Scheduling, Location are some of the functionalities of ArcGIS Indoors Mobile App.

Adding Business Value

Esri foresees a great potential for ArcGIS Indoors in large corporate complexes, retail and commercial locations, airports, hospitals, event sites, college campuses, etc. By combining indoor mapping information with navigation, scheduling and analytics, organisations can make life a whole lot easier for employees, customers, travelers and visitors. The product will be available for widespread use by the end of 2018.

Optimising solar energy generation using AI

The world is in dire need of clean and renewable energy sources. Non-renewable energy resources are not only finite, but are also incurring high cost and most importantly, are harming the environment. An important element of sustainable living is sustainable energy. To meet today's growing demand without compromising on the future, we need to develop sustainable energy sources like solar, wind, geothermal, hydropower etc. These renewable energy sources have low environmental impact, are widely available and are naturally replenished.

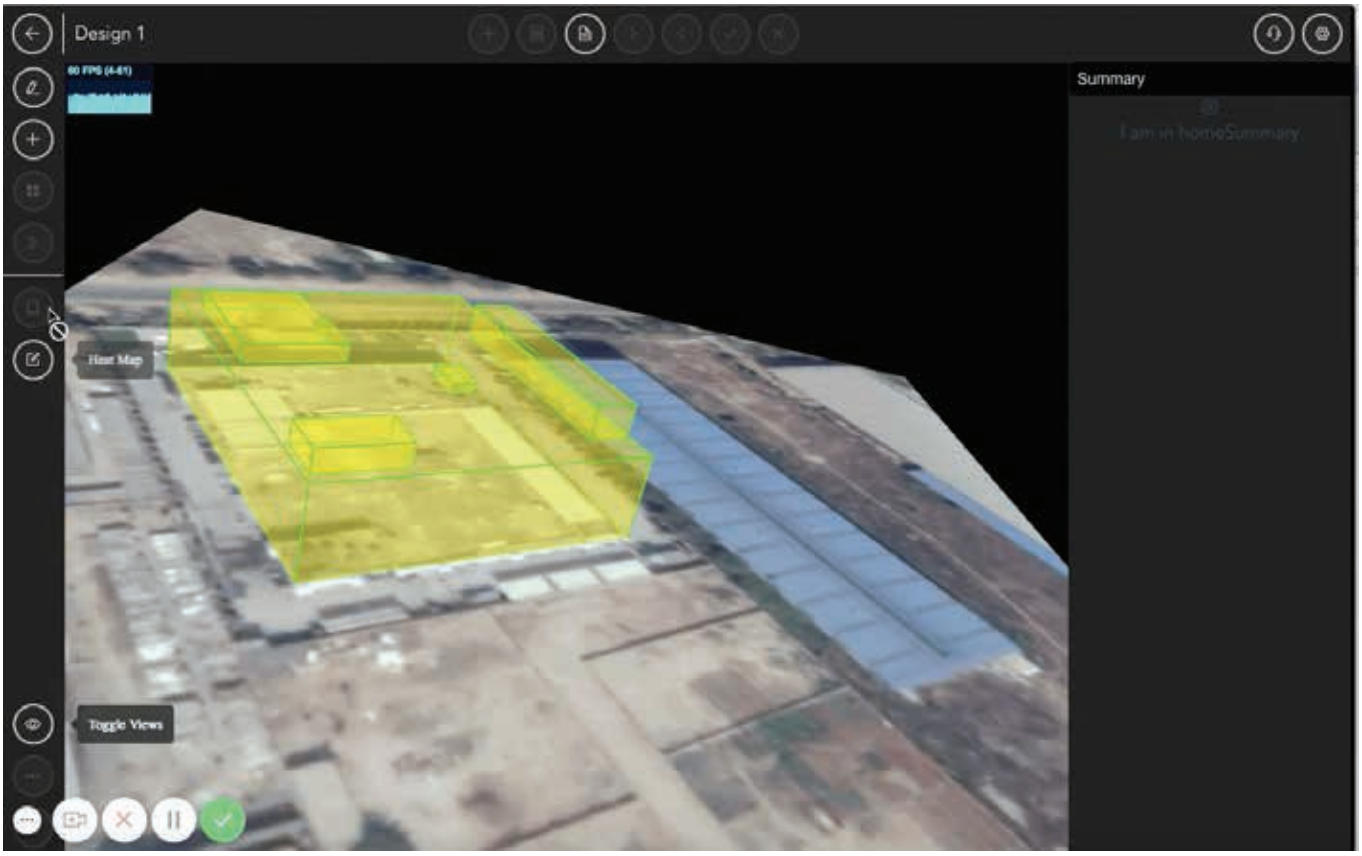
We are fast moving towards development of smart cities, and solar energy devices that are pollution free and environment friendly, support sustainable development of smart cities. Integration of solar power and other renewable energy sources is quickly becoming a hallmark of smart city planning.

India has already set an ambitious target to generate 60,000 MW of electricity from wind power by 2022. The Indian Government's Ministry of New and Renewable Energy announced a new wind-solar hybrid policy in May 2018.

While the Government is showing strong commitment towards making India future energy ready, the private sector is also not lagging behind. While established brands are creating waves in the realm, it is fascinating to discover the younger generation's commitment towards the cause.

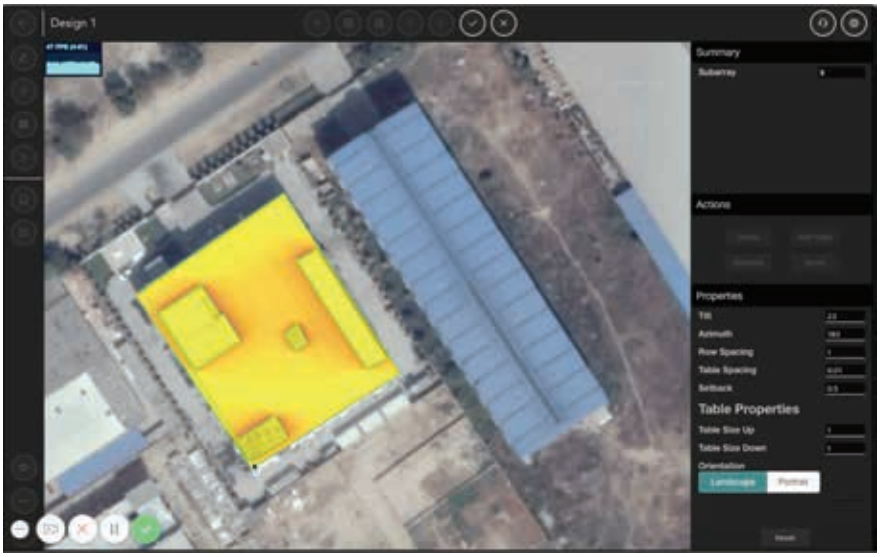
The Solar Labs

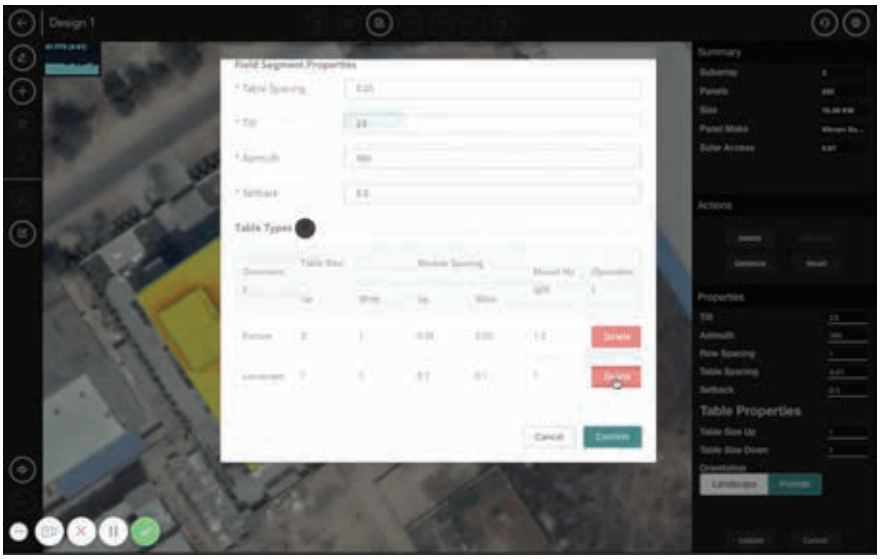
It is not everyday that you see a group of young brilliant minds leave the prospects of a cushy job, and channelise their efforts towards creating a better world through their innovation. This is the story of The Solar Labs, an award winning start-up, which helps solar companies to analyse sites remotely using site video and design an optimised solar PV system that generates the maximum solar energy for that site. The company's one of its kind, AI powered software



for solar system design enables companies to reduce engineering time and optimise system design for higher energy generation.

The Solar Labs was incubated at IIT Mandi Catalyst and NASSCOM 10k Startups. Siddharth Gangal, Founder and CEO calls himself a Solar Evangelist, and wants to do his bit to save the world from global warming. His commitment towards doing his bit in achieving sustainable development gets reinforced as he shares, *"It is very important to build renewable energy sources. Solar as an industry is growing around 50% year-on-year in the world. In India, it is growing at 80% year-on-year. There is huge potential in the solar industry."*





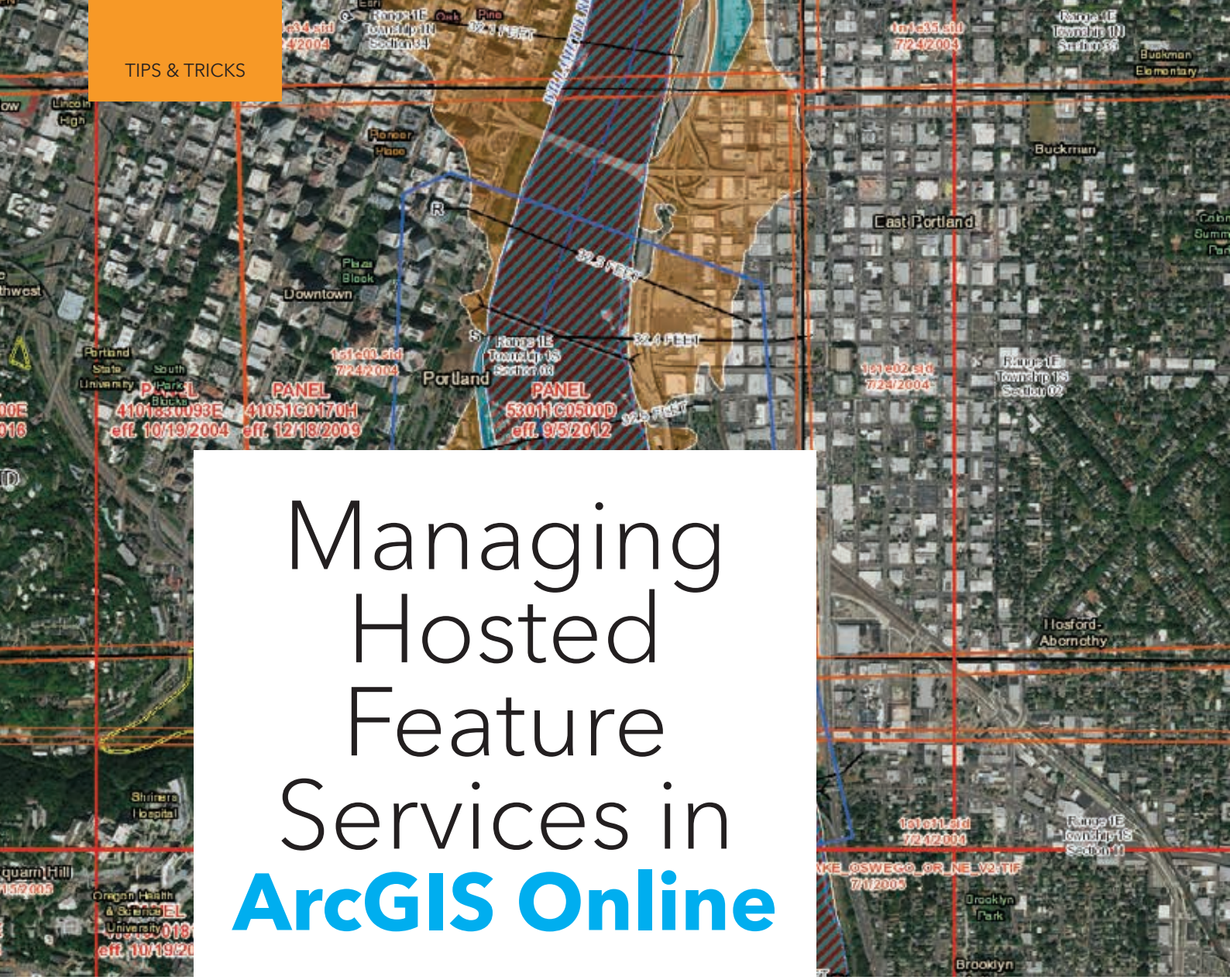
When asked about his company's innovative solution that can significantly ease the processes in the solar industry, he proudly shares, "We have developed a SaaS platform for solar companies to help them understand how many solar panels can be installed and we also help them in engineering the design. Our software recommends the optimum layout for wires, panels, inverters and others, on the roof top so that as a system they generate the maximum energy possible. Our software takes around 5% of the time to make designs that perform up to 10% better."

Using Artificial Intelligence, the Solar Labs software can find out for any roof what is the best way to place a solar system on the roof. The organisation is committed towards providing solar analysis for smart cities. It carries out city scale solar analysis, providing building level capacity, generation and financial estimates for solar installation. It helps in understanding the solar potential across the city as well as individual buildings.

What role is GIS playing in this system?

For placing solar panels on any roof, the primary analysis that has to be done is called the shading analysis. Since solar panels cannot create electricity in shade, this is crucial. There could be water tanks, staircases or even a taller building around which could cast shadow on the panels. GIS helps in identifying the right positioning of the solar panels on the roof. The Solar Labs is using Esri ArcGIS for visualisation. Additionally, winning Esri India's Geoinnovation program has helped it gain more confidence, better understanding of the technicalities and impactful associations.

The solar industry is growing very fast in India. Right now, the commercial and industrial segments are leading with the largest growth. However, in the next two years residential areas are expected to pick up significantly. As India focuses more on solar energy, the Solar Labs is inclined to get involved in larger projects, keen to play a vital role in the Indian sustainable energy growth story. In its journey towards achieving this goal, Esri India commits to remain a strong partner. As Siddharth says, *"For the next three months, we will be working extensively with Esri India and making arduous efforts towards improvising the product. We are excited to be part of the Esri App Marketplace as well."*



Managing Hosted Feature Services in ArcGIS Online

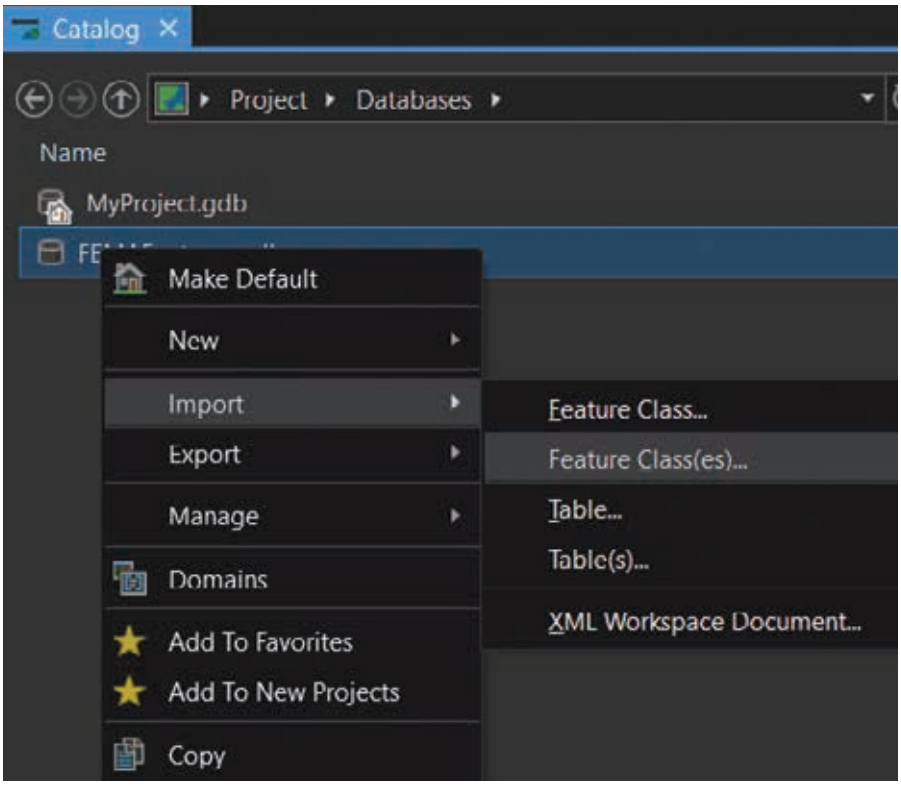
Hosted feature layers in ArcGIS Online are most appropriate for visualising data on top of your basemaps. The hosted feature service provides access to the many attributes associated with any polygon. Complex features contain properties that can contain further nested properties to arbitrary depth. In particular, complex features can contain properties that are other complex features. Complex features can be used to represent information not as an XML view of a single table, but as a collection of related objects of different types.

Due to these complexities, for a GIS professional, having to develop a hosted feature service with 2.5 million features can be terrifying. A feature service with very complex geometry can be very slow, as every time during pan/zoom of the map all of the vertices need to be redrawn. The more complex the features, the slower the web service responds. Hence, it is important to increase the performance of the ArcGIS Online feature services while maintaining the integrity of our data.

How to make ArcGIS Online Server handle large dataset easily

Here are few tips on improving the performance of ArcGIS

Hosted feature service with 2.5 million features can be terrifying. The more complex the features, the slower the web service responds. Hence, it is important to increase the performance of the ArcGIS Online feature services while maintaining the integrity of our data.



ArcGIS Pro menu for importing features into a file geodatabase

Server such that it can handle large datasets efficiently.

- ➔ Clean up the attribute table to reduce what needs to be served.
- ➔ Make the length of text fields as short as possible.
- ➔ Use integers instead of floating point whenever possible. For example, 2.45m could be converted to an integer of 245 cm.
- ➔ Remove unnecessary fields. And while you're at it, make sure the fields have understandable aliases.
- ➔ Set resolution and tolerance values to integers of an appropriate scale.
- ➔ Remove unneeded classes.
- ➔ Use the Check Geometry tools to identify issues. The tool produces a table that can be joined to the feature class to identify bad features. Then use Repair Geometry to fix those errors. You may need to run the tool more than once. These tools can cause changes to the polygon shapes, so check the results.
- ➔ Choose the correct coordinate system. Publish the service in that standard system– otherwise the server needs to reproject on-the-fly.

How to get the hosted service published faster

- ➔ No one can expect a 10 GB service to publish in a few minutes. But sometimes the publishing process seems to drag on indefinitely. Here's a trick to get everything to load:
- ➔ Create a new file geodatabase in your Catalog pane.
- ➔ Load the feature class into the empty file geodatabase.
- ➔ Go to ArcGIS Online. Click on Content > Add Item > From my computer. Browse to and select the zipped GDB.
- ➔ In the Contents dropdown select File Geodatabase and leave the Publish this file as a hosted layer box checked.
- ➔ Add the title and tag information.

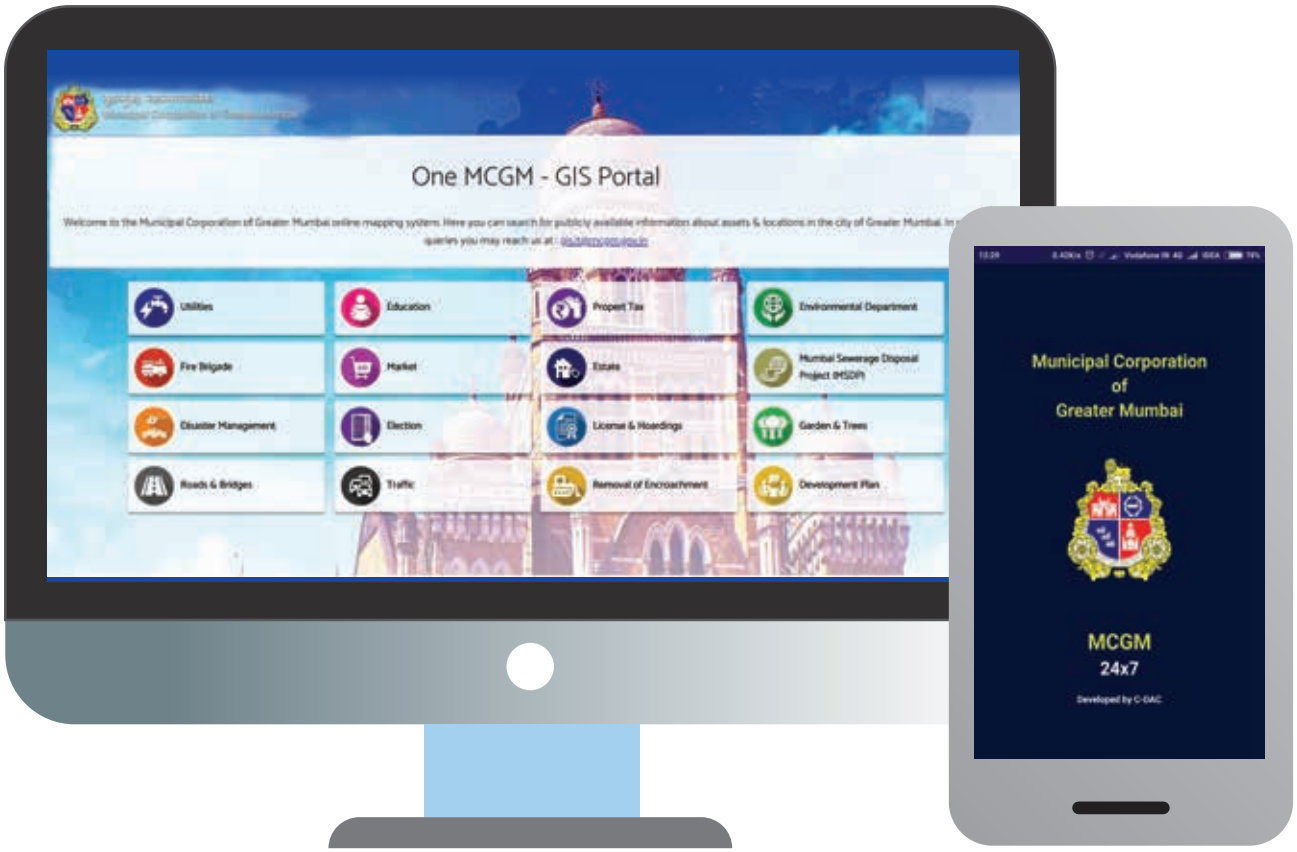
Optimise the settings

- ➔ Adjust the Cache as needed.
- ➔ Check Optimise Layer Drawing and Save.

Configure the web map

One trick in getting a highly performing web map or app is relying on the strengths of both the image service at coarse resolution and the feature service at higher zoom levels. Adjust the Set Visibility Range of both layers in the web map so that they appear/disappear at the optimal scale. Figuring out the zoom level takes a bit of trial and error, but once you figure that out, you'll have the best of both worlds.

Besides working with the layers in ArcGIS Online, you can also use the Copy Features tools in ArcGIS Pro and then run spatial analytics.



GIS implementation in Municipal Corporation of Greater Mumbai

Sustainable city is a city designed with consideration for social, economic, environmental impact and resilient habitat for existing populations, without compromising the ability of future generations to experience the same. In the approach, to create a sustainable city, the objective is to provide core infrastructure and provide a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions.

The Municipal Corporation of Greater Mumbai, also known as Brihan Mumbai Municipal Corporation is the civic body that governs the Mumbai city & its vision to integrate multiple information & communication technology & Internet of things to manage city assets and operations. Its goal is to improve the quality of life and efficiency of services that meet the citizen needs. The City municipal administration has been instrumental in conceptualising, designing and finalising the City plan along with citizen engagement. Under the City Initiative of the Government of India, it is planning to develop areas under its jurisdiction.

Business problem

The Municipal Corporation of Greater Mumbai (MCGM) covers a total area of 454 Sq.Km. and caters to a population of 12.43 million according to 2011 census. There are 24 wards under the corporation and more than 75 departments to provide various services to citizens of Mumbai.

Being the largest city of India, with a high density of population 20634 person /sq Km, the major challenge is to meet the increasing demands of governance and service delivery, for the citizens.

To maintain the sustainability of service delivery, MCGM embarked on an ambitious e-Government initiative, aimed at enhancing responsiveness to citizens' needs; increasing operating efficiency and effectiveness; improving financial health; and ensuring greater transparency within various departments like Sewerage Operations, Disaster Management, Environmental Department and Public Health Department.

There were challenges like:

- ➔ Need of a local spatial database.
- ➔ Requirement of a common base map.
- ➔ Unavailability of attribute and department GIS data.
- ➔ Lack of end to end GIS data management.

- ➔ Changes required in business processes.
- ➔ Isolated policy making.
- ➔ Challenges of significant and continuous technology changes
- ➔ Duplication of data.
- ➔ Significant use of hardcopy maps.
- ➔ Lack of skilled personnel.
- ➔ Lack of GIS data standards & sharing policies.

The two main challenges addressed initially were:

- ➔ Citizen Services through a GIS portal.
- ➔ Inter-department collaboration.

Solution details / innovation

GIS provides a common communication language to the different stakeholders of a city. It provides a language to citizens to interact with government. These two are major aspects of sustainability of a city.

A digitised base map of Greater Mumbai was created by digitising Tikka and Town Planning scheme images. Land parcels and roads were re-digitised, followed by scanning and digitising of 6000+ images to capture different features of the city incorporating the development plan for 20 years duration, all major utilities, revenue elements and social infrastructure to have an integrated database for better planning management and sustainable development of the city.

Esri GIS Integrator was envisaged to bring all MCGM GIS data & applications to a collaborative GIS content sharing platform.

Desktop GIS applications were deployed in 2008 for generating Development Plan remarks for department users. Esri India further helped MCGM Development Plan Department to launch an One MCGM Portal, which is used by the MCGM internal users. The Portal host all the GIS data of different departments and web applications that are shared across the user base.

In five departments, GIS was used for design, migrate / implement & maintain GIS data and web applications for end-to-end asset management. These departments are Sewerage Operations, Roads & Traffic, Hydraulic Engineering, Storm Water Drainage and Bridges. 35 layers of GIS information have been crated in One MCGM portal for catering to the requirements of these departments.

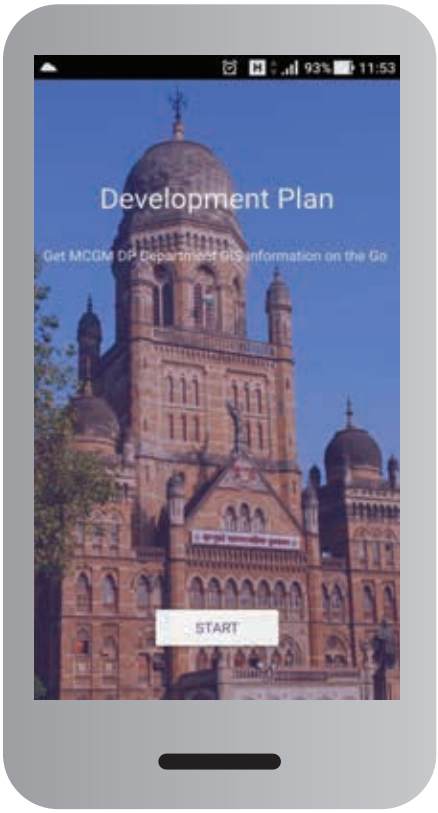
Sewage Operation (SO) Department: SO department manages the entire Sewerage network within the City and the Suburbs of MCGM area. Application Tools for location based management includes

- ➔ Asset Management
- ➔ Preventive Maintenance
- ➔ Complaint Management
- ➔ Condition assessment
- ➔ Fast & Easy Monitoring
- ➔ Easy Reporting
- ➔ Enhanced Visualisation
- ➔ Efficient planning
- ➔ Decision Support System
- ➔ User Management
- ➔ Distributed Data Editing

Development Department Remarks Generation: Development department (DP) plans and implements the development plan for the city of Mumbai. Each development plan spans 20 years, current one bring from 2014-2034. Based on the urban planning and town planning standards and policies, DP plan details the land use across the MCGM area, divided into 24 administrative wards. DP Plan consists details of existing amenities, existing roads, town planning schemes, coastal regulatory zones, land use zones, parcels boundaries, planned amenities, planned roads and road widening information, slum rehabilitation area etc. (100+ layers). Remarks Generation Application facilitates:

- ➔ Obtaining DP department's remarks is the first step of getting construction permission within the city of Mumbai for any type of construction.
- ➔ Online SRDP 1991 (for DP plan 1991-2011) and Online DP34 (DP Plan 2014 - 2034) applications developed by Esri India are available to any citizen who wishes to generate remarks against their input parcels for a nominal fee.
- ➔ Based on the selected input plots on the map, the application will generate the GIS remarks in pdf format.
- ➔ In addition to land use information, the application also fetches information from other department's data like Hydraulic Engineering (Water works), Sewerage Operations, Storm Water Drainage and contour.
- ➔ The application can be accessed through the following URLs

SRDP1991 - https://dpremarks.mcgm.gov.in/srdp1991

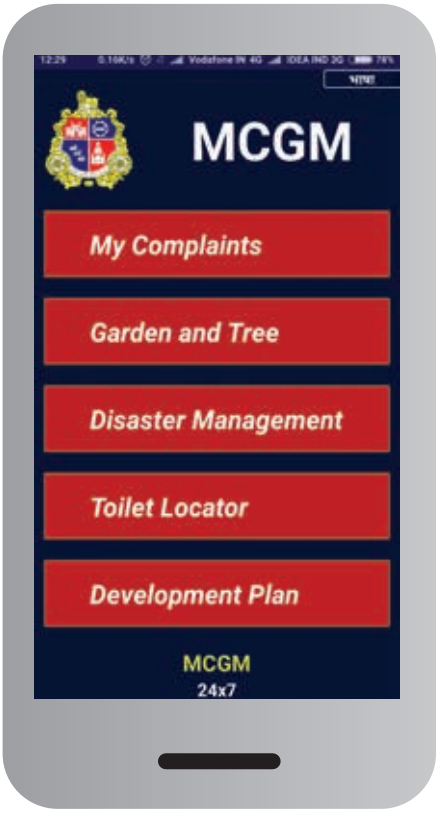


DP2034 - https://dpremarks.mcgm.gov.in/dp2034/

As part of One MCGM initiative, a **Mobile Application for citizens** was developed for viewing the various DP reservations.

Integration with SAP: One MCGM is integrated with different applications running in MCGM to create spatial reports

- ➔ Integration with Capital Value System (CVS)
  - Establishment of integrated communication between GIS and CVS applications.
  - Assignment of multiple SAC numbers to single building and sharing the building IDs with CVS system.
  - Assignment of Single SAC number to a single building.
  - Assignment of single SAC number to multiple buildings
  - Integrated GIS and CVS environment to execute above functionalities.
  - Consolidated Mapping Report.



- ➔ Integration with Auto DCR system, Building Construction Approval Management System (BCAMS) under EODB initiative.
  - Under One MCGM this integration is enhanced when an applicant applies for Construction permit in AutoDCR system. Applicant will select respective CTS/CS number in GIS and GIS will transfer Remarks to AutoDCR and the Common application form will get filled automatically.
  - Integration with SAP (PS) System for real-time projects monitoring.
  - When any new engineering work will be started, same will be updated in GIS. At the stage of WBS creation, users must mark work in GIS. Without this WBS cannot be released in SAP (PS) module.
  - Integration with SAP (RE) System for Real Estate Department.
  - Linking of Unique Property ID of SAP-RE system with Building polygon in GIS.
  - Search of GIS features to assist users to locate estate property on map.
  - Estate Property Mapping Approval by Supervisor.
  - Consolidated Mapping Report.

Dashboards: For executive monitoring of real time operations, a dashboard has been created.

Mobile based Workflow: GIS enabled mobile apps has been created for MCGM field staff to view and update project status from the field.

- ➔ GIS On the GO – Mobile app for citizens and field users was launched.
- ➔ Integration with ERP – SAP integration for project monitoring and maintenance was done.
- ➔ Decision Support System became better and helped in effective planning.

Esri ArcGIS platform has also helped in the following:

- ➔ Enterprise Geo-Database of MCGM.
- ➔ Institutionalization in Spatial data management.
- ➔ Survey Guidelines
- ➔ Standard Procedures for GIS data creation, usage, cleaning and auditing.
- ➔ Enterprise GIS Web applications
- ➔ GIS integrations with other applications.

Earlier arrangement required citizens to visit local ward offices of MCGM to seek information of DP reservations, City survey number etc. With the launch of Mobile Application, citizens now can view all the details of the plot/DP reservations. It has also become a Common Application platform.

One MCGM is helping citizens to request for services in an easier and faster manner.. The Municipality is in a better position to service its citizens, better monitor and control its activities and introduce Customer Relationship Management concepts; resulting in tangible and visible increase in the quality of services for the average citizen.

In future, MCGM plans to bring on board more departments with GIS data and create web applications for various public usage and internal users. It intends to launch One MCGM for public view and integrate it with other government GIS, private utility GIS Data and IoT sensors. Enriching data through citizen collaboration and effectively using GIS in 'Ease of Doing Business' initiative are other future plans of MCGM with One MCGM.

Power Reliability with GIS

BSES Yamuna Power Ltd. (BYPL) covers several areas of East and Central Delhi with its power distribution system. The organisation has over 14 lakh customers and 14 division offices. In an effort to improve its services, BYPL upgraded and augmented its infrastructure, investing over INR 6,600 crore in this exercise. Despite this success, BYPL was plagued by the problem of outages. It needed to efficiently identify and resolve them.

Anish Kalucha, CIO, BYPL

The company thereby, developed an Intelligent Outage Management System (i-OMS) that used the power of ArcGIS to improve the quality and reliability of the power it was supplying to consumers and make significant savings.

To know more about i-OMS, we engaged into a conversation with Anish Kalucha, CIO, BYPL .

What were the key challenges with the existing system?

The company's traditional Outage Management System (OMS) had certain disadvantages such as the fact that it was built on an old platform, had slow server response as a heavy application, was non-predictive in nature, non user-friendly, and non-compatible with smart apps. The OMS had to be downloaded frequently and offered limited reports.

The older version of OMS was relying on inputs from SCADA/DMS/EMS or IVR systems to estimate the location of the faults causing the outages, generate switch orders and manage work crews. This approach was reactive, since the analysis and the location of the faults was occurring well after the outage had taken place. The precedents that were critical to the analysis of potential and future outages or their likely impact were not being recorded or were lost. One of the major problems was getting data and the quality of data. The users were pulling data from the highly scattered databases. Many users had created their own databases and they were also not synced.

A GIS-based outage management system was the solution to our problems. Not only, it could help us manage outages better, but also have a single repository of all data.

How is the system helping in managing power outages?

The i-OMS is connected to other enterprise systems like SCADA, SAP and ERP systems. Since it's based on GIS, whenever there is an outage in field; that outage first goes to SCADA and since i-OMS is integrated with SCADA, the outage automatically gets updated in i-OMS. Whenever there is an outage, an SMS is automatically sent to all our consumers, so that they get first hand information about the outage in their area. They also get to know in how much time it will be resorted and the electricity will be back. While, consumers are getting the information, our field staff is also getting alerts on a real time basis. We have given them Android-based mobile application so that they can respond to outage at real time and close the information on field itself.

The same i-OMS is working at our call centers as well and when consumers call, our centers share with them the real time information about any planned/emergency outage or breakdown and even inform them about the time when that will be restored. The system has significantly reduced the cost of a breakage/shutdown for the utility and its rate payers. We are now being able to provide quality power 24x7. Overall productivity of network engineers has also increased by almost 20 percent!

What role has Esri India played in the scenario?

i-OMS has been effectively implemented by Esri India. Various technologies were used for the development of a GIS-based scheme creation module including the ArcGIS Server and ArcGIS API for JavaScript. As the application used the ArcGIS architecture, the accuracy of its corporate data assets was enhanced in an exponential manner.

How do you plan to make the system more effective using latest technologies like IoT and AI?

We are working on IoT, wherein we have installed sensors at all our transformers to continuously monitor their performance, like the oil level, oil and pump temperature, and gap which is available in RMUs. Whenever, there is low oil or high temperature, the sensors generate an alert to the maintenance staff stationed on the field and they can take corrective action immediately.

Bringing more harmony with GIS

Norman Myers, a British scientist had said that human footprint is expanding and its influence on the landscape is very apparent. So we need to conserve some areas where there is very high bio-diversity. In the 1980s he also identified few such areas, which he called bio-diversity hotspots. He said that if we are able to preserve these areas, we will be able to preserve 50% of the world's species.

Dr. Prashant Hedao, PhD, Auroville (India), visiting faculty at University of California at DAVIS

The extinction of species by human activity continues to accelerate. We are losing magnificent creations of the Mother Nature fast and unless and until we actively engage into conservation planning, the day when we will lose half of the species of the world is not far. Human-animal conflict is increasing and the answer lies in conservation planning.

Coorg - A case in point

Habitat loss, global climate change and human disruptions, such as pollution and deforestation and conversion of land for human use, are threats to wildlife biodiversity and are causing conflicts, fragmentation and extinction. It is estimated that in India about 5 million people live inside of protected areas and 147 million people depend on forests for their livelihood.

In the state of Karnataka in India, there exists a very scenic place called Coorg which is part of the Western Ghats, one of the global biodiversity hotspots. It attracts large number of tourists. It is also the largest coffee producing area in the country with almost 38-40% of the country's coffee being cultivated here. The majority of coffee grown in Kodagu is shade grown coffee and the estate area is very much like a forest. These estates support large biodiversity including large mammals such as elephants, tigers, leopards, bison and sambhar deer.

Being a booming tourist destination, the Coorg region is developing at a fast pace with widening of roads, infusion of a railway line and high-tension power lines. With such developments in infrastructure, while the region seems to flourish economically, the wildlife in the area is getting adversely affected. Fast infrastructure development has led to continuous cutting down of trees, thereby reducing the forested area, the natural habitat of the wildlife in the region. Left with lesser place to dwell and survive, the wildlife is forced to move out and venture into the nearby villages and coffee plantations in search of water and food, thus creating another situation of human-animal conflict.

As the wildlife, especially the elephants destroy the crops, farmers face economic losses. Add to that the life risk faced by the workers working in the plantations. The losses corroborate with the statistics that say every year all over India almost 400 people and 200 elephants die because of elephant-human conflict.

The forest department is trying its best to combat the conflict, but all the measures have failed, leading the department to consider GIS as the solution.

Dr. Prashant Hedao, PhD, Auroville (India), and a visiting faculty at University of California at DAVIS has been closely studying the elephant-human conflict taking place in the region. He shares, "All barriers have proven to be ineffective as elephants have managed to overcome them all, especially the solar fences and elephant proof trenches (EPTs). The forest department has been constantly thinking of a better solution to prevent the losses and speedy resolution of compensation claims. In such a scenario, GIS-based conservation planning has come up as the ideal solution." By using GIS, officials are able to have the highest rate of biodiversity preservation in the region. GIS has enabled them to achieve effective balance between the social and economic needs and habitat and species conservation.

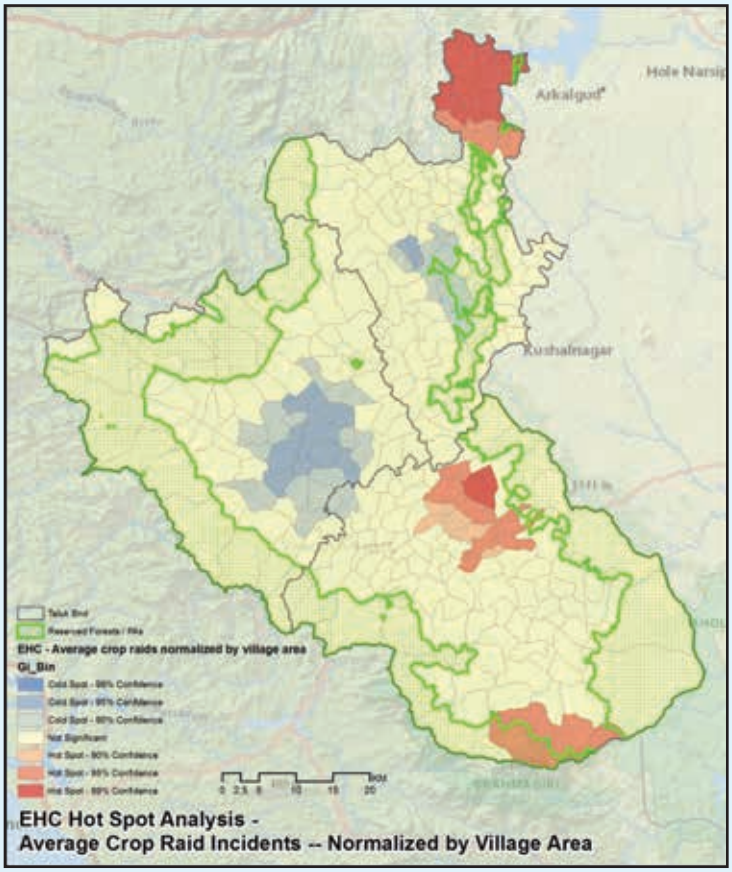
Benefits of using GIS

As we are aware, GIS has a very important role to play in achieving sustainable development. GIS modeling can help us understand and predict where and what impact will actually happen, and what the future will be. This makes GIS a very powerful tool. GIS brings numerous benefits to every industry and aspect of life, and conservation planning is no exception. From identifying risk prone areas to spotting high priority areas where immediate action needs to be taken, the benefits of using GIS in forest management and conservation planning are limitless.

For instance, in Coorg, GIS is helping the officials in mapping the areas where elephants have managed to break through the barriers. Based on the conflict data they are able to identify which areas are the conflict hotspots where the elephants are coming out, and then they try to find a pattern exactly why they are coming out from those specific areas. Once they understand the pattern, the site-specific solutions are easy to come up with. The hotspot analysis can also help in identifying the average crop raid incidents and the compensation paid.

For instance, as depicted by the following map, the hot spot analysis on average crop raid incidents per year in affected settlements aggregated to village polygons normalised by village area, per year shows that there are two three hot spot areas (in red) and two distinct cold spot areas (in blue).

The conflict data obtained through GIS also helps in creating risk maps for areas with similar conditions.



Risk mapping can be a powerful tool to understand in future where elephants might venture out. This is something very important to understand to stay ahead of the game.

GIS also enables the farmers whose crops have got damaged due to infiltration of elephants, get compensation faster.

Data can be collected on cell phone apps through field visits and that gets transmitted to the forest department's central district server for claim processing directly. The use of GIS has made the process of claim processing faster. Overall, by bringing in GIS in its conservation activities, the officials have been able to better identify conservation targets, set conservation goals for particular areas, and monitor the progress of these activities over time.

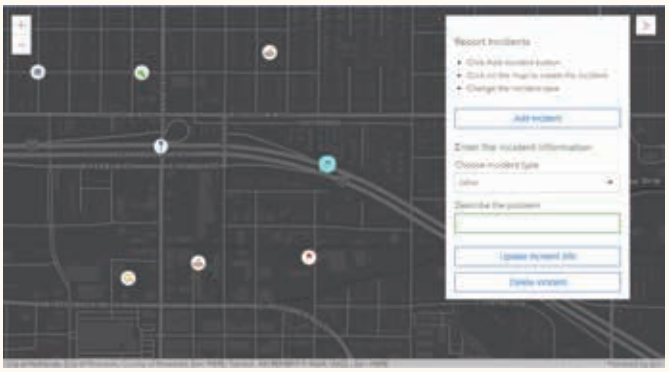
Today wildlife is not confined exclusively to protected areas and sizable numbers exist outside reserves which, among other things has resulted in increased human-wildlife conflict. The future of conservation will depend on how best we plan areas where humans and wildlife can coexist. A determination of how communities can share resources with the wildlife in areas where human use is inevitable and unavoidable must be made, and GIS-based analysis is the way for achieving this kind of effective conservation planning.

What's new in ArcGIS API 4.9 for JavaScript

ArcGIS API for JavaScript packs a punch with the new FeatureForm widget for attribute editing, drawing enhancements to include geometry reshaping, broader WebGL support, 2D and 3D navigation using game controllers and much more with Update 4.9.

FeatureForm widget

The API allows users to view and edit feature attributes. This widget is the first in a suite of widgets that will constitute the full 4.x editing experience. Each editable attribute has an auto generated UI based on the data type for a smooth editing experience.



Sketching update: Add and remove vertices

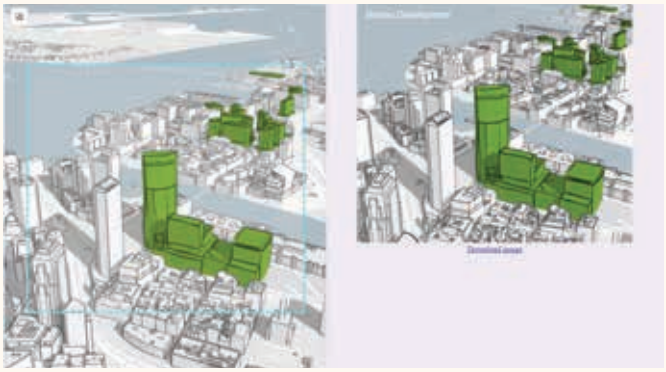
The API introduces the ability to edit polyline and polygon geometries by adding or deleting existing vertices. As an enhancement exclusive to the 4.x API, it is possible to undo/redo at the vertex level in addition to completed geometries.

Feature Layer updates

The API has added support for **querying related features** as well as **adding, deleting** and **updating** feature attachments in feature layers. In addition, similar to the CSV layer, when user creates a feature layer with a client-side data source (i.e. using a feature collection) he can perform the full spectrum of spatial, attribute and statistical queries.

Take a screenshot of a 3D SceneView

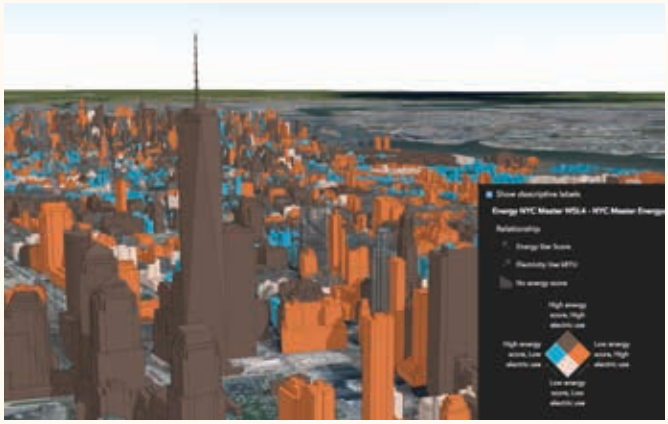
Using SceneView.takeScreenshot() user can now create a screenshot of the view and export it as an image. Different options like image format, quality, aspect ratio or image size can be specified.



Broader WebGL support for 2D mapping

WebGL is now the default drawing mechanism for FeatureLayer, CSVLayer and StreamLayer in MapView. This includes support for all versions of ArcGIS Enterprise and ArcGIS Online as well as feature collections.

Rendering graphics in WebGL has resulted in the far more rapid display of both small and large datasets. The number of features that can be displayed, while still maintaining a high level of performance, went from tens of thousands to hundreds of thousands.



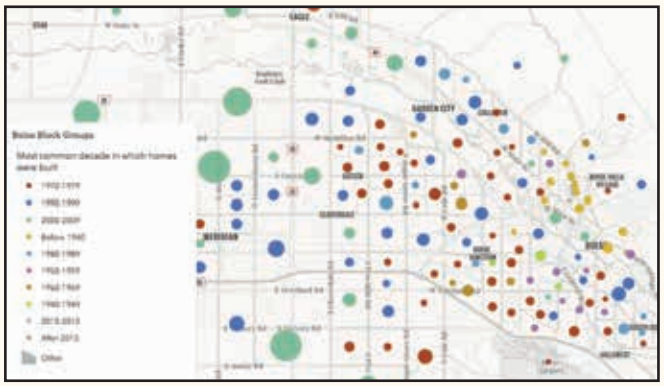
Gamepad and 3D mouse navigation

The API now includes support for navigation in 2D and 3D using any Standard Gamepad or 3Dconnexion device. In both MapView and SceneView the user can navigate with gamepad or 3Dconnexion devices. He/she can use them to view and explore maps and scenes.

Smart Mapping updates

The ArcGIS API has added four new renderer creator methods for generating Arcade-based renderers:

Predominance – allows you to color a layer's features based on which attribute among a set of competing numeric attributes wins or beats the others in total count.

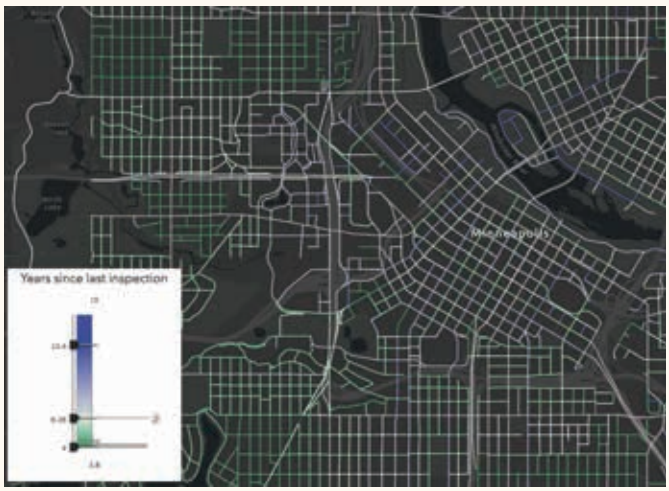


Rendering graphics in WebGL has resulted in the far more rapid display of both small and large datasets. The number of features that can be displayed went from tens of thousands to hundreds of thousands.

Relationship - renderers allow user to explore the relationship of two numeric fields using color.

➔ Age with color
➔ Age with size

Age Renderers will generate a renderer based on the age of the features as determined by the date field(s).



An optimised approach to working with CORS

CORS support has been enhanced in this version of API. The primary reason behind this is the move to WebGL becoming the primary way the API handles working with graphics.

Beginning in this version, the API assumes CORS support in web servers.

Widget Updates

BasemapGallery widget

The BasemapGallery widget now disables incompatible basemaps in 2D, the same way as they were always treated in 3D.

Do more with ArcGIS Online 6.3

Spatial Analytics

New tools for this release include:

- ➔ Summarise Center and Dispersion – measures the distribution of a set of point features to calculate the central feature, mean center, median center, or ellipse (distribution).
- ➔ Find Point Clusters - locates clusters of point features in surrounding noise based on their spatial distribution.
- ➔ Other Enhancements
  - Find Existing Locations and Derive New Locations can now use the spatial relationship nearest to when locating the features that are closest to features in another layer.
  - Results from Join Features can now be created as a hosted feature layer view for all attribute joins, including one to many relationships.

3D Scenes

- ➔ The user can now navigate scenes with gamepad and 3D mouse devices in Scene Viewer. These tools can be used to intuitively view and explore features, such as buildings and 3D models, underground assets, or interior rooms and corridors.
- ➔ Find features in scenes more easily by searching for layer attributes, such as names or IDs. User can now configure layers in scenes to allow viewers to search for and zoom to specific features in a layer. For example, user can enter the name of a hotel conference room, and Scene Viewer navigates to the room, highlights it, and displays a pop-up about the space.

Configurable Apps

Configurable apps are templates that user can configure easily, without any coding. New for this release are:

- ➔ Image Visit - With Image Visit users are driven to a predetermined sequence of locations in imagery to review attributes and add or edit features. The app minimises the time it takes for imagery to load, streamlining workflows for insurance inspections, control point verification, or checking AI classification results.
- ➔ Scene with Inset Map - Scene with Inset Map provides a bridge between 2D and 3D apps by embedding a 2D map into a scene to help orient users. User can also present 2D and 3D views side-by-side or stacked.
- ➔ Layer Showcase - Display a collection of layers with the new Layer Showcase app. Users can explore layer-based content from a group, view layers in a map or scene, and create a map or scene based on the layers in the app.

App Builders

App builders have been updated with the following enhancements:

- ➔ AppStudio for ArcGIS - AppStudio for ArcGIS 3.1 is a major release that has updated dependencies: ArcGIS Runtime 100.3, Qt 5.11.1. AppStudio Player has been redesigned and has received major UI and UX updates. The template apps have many new features, improvements, and fixes. The Map Viewer template in AppStudio now has support for offline Geosearch and a new measure tool and includes a

screenshot tool to create, save, and send screenshots of the current map.

- ➔ Operations Dashboard for ArcGIS - The Operations Dashboard for ArcGIS update includes improved support for local time zones, better handling of actions during dashboard loading, and many new configuration options for charts and other visualisations.
- ➔ Web AppBuilder for ArcGIS - Introduces a new Pocket theme designed for apps embedded in websites, story maps, or other locations with surrounding context, where only one widget is supported in a panel positioned on the left or the right. In addition, multiple widgets have been improved. User can now find layers by typing a keyword in Layer List, use Search to support typing coordinates in the search box to locate a place on the map, set dynamic maximum and minimum values dependent on data configured in Extra Data source for the gauge in Infographic, and hide or customise filter labels in Query. With 3D Daylight, you can now choose a date to reflect the sun's position at different times.

Apps for the field

Apps for the field have made numerous enhancements since the previous ArcGIS Online update including the following:

- ➔ Survey123 for ArcGIS - The website and field app now support Webhooks, enabling workflow automation and application integration. Nested repeats are now supported in the field app, as well as Geosearch and geocoding on Geopoint questions. New group and file upload question types have been added to the web designer and the web app. Additionally, a new filtering option has been added to the website on the Data tab, and enhancements have been made to feature reports and conditional template syntax when printing Survey123 reports.

Apps for the office

Some apps for the office have been updated, the following are highlights:

- ➔ ArcGIS Business Analyst Web allows
  - Summarise information for multiple study areas in a single table using infographics.
  - Share comparison report templates with other users in your organisation and use comparison reports that other users have shared with you.
  - Use improved layer styling and ability to reorder layers on the map.
- ➔ GeoPlanner for ArcGIS - This release introduces new color ramps in Modeler. User can now use Impact – Negative to Positive and Impact – Positive to Negative ramps to better visualize impact across systems. The Classify tool now allows user to set different color ramps to customize his analyses and improve visual impact.

Insights for ArcGIS

Insights for ArcGIS 3.0 includes updates that allow interactive presentations to include more context and branding. User can now use his organisation's colors, logos, and options for communicating his narrative with shared analysis results. Also, Insights now supports public sharing of pages, new link analysis capabilities, a predefined filter widget, KPI card, and more.

ArcGIS Companion

ArcGIS Companion makes it easy for the user to access his organisation from his mobile device. ArcGIS Companion has added more features and enhancements since the previous ArcGIS Online update. Some highlights include browsing content by folder and tags; editing item details, including tags, delete protection, and authoritative and deprecated status; filtering and sorting member search results in the organisation or groups; and managing group membership requests. Administrators can now use Companion to add and invite new members and view credit usage in the organisation over the previous 30 days and 24 hours.

Data Management

- ➔ If user published a scene layer from a hosted feature layer, he can now rebuild the scene layer cache to incorporate changes made to the hosted feature layer.
- ➔ ArcGIS Online uses globally distributed caches to improve performance of publicly shared hosted feature layers. User can control how often ArcGIS Online refreshes the cache per public hosted feature layer.
- ➔ User can now use Arcade expressions when calculating values in fields in your hosted feature layer. Write Arcade expressions for a variety of operations including spatial operations.
- ➔ User can rename the layers in his hosted feature layers and hosted feature layer views. If he publish a hosted tile layer from a hosted feature layer, he can rename the layers in the hosted tile layer too.

ArcGIS Living Atlas of the World

- ➔ The World Imagery basemap has been updated with the latest DigitalGlobe Basemap +Vivid imagery for several countries and the latest DigitalGlobe Basemap +Metro imagery for many cities around the world.
- ➔ The Wayback imagery archive has been expanded with additional releases of World Imagery layers.

Agendra Kumar, President, Esri India addressing the attendees

Esri India User Conference 2018

GIS - Inspiring What's Next

GIS is becoming ubiquitous. Whether the goal is to design better cities, operate more efficiently and sustainably or protect our precious ecosystems, GIS is evolving as the answer to all questions. The world is changing at a rapid pace, and this development is bringing with it new challenges. To effectively combat these challenges, the GIS community needs to contemplate not only what's next in GIS technology, but also how they can use their expertise to address the world's challenges.

These were the major points of discussion at the 19th Esri India User Conference 2018. With the theme 'GIS - Inspiring What's Next,' the User Conference (UC) hosted eminent speakers and experts in the industry to give a holistic outlook towards the latest trends in the world of GIS and showcase innovative, real-world GIS applications.

With a goal to engage with a wider audience, the UC took place in three cities of India - Kolkata, Hyderabad and Delhi NCR. The Conference brought more than 130 speakers from around the globe, 2200 delegates, 650 organisations and 17 partners and exhibitors together, creating the perfect ambience for exploring the latest innovations in GIS technology, networking and evolving for contributing more effectively towards creating a better future.

Setting the stage

Hosted on September 4 in Kolkata and September 6 in Hyderabad, the Esri India UC 2018 began with a welcome speech by Agendra Kumar, President, Esri India, wherein he spoke about how the world is getting more and more interconnected, which in turn is leading to digital transformation.

He stressed on the importance of leveraging location intelligence for better decision making. He emphasized how sectors like Smart Cities, infrastructure development and field force automation are leveraging GIS enormously. Giving an example of the infrastructure sector Agendra added, "To cater to the mobility requirement of the future, twenty times more roads are required by

2031 in India. Having a huge opportunity, a lot of solutions are going to come in the roads and highways and river and ports sectors."

Technologies like drones, cloud and artificial intelligence will impact the way GIS is used in future. Echoing this thought Dean Angelides, Corporate Director, International/ Alliances/Partners, Esri Inc. said, "GIS is advancing rapidly, integrating and leveraging many innovations. Web GIS is the modern GIS architecture, which is helping everyone do their work better. 'The Science of Where' is creating the perfect framework for 'What's Next' that will leverage the power of geography to take apt decisions." Discussions at the Technology Exposition also centered around the topic - 'Where mapping technology is headed next and how organisations can leverage it for more productive outcomes.'

For managing future challenges, GIS must be integrated with advanced technologies like machine learning, IoT etc. This was the major point of discussion at other Plenary Sessions of UC. One of the presentations showcased how by deploying Esri's ArcGIS on the SAP HANA platform, Omaha M.U.D. aims to provide its field personnel with more timely and powerful analytics.

Few organisations are already achieving excellence in their functioning using GIS, and Esri India was glad to acknowledge their efforts in making the world a better place through the GIS Achievement Awards at the UC. At the Industry & Technology Sessions, developers, analysts and others talked about varied GIS solutions, best practices, time saving apps and game changing smart maps to highlight the various innovations in GIS.

After having a successful stint at Kolkata and Hyderabad, Esri India UC 2018 saw a staggering response in Delhi. The two-day conference took place on September 10-11 and was attended by eminent GIS thought leaders, professionals and user community. The gamut of GIS applications discussed at the conference was expansive. The application areas ranged from disaster management to municipal governance.

Esri India is known for organizing stimulating Summits at the UCs and this year was no exception. Enabling the participants to explore varied dimensions of GIS, the fascinating Summits, wherein experts from different parts of the world shared their discoveries and experiences, rightly created a wave of excitement and motivation among the community.

Imagery Analytics for Natural Resources Management Summit

Sustainable development and management of natural resources is the key for the economic, social and cultural viability of any nation.

The Imagery Analytics for Natural Resources Management Summit provided the participants an opportunity to learn from the experts how best to use remote sensing for geospatial applications for natural resources management.

The intriguing presentations enabled the community to get a detailed look at new imagery and remotely sensed data processing and analytical techniques.

Theoretical understanding of concepts got enhanced as organisations like Harris Geospatial Solutions, illustrated how their solutions are using geospatial technology to solve real-world problems. Be it providing socio-economic security, sustainable development support, emergency and disaster prepared-

BESCOM team receiving the SAG award from Arvind Thakur, Vice Chairman & Managing Director, NIIT Technologies Ltd.

Rajendra S Pawar, Chairman, NIIT Technologies Ltd. lighting the lamp

Keynote Address by Dr. T K Sreedevi, IAS, Commissioner and Director of Municipal Administration Department-Telangana at Urban Transformation Summit, Hyderabad

ness or national security, protection and governance, geospatial technology is the answer to all.

Urban Transformation Summit

Geographic information system is playing a huge role in initiatives such as Digital India, Smart Cities Mission, AMRUT and thus driving digital & urban transformation in India. GIS is helping in unlocking the full potential of data to improve operational and business results. Sessions at Esri India UC, Hyderabad highlighted that cities are actively using GIS for property taxation, water distribution, smart waste management, public safety etc.

The Urban Transformation Summit provided an opportunity for key stakeholders to understand how they can lead and drive urban transformation by leveraging GIS across city functions and citizen services. It also helped them to connect with business leaders and innovators from government, defense, public safety, academia & environment and see how they are leveraging GIS.

Engaging presentations at the summit enabled everyone to deep dive into how GIS enables a safe city through capabilities such as multi-agency collaboration, shared real-time situational awareness and access to unbiased authoritative data, as well as community platforms.

How GIS can lead to effective urban planning and municipal governance was talked upon elaborately. Municipal Corportaion of Greater Mumbai (MCGM), which is one of the largest municipal corporations in India, made a presentation detailing how it has incorporated Esri ArcGIS for a host of services for increasing transparency, ease of doing business and improving the quality of services.

"Based on desktop-based and Web-based GIS map applications, Municipal Corporation provides development plans. It is integrated with payment gateways so that there is no difficulty in transactions," said Sanjay Nirmal, Assistant Engineer, Development Plan Department, MCGM.

"The key focus is on transitioning from GIS enabled to GIS-centric," he added.

GeoAI Summit

Artificial Intelligence (AI) has made rapid progress in recent years, matching or in some cases even surpassing human accuracy at tasks. The intersection of AI and GIS is creating massive opportunities that weren't possible before in areas such as helping increase crop yield through precision agriculture; in fighting crime by deploying predictive policing models or predicting when the next big storm will hit and being better equipped to handle it and much more.

Machine learning, deep learning and AI are increasingly being used along with GIS for a number of purposes. Integrating machine learning algorithms with ArcGIS provides better and more optimum results in less time. AI has seen considerable use in computer vision and language processing. Esri Cloud also provides the necessary infrastructure for machine learning and deep learning.

Cherie Muleh, Asia Pacific Regional Manager, Space and Intelligence Systems, Harris Geospatial shared, "Location expertise in machine learning includes visualisation, location services and movement optimization and location intelligence. Location services include geo-fencing and IoT. Movement optimization includes asset tracking, navigation, real-time movements."

Daily datasets are available from multiple sources. "Satellite images with deep learning help us in assessing the changes. Now that government of India has relaxed drone regulations, quality of data would improve," said Muleh.

"Other than map data, there is also IoT. There are weather sensors and camera sensors. A lot of these challenges are solved by machine leaning. People nowadays are expecting unprecedented precision. All of this is converging towards GeoAI as location component is very smart," said Abhay Swarup Mittal, CEO, Skymap Global, at Esri India UC Delhi 2018.

Another good example of a perfect integration of machine learning and GIS is SAP HANA. As part of the SAP and Esri collaboration, GIS developers, enterprise architects, data scientists, BI developers and students are able to solve a variety of challenges through the use of geospatial analytics and machine learning technology.

Giving an example of how SAP HANA can be effectively used in emergency management, Anand Raisinghani, Head – Platform and Data Management, SAP India said, "Cape Town enhances public safety by using a smart solution. The Emergency Policing and Incident Command (EPIC) solution integrates policing, fire and rescue, disaster management on a single integrated system on SAP HANA with real-time spatial mapping enabling situational awareness and insight to action."

WhereNext Summit

As the world becomes more digitally focused and businesses collect enormous amounts of data daily, understanding location data and its benefits has become very important. Today organisations are using location to make strategic decisions necessary to remain competitive and operational.

At the WhereNext Summit, it was exciting to discover how GIS technology using location drives efficiencies, deeper analysis and powerful insights for smarter, data-driven decision-making and business growth. It was fascinating to learn through the presentations how spatial analysis combined with the right enterprise tools and strategy enables innovation and competitive differentiation. The Summit answered questions on how Business Intelligence and GIS integration can provide powerful visualisation and analysis of business data through smart maps etc.

With increase in IoT applications, numerous devices are getting connected together, generating huge volume of data in real-time. To make sense of such a large volume of data, seamless integration of location capabilities of the devices is required and this is where GIS plays an indispensable role in enabling the IoT ecosystem. It is only through integration of GIS and IoT that businesses can utilize real-time data for most effective business outcomes.

GIS Agritech Summit

Today, GIS has become an indispensable tool for managing agriculture, enabling variety of applications like precision agriculture, crop management and quality control. With mainstream applications of Artificial Intelligence, IoT, Drones, 3D and Big Data emerging and their integration with GIS, the possibilities to do more have grown multi-fold. At the UC, the GIS Agritech Summit, hosted by AgNext in partnership with Esri India, helped the community to discover how technologies like Artificial Intelligence, IoT and Big data are transforming and at the same time solving critical problems faced by the agriculture sector and associated industries.

Dr. Roger Tomlinson Memorial Lecture

Esri India UC Delhi also commemorated the legacy of Dr. Roger Tomlinson, who was the first recipient of 'Esri Lifetime Achievement Award' in 1999. Dr. Tomlinson is regarded as the 'Father of GIS'. He developed the first GIS in 1967 and mentored the GIS fraternity for long.

While delivering Dr. Roger Tomlinson Memorial Lecture, Dr. P.G. Diwakar, Director, Earth Observation and Disaster Management, ISRO threw light on ISRO's achievements. He also detailed how by using GIS and other geospatial technologies, ISRO is providing assistance in disaster mitigation and relief and rescue operations. It was fascinating to discover how geospatial technologies can help us have a safer world.

GIS is maturing and so are our world's problems. The presentations at Esri India UC 2018 clearly established the fact that by applying the power of GIS, we can find effective solutions to these issues faster. Sustainable living is what we all need to strive for, and GIS is central to this.

Esri India UC provided an excellent opportunity for GIS thought leaders, professionals and enthusiasts to come together and collaboratively analyse what they need to do to improve efficiency, make cities smarter, protect biodiversity and integrate environmental thinking into virtually everything they do. It was an event that went beyond expectations in terms of learning, collaboration and development.

Dr. P.G. Diwakar, Director, Earth Observation and Disaster Management, ISRO delivered Dr. Roger Tomlinson Memorial Lecture

GIS for SUSTAINABLE LIVING

The global population is on the rise. This rising population is consuming nature's finite resources at a fast pace, forcing all of us to ponder over the crucial question - ***"Are we leaving enough for the future generations?***

The answer lies in sustainable development. Growth now needs to be inclusive. It is time we start working diligently towards creating systems that are "sustainable", ones that will keep on working indefinitely in the future.

Sustainability is essential for the survival of future generations as well as for ensuring that all humans can fulfil their potential and contribute to society. With the United Nations adopting the 2030 Agenda for Sustainable Development and deciding on 17 Sustainable Development Goals (SDGs), the significance of linking people, planet & prosperity has got unanimously recognized at all levels.

Nations worldwide are actively working towards achieving the SDGs and the progress achieved so far establishes the fact that GIS is fundamental to sustainable development. It is a tool that helps in visualising and understanding areas in danger of biodiversity loss, habitat degradation and resource depletion. By applying the Science of Where we can respond more effectively to humanitarian crises, support sustainable development, protect critical habitats, preserve places that matter and achieve more.

As Jack Dangermond, Founder & President, Esri puts it, "The use of GIS has changed how people understand our world and create practical solutions. We are very appreciative of this acknowledgement. It illustrates the increasing recognition of the role geoscience is playing in our global evolution." By leveraging the powerful GIS technology in new ways, we can build a better world by ending poverty, inequality, climate change, improving health and more.

At present, there are many successful case studies that showcase how geospatial data is being used to meet the sustainable development goals – directly or indirectly. Geospatial data, when combined with other statistical data, enables nations to create visualisation tools that help accurate assessment and evaluation of the development impact across the 17 goals in a consistent manner such that accountability is improved. Organisations like UNGGIM are constantly stressing on and advocating the need for the aggressive use of geospatial information and technology to enable societal benefits of SDGs.

Mapping climate change

Human activities and global warming are rapidly contributing to environmental degradation. Decreasing glacier area, unprecedented rainfall, changes in land use and land cover, forest degradation, floods, landslides and shortfalls in agricultural crop production are among the many problems brought on by environmental changes. These issues need timely monitoring and supervision. Effective monitoring of the environment and an improved understanding of the same requires valuable information and data that can be extracted through application of geospatial technologies such as remote sensing and GIS. As Jack says, "Climate change is a geographic problem, and we believe solving it takes a geographic solution. GIS users represent a vast reservoir of knowledge, expertise, and best practices in applying this cornerstone technology to the science of climate change and understanding its impact on natural and human systems."

A number of organisations around the world are already using GIS to make better decisions in the face of the changing climate conditions. One of the best examples is The Nature Conservancy's suite of online mapping decision support tools that are powered by the ArcGIS platform. Government agencies and other organisations are using tools like this to easily examine how to prepare for and respond to storm surge and flood damage. Since their introduction in 2008, the tools have been used for disasters both big, such as Hurricane Sandy, and smaller, such as coastal erosion in Washington State's Puget Sound region.

Changing climate conditions are also largely affecting life on land and life below water. Today we are seeing unprecedented land degradation, and the loss of arable land at 30 to 35 times the historical rate. Drought and desertification is also on the rise each year, affecting poor communities globally. Of the 8,300 animal breeds known, 8 percent are extinct and 22 percent are at risk of extinction. The SDGs aim to conserve and restore the use of terrestrial ecosystems such as forests, wetlands, drylands and mountains by 2020. Halting deforestation is also vital to mitigating the impact of climate change.

> The use of GIS has changed how people understand our world and create practical solutions. We are very appreciative of this acknowledgement. It illustrates the increasing recognition of the role geoscience is playing in our global evolution."
>
> **Jack Dangermond**
> Founder & President, Esri Inc.

Urgent action must be taken to reduce the loss of natural habitats and biodiversity, and biologists, ecologists and environmental regulators are relying on the analytical power of GIS for making critical decisions to manage the same. GIS is aiding in development and design of functional wildlife corridors and contributing to their effectiveness as an increasingly viable conservations planning strategy. For instance, Esri used GIS to develop a new tool for wildlife corridor design within the Sonoran Desert, a biologically diverse region that spans southern Arizona and California in the United States and Baja California and Sonora in Mexico.

It is also essential to manage the world's oceans to counter balance the effects of climate change. Over three billion people depend on marine and coastal biodiversity for their livelihoods. Today almost 30

Bhopal Smart City using GIS

Following the Indian Government's Smart Cities Mission, Bhopal is selected as one of the 20 lighthouse cities in the first round of the project. The core infrastructure elements in a smart city include adequate water supply, assured electricity supply, sanitation, including solid waste management, efficient urban mobility and public transport, robust IT connectivity and digitalisation, good governance, especially e-governance and citizen participation, sustainable environment and safety and security of citizens, particularly women, children and the elderly.

Bhopal Smart City Development Corporation, as a part of its Smart City initiative, envisaged a technology solution that could cater to the smart citizens of this new age and modern Bhopal. Bhopal Smart City Organisation was looking for a platform which can provide information to the citizens on what is happening and take citizens feedback, this was just the first step and was very important because they want citizens to be a part of it.

Smart Map Bhopal is envisioned as a city level GIS portal that will act as a one-stop destination for citizens, businesses and government departments to discover, consume and share information about Bhopal. Smart Map Bhopal, a web application that seamlessly functions across various devices has been developed using the Esri ArcGIS.

percent of the world's fish stocks are overexploited, reaching below the level at which they can produce sustainable yields. Marine pollution, is reaching alarming levels, with an average of 13,000 pieces of plastic litter to be found on every square kilometre of ocean. The SDGs aim to sustainably manage and protect marine and coastal ecosystems from pollution, as well as address the impacts of ocean acidification.

GIS has the potential to play a major role in the accomplishment of this goal, and Esri's recent partnership with Ocean Health Index (OHI), the first program to comprehensively assess ocean health, is a concrete step in this direction. The OHI itself is a joint project of Conservation International and the National Center for Ecological Analysis and Synthesis. Together, the organisations have integrated OHI scores as a data layer in Esri's ArcGIS Living Atlas of the World and will launch Ocean Health Hubs, which are online tools that enable ocean managers to explore data to better understand regional ocean health. In times to come, we hope to witness more sustainable ocean management decisions, as these newly accessible datasets will allow the users to better understand their regional ocean health.

There is no country in the world that is not experiencing first-hand the drastic effects of climate change. Greenhouse gas emissions continue to rise, and are now more than 50 percent higher than their 1990 level. Further, global warming is causing long-lasting changes to our climate system, which threatens irreversible consequences if we do not take action now. Green energy has become a necessity today, and GIS is becoming a facilitator in this domain as well. Moreover, as natural sources of energy are depleting fast, GIS based solutions are largely helping in finding the best site locations for wind, solar and other alternative energies.

Green energy with GIS

Efforts to encourage clean energy has resulted in more than 20 percent of global power being generated by renewable sources as of 2011. Still one in seven people lack access to electricity, and as the demand continues to rise there needs to be a substantial increase in the production of renewable energy across the world.

GIS is currently being used to analyse the potential for renewable energy (RE) as a source for producing electricity and biofuels around the world. Many models are being developed to aid in planning for renewable technology to replace existing fuel sources or to be introduced into rural areas with no current electrical

Wind and Solar- Alternate energy resources

infrastructure. These analytical tools are enabling policy-makers, utility companies, planning commissions and environmentalists to develop renewable energy resources, and also search for the best locations and corridors for transmission and distribution.

Just like energy, another natural resource that is under great threat of exhaustion is water. With population rising at an unprecedented rate, more than 40 percent of people around the world are plagued by the problem of water scarcity. And, what's more? This alarming figure is projected to increase with the rise of global temperatures as a result of climate change. Although 2.1 billion people have gained access to improved water sanitation since 1990, dwindling supplies of safe drinking water is a major problem impacting every continent.

In 2011, 41 countries experienced water stress. Increasing drought and desertification is already worsening these trends. By 2050, it is projected that at least one in four people will be affected by recurring water shortages. To ensure universal access to safe and affordable drinking water for all by 2030, we need to act today and location intelligence can help us move closer to this goal as well.

Clean water and sanitation for all with GIS

Water is a scarce resource which must be preserved for our future generations. When a waterline breaks, customers are without water, and industries may have to stop production. To repair the break, water department employees spring into action, quickly responding to water outage complaints no matter what hour of the day or night.

Department superintendents are responsible for routing crews to multiple problems simultaneously. If crew members do not know the exact location of underground lines, locating lines and determining connections will take longer. This means customers may be without water longer, more water will pour onto the ground and be wasted, and additional expense will be incurred by the water department, which ultimately results in higher rates for customers.

Global warming is causing long-lasting changes to our climate, threatening irreversible consequences if action is not taken now. Green energy is a necessity today, and GIS is an important emabler in this domain.

Source: Mapping a Healthier Future Report, published by the Uganda government with the World Resources Institute

Water Management

Current and accurate information about underground waterlines is critical for water departments and this is where GIS helps. These lines are mapped, and updated copies of these maps are distributed to water departments periodically. For faster action and minimal wastage, it is necessary to map the small lines along with the large lines. Delay in locating a break in a water line can cause wastage of this vital resource. GIS and mapping can significantly help in reducing the wastage.

Along with managing water wastage, we need to pay attention to the rising levels of water pollution. The widespread problem of water pollution is jeopardizing our health. Unsafe water kills a large number of people each year. Meanwhile, our drinkable water sources are finite: Less than 1 percent of the earth's freshwater is actually accessible to us. Without action, the challenges will only increase by 2050, when global demand for freshwater is expected to be one-third greater than it is now.

Water pollution has been a pressing issue in India. Consequently, the Government of India is taking concrete steps to clean as well as conserve the water bodies. The National Mission for Clean Ganga is one such initiative, which employs GIS technology for the Ganga rejuvenation task.

The key to an intelligent water system is having one go-to repository for all data. Intelligent water management begins with GIS. GIS software goes beyond locating pipes and facilities. It can be used to manage an asset registry, analyse system performance, optimise work, and easily collaborate. Strong mapping and analytics combined with easy-to-use apps allows one to

Cleaner Ganga with GIS

The National Mission for Clean Ganga (NMCG), a nodal authority to implement and monitor the government's ongoing 'Namami Gange' (Ganga rejuvenation) program, has tied up with the Survey of India to have high-resolution Digital Elevation Models (DEM) to monitor the entire basin.

This would not only help in identifying the entire topography, but also help the policymakers to make more informed decisions. These models will provide valuable information for use not only in making urban river plans but also for identifying baseline of river floodplains and regulating them for their restoration and preservation.

The high-resolution GIS-enabled data will help in regulating the proposed protected and regulatory zones along the banks of river.

The area of this project extends up to 10 km on both sides of the banks of Ganga. The major task of the project is to unite GIS ready database along with administrative boundaries up to village level and make proper public drainage network database under it.

GIS will also help to assess the water quality of the river. Currently, the ISRO backed Bhuvan Ganga Geoportal is actively playing its role in monitoring of water quality, hydrology, geomorphology and bio-resource.

see how today's actions affect tomorrow's water system.

A primary challenge for government agencies working on water and sanitation issues is coordination – planning and implementing effective interventions across multiple sectors and actors. Data is often siloed, with poverty figures kept separately from information on water access, sanitation and hygiene.

A report, Mapping a Healthier Future, published by the Uganda government with the World Resources Institute, shows how new kinds of mapping can help tackle these coordination problems and lead to more effective interventions. GIS maps are valuable tools to help overcome common coordination challenges. Better information means better decisions about how to allocate resources, and a good map can literally put all parties on the same page, opening the door for more efficient, transparent decision-making.

An examination of spatial relationships between poverty, safe drinking water, improved sanitation and better hygiene behaviour, not only fosters healthier living among people, but also provides new information to help craft more effective and evidence-based poverty reduction efforts. This kind of spatial information also empowers the public to query government priorities, advocate for alternative interventions and demand better decision-making.

Smarter, healthier people enable creation of more sustainable cities and communities, which are a necessary ingredient of sustainable development.

India is showing a strong commitment towards developing smart and sustainable cities. The Government of India has set up the Smart Cities Mission, according to which it intends to develop 100 citizen friendly and sustainable cities across the country. Bhopal has been amongst the 20 lighthouse cities.

GIS is an integral part of a smart city, and Smart Map Bhopal is envisioned as a city level GIS portal that will act as a one-stop destination for citizens, businesses and government departments to discover, consume and share information about Bhopal.

Sustainable cities with GIS

Making cities safe and sustainable means ensuring access to safe and affordable housing, and upgrading slum settlements. It also involves investment in public transport, creating green public spaces and improving urban planning and management in a way that is both participa-

People can contribute more towards creating a sustainable future if they acquire necessary knowledge, skills, attitudes and values. Education in GIS is an integral part that empowers people to change the way they think and work towards a sustainable future.

tory and inclusive. GIS based urban analytics is the answer to many complex issues that today's cities face.

Urban analytics helps cities figure out the questions that they need to ask in order to drive for any type of measure – health, safety and sustainability. A question about sustainability that usually gets translated into urban analytics is quality of buildings. It can help in analysing how to identify, track and predicatively find buildings that are likely to challenge a building quality, or how to fix those buildings. For instance in New York City, Esri used a reactive facade strategy, which helped it to know that a facade was dilapidated, and the building was going to fall down. We can take a historical view of all of the buildings and record their specifications, year of establishment etc. to understand when a facade is ultimately going to crumple. Such findings would ensure sustainability. Urban analytics can be used to ensure that buildings are designed in a way that uses better material or less material, less energy and still meet all the requirements.

It is estimated that by 2051 India will be considered as an urban nation. With a continuous increase in the urban settlement, the country needs a sustainable and equitable urban settlement plan. The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) aims to provide solutions regarding sustainable coverage of water supply, sewerage facilities and more facilities for non-motorized transport.

Master plans required to spearhead AMRUT mission are based on base maps which need crucial and accurate information regarding planning areas, building layouts, spatial information on development, use of each portion of land, etc. To facilitate such detailed real-time monitoring and assessment of spatial data like growth of cities/towns, land-use status, and physical infrastructure, etc. GIS was adopted.

The move to improve the integration of GIS with BIM is one of the ways Esri is helping design smart communities.

The formulation of GIS-based master plans is one of the key reforms under AMRUT.

GIS can significantly aid in monitoring an area or conducting a feasibility study of a location for a specific purpose, for instance ascertaining the suitability of a location for the construction of a bridge or dam. Feasibility studies of smaller structures like schools and hospitals can also be carried out effectively using GIS.

GIS also helps in identifying changes in geographical features or behaviour of a land over a specified time. Such information enables professionals to make informed decisions about the development condition of an area and plan accordingly. Planners make use of GIS to smooth the progress of citizen participation and community input as they develop a vision for the community that enhances the quality of life for all citizens. Citizens are the life and blood of any city and first-hand inputs from them as to what can be done to make their city smarter can aid in crafting out amazingly productive methods/means for urban planning. PPGIS (public participatory GIS) platform enables this effective engagement process.

People can contribute more effectively towards creating a more sustainable future if they acquire the knowledge, skills, attitudes and values necessary to shape the same. Education is one of the most powerful and proven vehicles for sustainable development. Education for Sustainable Development, of which education in GIS is an integral part, empowers people to change the way they think and work towards a sustainable future.

Esri has been playing an important role in creating such awareness by providing more than 7,000 universities worldwide with software for teaching and research, supporting primary and secondary schools, libraries and youth organisations, and partnering with organisations like the National Geographic Society and Association of American Geographers on projects like GIS Day and the GeoMentor program. Such initiatives amplify Esri's conviction that by working together, we can apply our collective geospatial work to achieve remarkable and ambitious projects such as The United Nation's 2030 Global Agenda for Sustainable Development and its 17 goals. We need to move from a future that simply happens to one that is purposefully designed, with a full understanding of the consequences. This will take more conscious and collective action, with GIS being the common thread.

RESEARCH PAPER

Delineation of groundwater potential zones in arid region of India

A Remote Sensing and GIS approach

Abstract

The present research is an attempt to find out the potential groundwater zones within Kachchh district of Gujarat, India supported by the scientific investigation of lithology, geomorphology, geohydrological characterization of geological formations and their interrelationship. Thematic layers of drainage, lithology, geomorphology, lineaments, slope, soil, digital elevation model, rainfall, landuse and land cover and well inventory have been generated by using toposheets, geology, geomorphology and soil map, Landsat-5 Thematic Mapper, April, 2010 digital satellite image, water level data of 90 observation wells for last 11 years (2000-2010), litholog data of 28 deep bore wells groundwater along with limited ground truthing.

The groundwater potential zones identified through GIS analysis have been classified into five categories-very poor, poor, moderate, good and excellent. The potential zones were obtained by overlaying all the thematic maps in terms of weighted overlay methods using the spatial analysis tool in ArcGIS Desktop. During weighted overlay analysis, the ranking was given for each individual parameter of each thematic map and weights were assigned according to their influence such as lithology (20%), geomorphology (15%), lineament density (15%), drainage density (15%), soil (10%), slope (10%), rainfall (5%), land use and land cover (5%) and digital elevation model (DEM) (5%) and it was found out that the potential zones in terms of very poor, poor, moderate, good and excellent zones covered 13.7%, 42.8%, 27.3%, 10.8% and 5.4% respectively of the total area. The result also has been validated by yield data collected from existing sources and confirms that the higher yield categories are falling within excellent groundwater potential zones where yield ranges from 23-40.3 litre/second and yields with lower value ranging from 8.1-10.6 litre/second are falling within poor groundwater potential zones.

Material and Methods

This study was undertaken by thorough, well-programmed and integrated approach set up on robust methodology for data collection, field survey, identification, selection and evaluation of water level data. The study utilised the satellite data of Landsat ETM+ of April, 2010 (Path 151 Row 43, 44 and Path 150 43, 44) for generation of LULC using hybrid classification technique and ground truthing. Toposheets at the scale of 1:250,000 and ancillary data such as geological, hydrogeological, soil map were used for generation of respective layers. Data on LULC, drainage, faults, were collected from respective district authorities. Rainfall data, groundwater level data were also collected to validate the results for final groundwater potential map. Drainage was extracted using digital elevation model (DEM). Extraction of geomorphology, lithological, linear features like lineaments and faults, land use/cover, soil map etc. was done using different digital image processing techniques. Aster DEM was used to extract lineaments and landform mapping. All data were integrated in a GIS domain and analysed to assess the effect of groundwater controlling features. Finally groundwater potential map was generated using overlay technique. Overlay analyses was done using spatial analyst extension tools of ArcGIS 9.2, using weighted linear combination technique.

Results and Discussion

Factors that have significant influence in groundwater distribution and occurrence that have been used for integration to demarcate/classify potential groundwater zones are:

Lithology vs Groundwater Prospect

The geological formations of Kachchh district have been classified into four major hydrogeological units as far as occurrence and movement of groundwater is concerned:

1. Mesozoic formations
2. Deccan trap (Hard rock) as aquifer
3. Tertiary formations
4. Quaternary sediments

The geological units belonging to the Bhuj Formation form the most

productive aquifer system in the district.

Quaternary Sediments/ Recent Deposits

Alluvium occurs in channels of large ephemeral streams and coastal tracts spread over the district. The alluvium yields small quantities of brackish water from shallow wells in Bhachau taluka. Coarse facies yield small to moderate supplies of brackish water to wells in Anjar-Khedoi region. In parts of Abdasa and Lakhpat talukas, the water table is generally below the formation. The water level variation graph shows a good positive water level fluctuation within Mandvi and Mundra taluka.

Geomorphology vs Groundwater Prospect

Various geomorphic classes/units were identified as per the guidelines laid down in Rajiv Gandhi National Drinking Water Mission (NRSC 2007):

1. Coastal Zone - demarcating the southern fringe
2. Kachchh Mainland - forming the central portion of rocky uplands, northern hill range and coastal plains,
3. Banni Plains (less than 5 m MSL)- marked by raised fluvio-marine sediments, mud flats and salt pans
4. The two Ranns Great Rann (~2 m MSL) in the north and Little Rann in the east comprising vast saline wasteland.

Water level data analysis was also performed across all the geomorphological units within the study area to arrive at the scale value of each geomorphic unit while giving the weightage in overlay analysis. Table 1 show that the average pre- and post-monsoon water level data at the range of 17.5 and 11.9 mbgl for alluvial fan giving rise to average water level fluctuation of 5.6 m.

Lineament Density vs Groundwater Prospect

Lineaments like joints, fractures and faults are hydorgeologically very important and may provide the pathways for groundwater movement (Sankar 2002). The lineament trends are along NNE–SSW, NE–SW and NW–SE. The lineament count density is high to very high in areas covered by alluvium and pediplain (0.18 to 0.79) and the area surrounding alluvium and pediplain shows moderate lineament density (0.11-0.17) and for the rest of the area lineament density is less than 0.1.

Drainage Density vs Groundwater Prospect

Drainage density is one of the most important indicators of hydrogeological features, because drainage pattern and density are controlled in a fundamental way by the underlying lithology (Charon 1974). The drainage density values were reclassified to prepare a drainage density map and categorized into four categories, namely, very high (>1.3 km), high (0.76–1.2 km), medium (0.5–0.75 km), and low (0.19-0.49 km) and very low drainage density class.

Soil Type Vs Groundwater Prospect

The study area is mapped with ten types of soil covers. Apart from Rann the next highest coverage of soil type is calcareous loamy soil with almost 21% coverage area.

Slope Vs Groundwater Prospect

Flat areas (slope is low) are capable of holding rainfall, which in turn facilitates recharge as against to elevated areas with high run-off and low infiltration. The study area is mapped with five classes of slopes with the influence factor to this theme is given as 10% on scale of 100%.

Sl. No.	Geomorphic Unit	Average Water level (m bgl)		Avg Water Level Fluctuation (m)	Scale Value Assigned
		Avg Pre Monsoon	Avg Post Monsoon		
1	Alluvial Fan	17.5	11.9	5.6	5
2	Alluvial Plain	10.8	9	1.8	3
3	Dissected Hills (Sedimentary Origin)	14	13.2	0.8	2
4	Dissected Hills (Volcanic Origin)	18.1	16.7	1.4	2
5	Mud Flat	8.8	7.4	1.4	1
6	Pediplain	13	8.1	4.9	4
7	Piedmont Zone	30.4	26.4	4	4
8	Plain	14.2	11.8	2.4	3
9	Salt Flat	10.7	8.6	2.1	1
10	Valley Fill	15.6	8.4	7.2	5
11	Salt Encrustation (No Observation wells are falling)				1

Table 1: Average pre and post-monsoon water level data

Rainfall vs Groundwater Prospect

The long term mean annual precipitation ranges between 226 mm/year in Gandhidham Taluka 429 mm/year in Mundra taluka. Bhuj and Lakhpat taluka also experience less rainfall compared to other talukas. Higher the precipitation, more the water will be available for surface runoff and infiltrations and will naturally recharge the groundwater.

Land use/ Land cover vs Groundwater Prospect

The land use / land cover of the study area is characterized by a mixture of salty land, agricultural activities and wasteland besides water body and rocky exposures. Most of the Great Rann and Little Rann are defined as salt flat (37% area coverage). Apart from these two Ranns the mainland and islands on the northern side are covered by grassland (with 10% coverage), open areas (with 9% coverage), rocky land (with 8.6% coverage) and so on.

Digital Elevation Model vs Groundwater Prospect

Digital elevation model shows most of the area is under flat or gentle altitude and therefore 5% influence on a scale of 100% was given in the contribution of groundwater prospect within the study area.

Groundwater Potential Zoning

All the thematic maps were converted into raster format and superimposed by weighted overlay method.

From the analysis the groundwater potential zones in-terms of excellent, good, moderate, poor and very poor zones with the area of 2321.1 km2, 4683.8 km2, 11807.2 km2, 18508.8 km2 and 5924.1 km2 respectively (Fig 1) were obtained.

Model Validation

The groundwater potential zone map of the study area was validated by the yield data collected from field for 19 wells through Gujarat Groundwater Authority. The validation study confirms that the higher water yield categories are falling within excellent groundwater potential zones where yield ranges from 23-40.3 litre/second. Yields with value

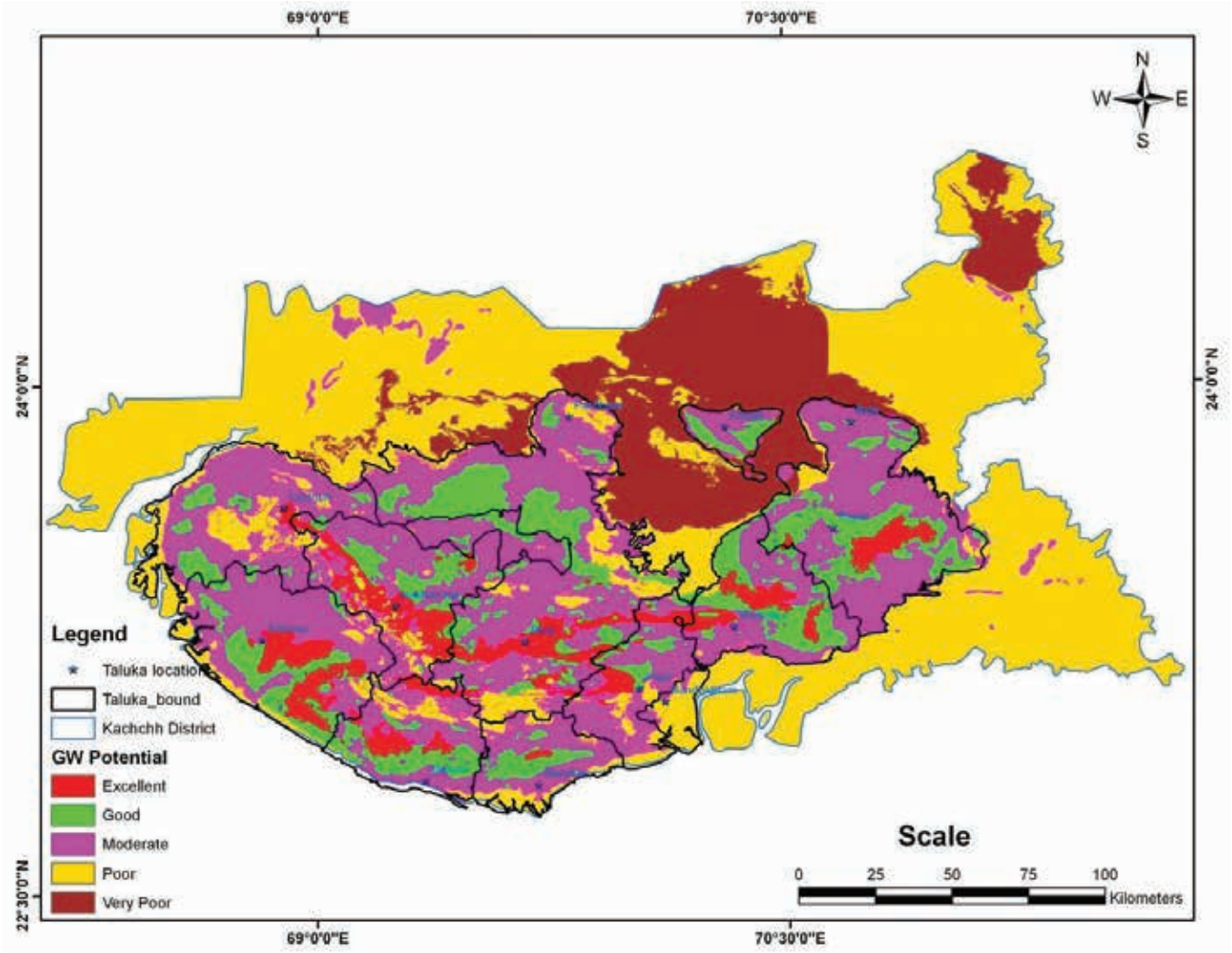


Fig 1: Groundwater Potential Zones within Study Area

ranging from 16.7-19.1 litre/second are falling within good groundwater potential zones. Yields with 11.4-15.8 litre/second are falling within moderate potential zones and yields ranging 8.1-10.6 litre/second are falling within poor groundwater potential zones.

Conclusions

Semi-arid climate with very scanty rainfall (average 350-400 mm) gives rise to acute shortage of potable water in the district. With the specific combination of geology, geomorphology, climate and topography, there are structural constraints in the quantum of groundwater availability in the district.

The groundwater prospects are more along the central belt of the Kachchh mainland towards north of the Deccan Trap formation. Particularly towards southern belt of Nakhatrana and Bhuj Taluka, the water level also shows a shallower trend across this belt; however the water level shows a gradual decline towards S-SE direction of the district. On the southern part of Katrol Hill water level depth is much higher comparative to northern part. Apart from this northern prospective belt, good prospects are also observed along the coastal belt towards S-SW part of the district particularly along the southern belt of Abdasa and Mandvi taluka. Almost all the Rann area falls under poor to very poor groundwater prospect zones. The water level map shows the groundwater table gradient is towards S-SE within the district. Inferred aquifer thickness, derived from the litholog study, is higher within the Bhuj basin half grabens towards north of Katrol Hill Fault particularly within the Nakhatrana taluka and the Deccan trap formation act as a barrier of the groundwater flow further towards south. The water table depth south of Katrol Hill is much deeper than in north of Katrol Hill.

The integration of Geographic Information Systems (GIS), Earth Observation data, ancillary data, field investigations and the geological knowledge of the area under investigation, provided a powerful tool in groundwater investigation. Weighted overlay modeling technique was used to develop a groundwater potential zonation map with nine themes controlling the groundwater occurrence in any region with different weights and rank parameters. The results of this model were calibrated against observed data collected from the existing wells' information.

Dr. Prabir Kumar Mukherjee
GIS Consultant, Tata Consultancy Services Ltd., Delhi

Chander Kumar Singh
Assistant Professor,
Department of Energy and Environment
TERI School of Advanced Studies

Saumitra Mukherjee
Professor of Geology Remote Sensing and Space Sciences,
School of Environmental Sciences
Jawaharlal Nehru University

The Business Value of Sustainability

Leading companies are discovering compelling links between corporate citizenship and profitable business.

Mike Johnson
Director, Commercial Sector Global Business Development, Esri Inc.

In quick succession in October 2018, the Nobel Prize in economics was co-awarded to a Yale professor who pegged the cost of poor environmental practices to economic health, and a United Nations (UN) panel of scientists revealed that the world has less than a decade to take action against devastating climate change.

Sustainability is Once again Front-Page News

And while governments struggle toward collaborative solutions, businesses are driving corporate sustainability efforts backed by big data analytics and location intelligence.

The UN's Sustainable Development Goals

On September 25, 2015, heads of state gathered at the United Nations headquarters in New York City. At that summit, 193 countries signed on to a new set of global sustainability targets. The UN's Sustainable Development Goals (SDGs) use simple language to lay out an international regulatory framework for radical changes to be made in the world by the year 2030.

The SDGs are known as a government initiative, but companies worldwide consulted on their development, and they will have a potentially enormous impact on the business world. In part, that's because their successful implementation will require investment and support from the private sector. A report by the UN's Sustainable Development Solutions Network estimates the cost of SDGs at US$1.4 trillion per year until 2030. The same report notes that approximately half of the investments can be privately financed.

The sustainability effort is of particular interest to companies that convert natural resources into products–among them energy providers, car manufacturers, and food purveyors. For those businesses, investment in the SDGs can be critical to conserving the raw materials of production for decades to come–and locking in long-term competitive advantage.

Across the business world, executives can see the implication: sustainability could soon become a major business opportunity.

The Role of the Private Sector

Just one day after the September 2015 summit, then-UN secretary-general Ban Ki-moon held the United Nations Private Sector Forum to discuss the role of busi-

nesses in achieving the Sustainable Development Goals. More than 200 executives from organisations around the world joined him in New York, including leaders from Dell, Deloitte, Facebook, Fidelity, PepsiCo, and Siemens AG.

The secretary-general told business leaders, "I am counting on the private sector to drive success. Now is the time to mobilize the global business community as never before. . . Trillions of dollars in public and private funds are to be redirected towards the SDGs,

creating huge opportunities for responsible companies to deliver solutions."

Corporate organisations seem to agree. In a 2017 McKinsey survey, nearly 60 percent of organisations said they are more engaged with sustainability than they were two years prior, with engagement levels rising to 80 percent in certain industries like packaged goods and infrastructure.

Indeed, as climate change continues, companies that rely on natural resources are taking a hard look at the long-term viability of their products. In some regions of the world, for example, water supplies might soon run out. Reliable cropland could turn fallow as temperatures and weather systems shift. And yet, just 21 percent of business executives told McKinsey that business growth was a top driver of their sustainability initiatives. One way to read that finding: a select few industry leaders have figured out that smart, sustainable practices sow the seeds of long-term growth and competitive advantage.

Where Sustainability Meets Opportunity

One such company is Nespresso. An autonomously managed subsidiary of Nestlé Group, Nespresso is known globally for its premium single-serving coffees. Key to Nespresso's success and customer loyalty is the company's emphasis on—and investment in—the consistency of its coffee's flavor.

However, coffee is a delicate crop, frequently grown in developing countries and highly dependent on healthy ecosystems. This leaves coffee—and Nespresso—susceptible to the increasingly volatile effects of sociocultural events and climate change. For Nespresso, acting today to avoid the perils of tomorrow is not just good citizenship; it's sustainable business.

"Sustainability is really at the core of our business. It is an imperative to our long-term business success," explains Yann De Pietro, operations and sustainability technology manager for coffee at Nespresso. "There have been studies saying that by 2050, Arabica coffee may not be available anymore in some countries if we don't do anything now."

The company is working to combat that decline so that the seeds of Nespresso's competitive advantage remain fertile long into the future.

Innovative companies are adopting tools such as artificial intelligence, IoT, and analytics to address these challenges in ways that also benefit the business—doing well by doing good. In fact, according to the McKinsey report, nearly half of the organisations using technology to advance sustainability are employing big data and advanced analytics, which typically includes location intelligence.

Controlling Challenges through Sustainability

Nespresso has made a deliberate choice to integrate these challenges into its decision-making process and act on them through sustainability programs. These programs help convert liabilities into business opportunities while supporting the farmers and communities that grow coffee.

Nespresso works with over 100,000 farmers in 13 countries, up from 300 farmers 15 years ago. In 2003, the company launched its responsible coffee sourcing program, the Nespresso AAA Sustainability Quality Program, in partnership with the Rainforest Alliance. The program is designed on two convictions: that high-quality coffee and the sustainability of farming communities are interconnected, and that only by building trusting, long-standing relationships with coffee producers can Nespresso hope to make a positive difference.

The company supports the implementation of sustainable agricultural practices at farms by investing in technical assistance, paying premiums directly to coffee farmers, and co-financing infrastructure improvements.

As part of that effort, the company has invested in a network of over 450 agronomists—specialists who provide coffee growers with on-site

A Dashboard View of Sustainability

Sustainability can often be measured through the effects that company operations have on local and global systems. Leading business executives are turning to sustainability-focused dashboards to discover the intelligence they need to track operations.

The insight that appears on a dashboard depends on the company's industry and the executive's responsibilities. A retail CXO might monitor fluctuations in carbon emissions throughout the supply chain. A manufacturing executive might track water consumption at processing plants around the world.

> Today Nespresso is using GIS and location intelligence to build a comprehensive view of farming operations and accessibility across regions. "We have started to have a global vision of accessibility of the farms."

De Pietro
Operations and sustainability technology manager for coffee, Nespresso

technical assistance and trainings on practices such as pruning, crop renovation, fair treatment of workers, water usage, and biodiversity conservation, all of which can earn farmers industry certifications.

Through the AAA program, Nespresso invests approximately US$35 million per year in technical assistance and premiums paid to farmers for their quality coffee. The educational program is free to farmers and doesn't require them to sell to Nespresso, De Pietro explains. But the benefits to each side help create long-lasting relationships and loyalty.

Nespresso has a publicly stated goal of sourcing 100 percent of its "permanent range" coffee—the brand's most prominent line of coffee capsules—from AAA farmers by the year 2020. In 2017, the company bought approximately 90 percent of its beans from those farmers.

The AAA Sustainability Quality Program falls under Nespresso's broader strategic framework, The Positive Cup, which focuses on four areas: coffee, aluminum, climate change and engagement. In addition to its goal of sourcing all coffee from AAA growers by 2020, Nespresso has committed to other milestones that include sourcing 100 percent of its aluminum from responsible, ASI-certified sources, offering consumers convenient solutions for recycling, reducing the carbon footprint of each cup, and reaching carbon neutrality for its operations.

In 2016, the company tied those efforts to the UN's Sustainable Development Goals, committing to making an impact on 11 of the 17 SDGs. In addition to Climate Change and Water Stewardship (which contribute to SDGs 13 and 6, respectively), Nespresso called out Responsible Consumption and Production (supporting SDG 12) and Decent Work and Growth (for SDG 8) as foundational to consumer goods organisations such as itself.

Progress through Digital Transformation

While its sustainability program has been in effect for years, Nespresso has seen recent rapid results due to advances in digital technology.

"Digital transformation is a key change for sustainability" at Nespresso, De Pietro says. "[We] want to provide maximum impact. So we need the tools to help us to maximize our efforts."

On the balance sheet, the results look promising. When Nestlé announced its 2017 results, it singled out Nespresso's mid single-digit growth worldwide and mid-teens growth in North America. The parent company's growth was led by coffee, pet care, and health-science products.

At the center of Nespresso's digital transformation is location intelligence. The company has built a robust monitoring and evaluation system using advanced digital technology that records, maps, and shares data about farms, farmers, and coffee crops. This reveals local feedback and insight on AAA's impact, as well as the status of each farm, including its objectives, achievements, and performance. The digital platform—which is powered by a geographic information system (GIS) and data analytics—also reveals insights into the way farmers deliver coffee beans to central mills to be harvested,

a key factor in supply chain productivity and efficiency.

Bringing Intelligence to Location Data

One of De Pietro's goals is to help farmers get their crop to market more efficiently. A recent analysis in Colombia exemplifies how location intelligence can create business advantage for the company and its partners.

A location analysis revealed that farmers brought their crops to certain Colombian mills—many of them close to their farms—less frequently than projected. De Pietro queried the GIS technology to dig deeper into the data so that he could understand these behavioral patterns. What he discovered was a reminder of topography's effect on time to market.

With basic maps, he says, the team could work out the distance between farmers and mills. But only with sophisticated location intelligence could they understand the true travel distances to each central mill. Applying a similar analysis to the agronomists who visit Nespresso's AAA farms, De Pietro and the team found a similar pattern. The analysis uncovered areas where the terrain required long rides or walks through the mountains to reach certain farms, making frequent visits impractical. For a company that works with 100,000 farmers, having a digital engine to deliver that kind of intelligence is crucial.

In both cases, location intelligence pointed the way to better business and sustainability practices. If the mills were more centrally located, farmers could get coffee to market more quickly. And when the agronomists can reach the farms faster, they can hasten the day when 100 percent of Nespresso's coffee is sourced from sustainable farmers.

Just as retailers and logistics companies use location intelligence technology to plot out the most efficient drive times for customers or delivery personnel, Nespresso embraces the realization that the distance to a location is less important than the amount of time it takes a customer or farmer to get there.

Today Nespresso is using GIS and location intelligence to build a comprehensive view of farming operations and accessibility across regions. "We have started to have a global vision of accessibility of the farms," De Pietro says.

As Nespresso makes progress in Colombia and around the world, the organisation maps its efforts back to the UN's Sustainable Development Goals as a way to organize and guide strategic decision-making. The AAA program, for instance, directly impacts SDG 8 (through inclusive growth), SDG 2 (by promoting sustainable agriculture), SDG 4 (through learning opportunities for all), SDG 1 (through efforts to eradicate poverty), and SDG 6 (by way of water stewardship).

The Future of Sustainability

The use of location intelligence to shed light on the granular details of day-to-day coffee farming sets Nespresso apart. By examining and adjusting locations for farmers, the company frees up precious time and increases productivity. This impacts not only farming, but also time for education and strategic planning—the very activities Nespresso hopes will sustain its coffee crops far into the future.

But questions remain on how to effectively implement wide-scale change across industries. The global community faces major challenges on this front in the coming decades. The Sustainable Development Goals, for example, are not on track to be realized by 2030. The UN acknowledges where countries are lagging behind, stating, "This ambitious agenda necessitates profound change that goes beyond business as usual."

Business-as-usual attitudes are among sustainability's challenges. Some of the largest and wealthiest organisations in the world are not actively participating in sustainability efforts. The UN's SDG Commitment Report 100, released in 2017, found that American companies score far worse tahan their European counterparts. Of the 18 companies with no mention of sustainable development themes, 15 are American.

Regardless, there are strong incentives to invest in corporate sustainability strategies, for reasons both reactive and proactive.

For instance, a team at McKinsey found that up to 70 percent of an organisation's earnings can be impacted by risk-related sustainability issues. Michele Giddens, a specialist in sustainable and impact investing, sees businesses beginning to accept and support a shift to a circular economy where optimizing sustainability can increase long-term growth.

Nespresso's example spotlights the reality defined by these scenarios. Its core product and the heart of its brand—coffee—is at risk from climate changes in coming years. The company is approaching these challenges proactively, taking steps to not only mitigate risk, but also use digital technology and location intelligence to create strategic differentiators.

Treating sustainability as both a guiding principle and an opportunity to gain competitive value may be the way forward for other innovators in the business community.

GeoMentors

Enabling the geo-community through knowledge sharing

GIS-based services are growing at an exponential pace and so is the need for trained and qualified manpower to cater to the needs of the industry and further innovation. There exists a considerable demand-supply gap and it is only through active coordination between the industry and academia can this gap be minimised. Preparation must begin early. Right from the school days, students must be made aware of the wonderful world of GIS and efforts must be made to cultivate in them an interest in this fascinating field, such that they choose it as a career option later in life.

Esri India has exhibited a long-standing commitment towards making the student community more aware of GIS. Be it making easy and cost effective software available for using GIS for enhanced learning, organising workshops and training programs in schools and colleges for students and teachers or conducting online courses, its role in preparing the future generations for using GIS for greater good has been pivotal. As the next step towards this goal, it recently launched the GeoMentor Program. Being considered as one of the most impactful programs of Esri India, the program is here to strengthen the GIS community through exchange of ideas and most importantly through passing on the knowledge gained to the next generation.

With issues such as climate change, urban sprawl, biodiversity loss, sustainable agriculture etc. increasingly affecting our lives, spatial thinking skills have become more relevant than ever before. This is exactly what the GeoMentor Program aims to provide the young generation with. Equipped with GIS skills, the students are able to better analyse and interpret the world.

Technology is an excellent tool to engage students inside the classroom. GeoMentoring provides an excellent opportunity for GIS experts like you to do their bit in giving the world a more capable workforce that not only understands the benefits of using GIS, but also possesses the technical competence to execute the ideas. As Rahul Krishna Pandey from RMSI Pvt. Ltd. shares, "As a Geospatial IT Professional, I believe sharing information and experience back to community is the best service that I can offer. This gives me excitement and a deep sense of satisfaction and when I interact with school teachers and students. I feel much honored to be associated with Esri as a GeoMentor under K-12 "GIS For Schools" Program in India."

GeoMentoring equips the young minds with spatial reasoning abilities, using which, eventually, they are able to better identify, describe and analyse important spatial relationships and solve many crucial problems. Be it environment conservation, protecting biodiversity, combating climate change or fighting wildfires, students are able to develop innovative GIS-based solutions for these issues in future.

The GeoMentor Program is apt to build a strong framework for GIS education in India by bringing volunteers, professionals, students and teachers together. Through this program, GeoMentors get a unique chance to enrich the educational lives of students and teachers. Self-learning enhances while teaching and this is true in case of the GeoMentor Program as well. While imparting training on ArcGIS Online, as a GeoMentor, you get to learn more about GIS technology.

Esri India Technical Services

Experience the best of Esri technology along with best of technical expertise.

Email Support
customercare@esriindia.com

Support Helpdesk
Toll Free: 1800 - 102 - 1918
(9:00 a.m. - 5:30 p.m. IST, Monday-Friday)

Online Support
esriindia.com/tech-support

Live Chat
(9:00 a.m. - 5:30 p.m. IST, Monday-Friday)

Esri India Locations

Ahmedabad
505, Shree Balaji Heights, Beside IDBI Bank,
Near Tanishq showroom, C.G. Road
Ahmedabad - 380009, Gujarat

Bengaluru
Ramakrishna Towers, 4th Floor, 31/2,
Rupena Agrahara, Begur Hobli,
Hosur Road (Near Silk Board Flyover)
Bangalore - 560 068, Karnataka

Chandigarh
SCO 156-160, Sector 8C, Madhya Marg
Chandigarh - 160009

Chennai
629, Regus Millenia, RMZ Millenia Business Park
Level 6, Phase II, Campus 4B, Unit 602A,
No:143, Dr.M.G.R Road,
Perungudi Chennai - 600096, Tamil Nadu

Gurugram
223-224, Udyog Vihar, Phase-1,
Gurugram - 122002, Haryana

Hyderabad
Q City, Block B, 6th Floor, Sy. Nos. 109, 110, 111/2
Nanakramguda Village Serilingampally Mandal
R.R. District, Hyderabad – 500 032, Telangana

Kolkata
3B-501, 5th Floor, Eco Space Business Park
Rajarhat, New Town,
Kolkata - 700 156, West Bengal

Mumbai
4th Floor, Marwah Center, Kishanlal Marwah Marg,
Off Saki Vihar Road, Andheri (E)
Mumbai - 400072, Maharashtra

Noida
H-7, Sector 63
Noida- 201301, Uttar Pradesh

Parwanoo
Parvati Bhawan, Khasra No. 381/1, 380/2,
Village Kamli, Parwanoo,
Distt. Solan - 173220, Himachal Pradesh

Other Branch Offices
Bhopal
Dehradun
Lucknow
Thiruvananthapuram
Vijayawada

esri India

Esri India Technologies Ltd.

H-7, Sector 63
Noida - 201301, Uttar Pradesh (India)
Tel : + 91 120 4285000 / 5200
Fax : + 91 120 4285333
Email : info@esriindia.com
Web : http://www.esriindia.com