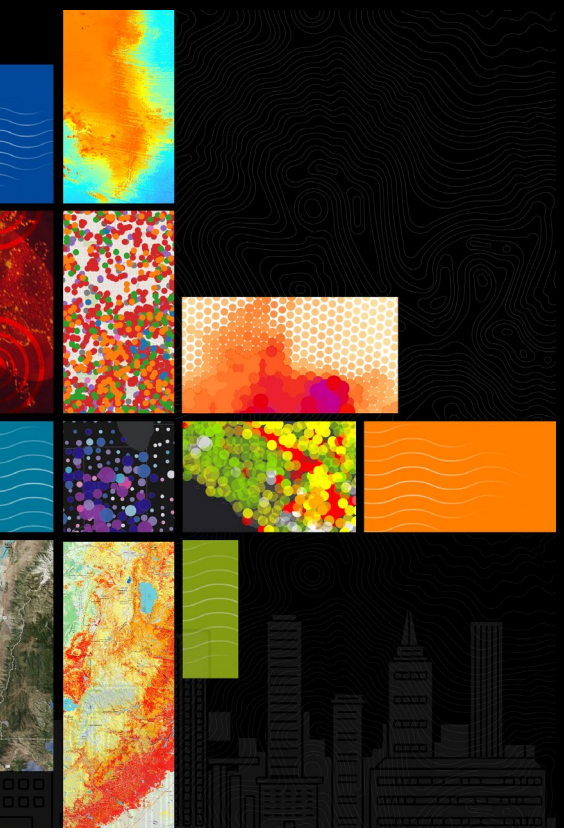

GIS Building a Resilient Nation

The first two decades of the 21st century have redefined order of the world in many ways. Growing economies, exploding population, increasing urban migration, ageing population, shifting agricultural patterns, changing climate and pandemic have transformed societal dynamics and impacted every facet of our lives. What concerns is complexity, severity, and pace at which some of the disruptions and crisis have hit us and the negative impact they are causing on the economies and communities alike. These trends are expected to continue with most likelihood of acceleration of the pace.

With food, water, health, energy, and financial ecosystems getting impacted, no country has been spared. Urban and rural communities have been equally affected. Nations that invested in building resilience have fared better than others in dealing with these shocks and could ensure minimal impact on their citizens. Resilient nations "Prepare Strategically, Respond Rapidly and Recover Methodically" during the crisis times and return to normal as effortlessly as possible. Leaders embed resilience in their design for rapid response and recovery to stay ahead to ensure growth. Resilient communities respond, withstand, and recover at faster pace by utilizing the available resources to minimize the impact of disruptions. Undoubtedly, geospatial technologies are playing a critical role in helping these nations, leaders, and communities to build a higher degree adaptability to bounce back.

India in particular has been highly vulnerable to these disruptions and shocks. With infrastructures and systems still evolving, lot needs to be done in terms of readiness and adaptive capacity to respond effectively and efficiently. It is important that the gaps are plugged and ability of the communities to deal with the disruptions and bounce back is strengthened. As a developing country, it is critical that nation's roadmap embraces resilience by design without compromising on the efforts to achieve cherished vision of "Atmanirbhar Bharat (Self-Reliant India)". "Atmanirbharta (Self-reliance) is about resilience, leveraging internal strengths to anticipate future trends, prepare, manage and mitigate the disruptions effectively and efficiently.

What is Resilience?

Resilience is ability of the individuals, communities, organizations, and governments to adapt and recover from disruptions without compromising long-term prospects for the development. Resilience is about anticipating, planning, and reducing risk to effectively protect persons, communities and countries, their livelihoods, health, cultural heritage, socio-economic assets, and ecosystems (UN, 2015).

We live in a connected world where interdependence is historically high. Information and communication technologies have become backbone of economies and livelihoods. There is an increased flow of trade, capital, money, and people across the boundaries. Global businesses and supply chains are interrelated with organisations, resources, and processes to deliver goods and services to their consumers. While we are more connected and integrated today, the systems are also more fragile and vulnerable to external impacts. A disruption in one place can swiftly transcend across the borders and trigger breakdown across the ecosystems and chains. The Coronavirus disease (COVID-19) pandemic has revealed how these vulnerabilities can disrupt and cripple economies, and at the same time brings to fore the importance of being prepared to adapt and recover.

With increasing frequency and suddenness of disruptions, governments, businesses and communities are at increased risk of getting trapped into situations that are detrimental for nation's development and sustainable growth. By building resilience governments, businesses and communities, the nation can- a) Anticipate risk, b) Prepare to adjust, c) Share and Learn, d) Integrate, Coordinate and Collaborate and e) Ensure inclusiveness. And to be able to do so, it is important that all the responsible factors are brought together on a common framework which can integrate all types of data and knowledge, spatially and temporally. With its unique ability to integrate data about everything and, at the same time, ability to provide a platform for intuitively understanding data and knowledge as an integrated whole, GIS becomes an essential and irreplaceable tool for building resilience. GIS not only helps with a better understanding of the evolving situations, but also provides a platform for collective problem-solving, decision-making, and perhaps most critical of all for building resilience and collaboration.

Why GIS Technologies hold the key?

In a connected world where ecosystems are intertwined and interdependent, production and supply chains are integrated and interlinked more than ever, protracted crisis's, uncertainties and surprises are the new reality. Some call it "new normal". Several disruptions can happen together, triggering simultaneous shocks and stresses across the ecosystems. To strengthen resilience and adaptability of nation and its communities, there is a compelling need to explore and understand these interconnections, contextualize location, and analyse the interdependencies spatially and temporally.

"The Science of Where" becomes important more than ever for understanding and managing these interconnections. By harnessing geographic context, GIS provides unmatched capabilities to discover insights from within data and transform how organizations and communities see, think and act. With its simplification and deployment on the web and in cloud computing as well as the integration with real-time information (the Internet of Things), GIS promises to be a robust platform for building nation's resilience framework. As a unified digital environment that can provide a way to understand knowledge through data exploration, analytics, visualization and sharing and dissemination, GIS based resilience platforms:

1. **Embrace Complexity -** Bring together diverse data sets and systems , aid in identifying complex development challenges, and address within the political, economic, ecological, and social systems in which they exist. With advanced cloud capabilities and tools to leverage big data, Artificial Intelligence (AI), and Machine Learning (ML), an integrated GIS platform can bring together disparate systems and processes, along with multidisciplinary data on a unified platform for enhanced decision support. Using its situational awareness capabilities, GIS allows stakeholders to be more efficient and contain disruptions locally by limiting them and preventing widespread impact across the ecosystem. Modelling and simulations help building predictive scenarios for understanding the disruptions in a better way.

2. **Enable Inclusive Decision Making -** GIS fosters participatory problem-solving approach by facilitating seamless interactions between governments, institutions, businesses, NGO's, communities, and other stakeholders at different scales. By facilitating participation and multi-agency collaboration on a common platform, armed with contextual and actionable intelligence, stakeholders can take informed decisions. Mobile tools empower stakeholders to stay connected anywhere, anytime

on any device and take active part in the decision-making process to develop, adopt and implement equitable and sustainable solutions.

3. **Promote Flexibility, Learning and Innovation-** With multidisciplinary factors, multiple stakeholders and evolving situations in the play, rigid solutions cannot build resilience for change. GIS platforms being versatile, scalable, adaptive, and responsive support dealing with complex situations as they evolve. They promote inclusiveness, allowing individuals and communities to be supported within social structures. Using big data and machine learning, historical data and knowledge can be put to best use for learning, innovating, developing new approaches to deal with shocks and stresses.

With its extraordinary potential to touch every web-connected being through a common language of maps, GIS-based resilience frameworks are incredibly powerful to communicate, analyse and share information for solving complex problems. GIS powers nation's resilience infrastructures with - risk information and analytics, hyperlocal hazard detection and early warning systems, scalable data analytics (national, state, district and community-level), tools for decision support and action on the ground which enable timely interventions towards strengthening resilience and adaptability.

ArcGIS-enabled geospatial infrastructure for a Resilience Framework

Esri inspires and enables people to positively impact their future through a deeper, geographic understanding of the changing world around them. By providing data-driven insights with location intelligence for decision support, ArcGIS platform enables a geospatial infrastructure that support nations and organizations in strengthening their resilience frameworks. This geospatial infrastructure helps governments and practitioners solve real-world problems and make critical decisions by analysing risks, evaluating potential impacts, planning resilience activities, and viewing status of resilience efforts.

Understanding geospatial infrastructure.

The Geospatial Infrastructure: helps governments and organizations with secure rapid enterprise deployment, mapping and visualization and analysis and discovery with automation tools for creating, analyzing, and sharing geographic information which can be customized by adding ready-to-go capabilities and applications. By connecting existing data stores and ready-to-use storage, Esri's extensive collection of curated geospatial content can help decision makers with intelligent insights. Agencies can connect people, locations, and data across the risk management lifecycle holistically using interactive maps with smart, data-driven styles and intuitive analysis tools that deliver location intelligence. The analysis and actions can then be further communicated to other departments via compelling web pages and applications.

Prevention & Mitigation: ArcGIS platform provides powerful capabilities that aid in identifying, assessing, and understanding risks that cause disruptions and shocks. Locations of the shocks are not always predictable. With its advanced capabilities for mapping, imagery and remote sensing, ArcGIS enables users to visualize, analyse, and manage data in 2D, 3D, and 4D to gain new insights for prevention, mitigation and informed decisions. Using multidisciplinary factors and historical data, ArcGIS tools aid in improving predictions regarding subjects that will be impacted. Such localized evaluation helps in proactive measures to deal with the impact of the disruptions.

Preparedness: Spatial modelling and simulation of disruptions and shocks help agencies with strategic preparedness. By integrating real-time

GIS for Strengthening Nation's Resilience

Rapid pace of changes, increasing vulnerabilities and associated complexities which nations face warrant transformative actions to address problems and strengthen resilience. It is time to shift the paradigm from siloed approach of addressing problems, which are becoming obsolete and ineffective, to an integrated inclusive approach. Geospatial technologies offer unique advantage in fostering an integrated-systems-based approach and intuitive understanding of what is going on at all scales – locally, regionally and globally, which are critical to nation's resilience.

As an intelligent nervous system with enhanced situational awareness, through its data driven insights, GIS aids in sensing health of ecosystems to plan and prepare and provides tools to respond and recover. Be it Economic (Energy, Infrastructure, Agriculture), Social (Urban, Rural, Health, Transportation, Public Safety) or Environmental (Climate) components, GIS empowers all the stakeholders equally with data insights and tools. Most of these being dynamic in nature and intertwined with multiple factors, GIS plays a key role in facilitating planning, managing, and monitoring these subjects efficiently and effectively.

data from sensors/IoT devices and social media on maps and big data capabilities, agencies can identify temporal patterns and extract actionable location intelligence. By analysing dependent factors, agencies can have a bird's eye-view as well as ability to drill down to details to assess accurate situations on the ground and plan remedial actions. Expected impact, estimated aerial spread and likely scenarios based on different characteristics help agencies identify areas that would be affected by disruptive events well in advance and prioritize resource mobilization.

Using GIS-based Data Analytics to effectively analyze and respond to risks.

Response: Situational awareness along with actionable intelligence being the key factor, it is important that all responders are armed with updated information as situations dynamically evolve and data-driven decisions are taken. Be it evacuation routes, rehabilitation shelters, or other services that are key to successful response operations, it is updated information presented in spatial context that makes the difference and helps stay ahead. The GIS-enabled mobile apps support field operations, community and citizen engagement by bridging the gap between teams on the ground and command-control reducing response times and maximising resource utilization. With drones proving to be extremely useful in rapid response to disruptive events, data from Drones / UAVs can be seamlessly integrated into the geospatial infrastructure to generate images for visualization and analysis.

Rehabilitation and Recovery: The aftermath of disruptions is always painful and warrants a methodical recovery. While Post Disaster Needs Assessment (PDNA) is the first step towards a holistic recovery, it is important to recognize that the disaster recovery process goes beyond the PDNA and aids in identifying a criteria-based prioritization, planning and implementation of the recovery agenda. The geospatial infrastructure plays a critical role in ensuring that disaster recovery processes are prioritized and embrace inclusiveness, resilience, and sustainability. Situation analysis using dashboards, impact analysis tools, and workforce management tools help in providing prioritized relief to affected citizens and their needs in the shortest time. This enables the affected communities to build back in a more adaptive way. The information and knowledge shared during the process supports in building actionable agendas for strategic planning, disaster risk reduction, and policy decisions to strengthen resilience.

Economic Resilience

Risks and uncertainties impact the ability of nations and communities to build capacities, and infrastructure (physical and digital) for developmental efforts and economic growth. Building economic resilience calls for comprehensive policies and strategies, institutional and participatory interventions for strengthening energy and food security supported by robust infrastructure that can promote economic activity. By using GIS governments gain a better understanding of the economic landscape and conditions, identify risks and vulnerabilities, analyze causes, and impacts of the shocks, their likely impacts in social and environmental context. This complements their efforts in developing – policies, strategies, human resources, institutional and financial resources for strengthening economic resilience.

Energy Resilience

With increase in population and urbanization, demand for energy has been increasing rapidly. Water and coal, the two dominant resources for energy generation are already under pressure. Nuclear energy, solar energy and wind energy too are dependent on natural resources. Climate-related impacts on these resources add further stress on the energy security. Governments and energy producers use GIS to manage the energy balance, gain visibility into regions natural resources, planning and designing energy projects, optimize the generation, distribution, and transmission activities along with judicious use of the natural resources.

Application Areas *- Energy Infrastructure Management, Natural Resource Management, Distribution and Transmission Management, Outage Management, Mobile Workforce Management, Distribution Integrity Management, Critical Infrastructure Protection, Emergency Response / Disaster Management*

Agriculture and Food Resilience

Even without climate change, world food prices are expected to increase due to growing populations and rising incomes, as well as a greater demand for biofuels. The effects of a changing climate will have a significant impact on the world's food supply. Seasonal water scarcity, rising temperatures, changing rainfall patterns, and intrusion of sea water threaten crop yields, jeopardizing the country's food security. Food producers and agriculturists need GIS to understand dynamics of agro-climatic features, evaluate risks and work towards adopting sustainable agricultural practices and strengthen resilience.

Application Areas *- Land Management, Crop Life Cycle Management, Water Resource / Irrigation Management, Precision Agriculture, Fertilizer Management, Pests and Disease Management, Farm Produce Management, Disaster Management*

Infrastructure Resilience

By presenting data on a common platform, GIS provides powerful capabilities to design, build, manage and operate physical and utility infrastructures. Digital spatial models and networks help agencies to visualize, identify risks and vulnerabilities and build capabilities to respond to shocks. Mobile solutions augment field teams for inspections, maintenance, and operations. GIS also aids in managing long-term transactions typical of the planning, analysis, design, while preserving data integrity and overall system performance.

Application Areas *- Land Information Management, Building Information Management, Public Services Management, Energy Management, Public Safety & Physical Infrastructure Security Management, Utility Infrastructure Management (Electric, Communications, Water and Gas), Outage And Distribution Management, Mobile Workforce Management, Emergency Response / Disaster Management*

Social Resilience

Along with the nation's structural components, it is critical that the social components – people, communities and associated subjects are also strengthened to deal with disruptions and shocks. Using GIS, nations can build social resilience by empowering its citizens and communities with information and tools using which they can prepare, respond, and recover from threats and quickly adapt to the changes.

Urban Resilience

Increasing urbanization and migration is constantly adding pressure on the urban infrastructure. In the absence of a resilient framework, disruptive events can unfold rapidly and cripple economic and social activity. GIS assists urban administration and its stakeholders by presenting data from multiple sources for an efficient decision support, sharing and collaboration of data and services, better coordination among stakeholders, efficient citizen services and optimized usage of resources. GIS GIS-based city operations centres have proved to be very effective in enhancing urban resilience by bringing together utility networks, assets and infrastructure on a common platform and aiding in prevention, preparedness, response and recovery during disruptions while at the same time supporting financial self-sufficiency.

Application Areas *- Urban Sprawl & Growth Management, Cultural Heritage & Tourism Management, Capital Improvement Program Management, Healthcare Management, Social Infrastructure Management, Institutional Infrastructure Management, Economic Infrastructure Management, Healthcare Management, Public Safety & Physical Infrastructure Security Management and Emergency Response & Disaster Management*

Rural Resilience

Rural communities face unique challenges. Poverty, social inequalities, and lack of education makes them disproportionately vulnerable to disruptions including natural disasters and health related hazards. By bringing together all the rural subjects together on a GIS platform, governments can build rural resilience at a block/village level and empower the rural communities to mitigate, respond, and recover from the disruptions and shocks. Spatial tools for decision support promote self-sufficiency by arming rural communities to take sound decisions on livelihoods, sustainable agriculture, and natural resource management.

Application Areas *- Rural Infrastructure Management, Land Management, Sustainable Agriculture Management, Natural Resource Management, Livelihood Management, Economic Opportunity Management, Cultural heritage & Tourism Management, Healthcare Management, Climate Change Management, Ecology and Biodiversity Management, Conservation Management, Disaster Management*

Transportation Resilience

Disruptions to transportation networks have cascading effect on the societies and economies. GIS assists transportation personnel across the transportation life cycle. Presenting data from multiple sources for planning & monitoring, build and maintain digital network models for transportation systems, including roads, signage, signals, pavement, markings, transit, and traffic control, provide public access to traffic and road conditions, weather, and other traffic data for accurate and timely information which is critical to respond to disruptions and emergencies.

Application Areas *- Road & Rail Infrastructure Management, Airport/Seaport Infrastructure Management, Land Information Management, Outdoor Advertising Management, Public Information Services, Transportation Infra Security, Emergency Response/Disaster Management*

Public Safety and Disaster Resilience

With human lives and property at stake, public safety and disaster resilience calls for meticulous planning and response management. GIS plays a vital role in prevention, mitigation & preparedness, response, and recovery including planning and analysis, risk assessment, public evacuation planning and damage assessment. By fostering multi-agency interoperability GIS provides common operational picture to all stakeholders along with actionable intelligence. It aids in streamlining organizational processes, workflows, and best practices.

Application Areas - *Surveillance Management, Incident Management, Disaster Management, Emergency Operations Management, Critical Infrastructure Protection, Transportation Security Management, Emergency Response / Disaster Management*

Health Resilience

With declining fertility, increase in life expectancy adding stress to the health infrastructure, climate change is compounding the health challenges. Communities, especially poor and vulnerable are faced with increasing threat due to malnutrition, pollution, vector-borne diseases, heat waves, etc. GIS is a highly effective tool for healthcare decision support including research, epidemiological studies, surveillance, management of diseases and healthcare infrastructure. Social services organizations rely on GIS to analyze transportation networks, demographics, and other layers of essential information for assessing, delivering, and integrating their programs.

Application Areas - *Healthcare Planning and Management, Healthcare Research, Healthcare Infrastructure Management, Healthcare Supplies and Services Management, Health Transportation Management, Emergency Response and Disaster Management*

Environmental Resilience

Environment and its resources have significant impact on sustenance of nation's growth. With directly impacting energy and food security, there is a compelling need for conservation and sustainable management of these resources. Impact of human exploitation of natural resources, climate change and resultant disaster risk can pose risk to human survival on the planet. By bringing together multidisciplinary factors and actors GIS, can play a vital role in strengthening environmental resilience of the nations.

Climate Resilience

Climate change is a global environmental problem transcending boundaries. Geospatial technologies are vital to governments, nonprofits, and businesses to respond to climate-driven events, such as floods, earthquakes, and droughts. GIS aids in locating areas where temperatures are particularly high or erratic, discovering how natural atmospheric processes might affect global warming, create models to show how a warming climate might impact the ecology of various regions, examine the relevance of shifts in land cover, deforestation, urban activity, and visualize multiple factors with the potential to affect crop growth, industry, wildlife and much more.

Application Areas - *Environmental Management, Weather Information Management, Climate Change Management, Biodiversity Management, Natural Resource Management, Pollution management, Conservation Management, Disaster Management*

In closing

Disruptions and shocks are here to stay and are new-normal. Nations and communities all oer the globe continue to make concerted efforts to address these challenges. While it is not humanly possible to stop the disruption from occurring, but through building resiliency the nations prepare ahead of time, operate effectively during a crisis, and recover quickly. They stay ahead of others by Preparing Strategically, Responding Rapidly and Recovering Methodically.

While governments have been embracing GIS technology to address the situations, the need of the hour is to have an integrated-geospatial infrastructure that has sustainability at its core, fosters inclusiveness, participation, and collaboration of stakeholders by embracing all linkages and interdependencies. It is time for capitalizing on the geospatial intelligence and unleashing the power of Big Data, Artificial Intelligence (AI) and Machine Learning (ML) spatially to build resilience through knowledge-based geo-enabled decision support frameworks for Aatmanirbharta and safeguarding our future.