

PROWESS OF GEOGRAPHIC INFORMATION SYSTEM: A PREMEDITATED ADVANTAGE TO STURDIER ARMY



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Abstract

Geographic Information System (GIS) has emerged as a game-changer in many industries, altering how businesses analyze and interpret spatial data in today's fast evolving technology landscape. Geography, data and technology are all combined in GIS to create a potent tool for comprehending and displaying intricate connections between various components of the physical world. After providing some basic information on GIS, we examine its applications in military settings and instigate how various forces throughout the world use it. The use of GIS in military operations is then discussed, with areas for further research suggested and emphasis placed on the Pakistan Army's GIS capabilities. The paper ends with a reflection on GIS's continuing importance in contemporary warfare.

Napoleon Bonaparte's assertion

"The whole art of war consists in getting at what is on the other side of the hill" resonates with the power of GIS to reveal the hidden aspects of the battlefield.¹

Keywords

GIS, Military Operations, Geospatial Intelligence, Tactical Advantage, Modern Warfare.

Introduction

First computerised Geographic Information System (GIS) was created in the 1960s by Canadian geographer Roger Tomlinson to organise and analyse data for land use planning. Since then, GIS has developed into a potent tool for gathering, storing, processing and displaying geographic data. To produce interactive, geographically explicit maps, it combines data from satellites, aerial images, surveys and other sources.²

Urban planning, environmental management, disaster response, military planning & operations and other fields have all been impacted by GIS. The decision-making process in various domains has been changed by its capacity to give spatial context to data.³ It enables organisations to centralise and organise enormous amounts of spatial data, which is then analysed to extract valuable insights and patterns, resulting in better decision-making and increased operational efficiency. By combining spatial data with maps, charts and graphs, GIS offers platform for visualisation and communication that helps stakeholders to make data-driven decisions. Finally, geographical analyses—which entails assessing geographic patterns, correlations and trends—are extracted. It is used to study pinpoint problem areas, foresee potential outcomes and allocate resources more efficiently. For instance, in the realm of public health, GIS can be utilised to

pinpoint treatments in a more exact and efficient way by identifying regions with a high frequency of diseases.^{4,5,7}

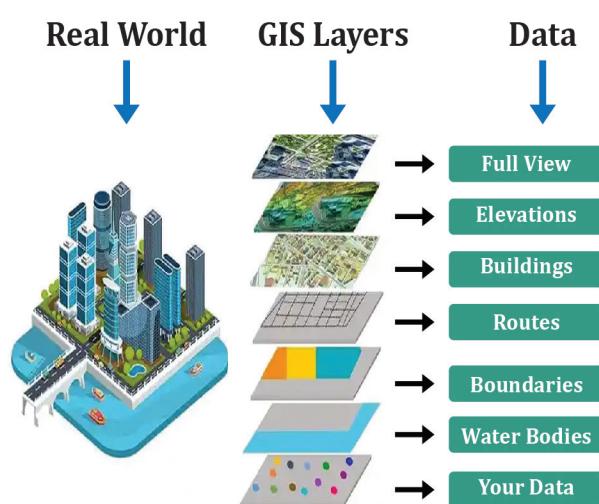
The application of GIS in contemporary military operations represents a fusion of advanced technology and strategic acumen. In an age where information is power, GIS equips military forces with the tools to comprehend and manipulate the complex spatial dimensions of the modern battlefield. It offers a multifaceted advantage encompassing strategic planning, logistics and real-time tactical decision-making.⁶

This article will explore the capabilities of GIS in military contexts, drawing comparisons between the ways different armies leverage this technology. Additionally, we will provide insights into the future employment of GIS in military operations, suggesting fields that warrant exploration to enhance its utility further.⁸

The Everyday Utility of GIS

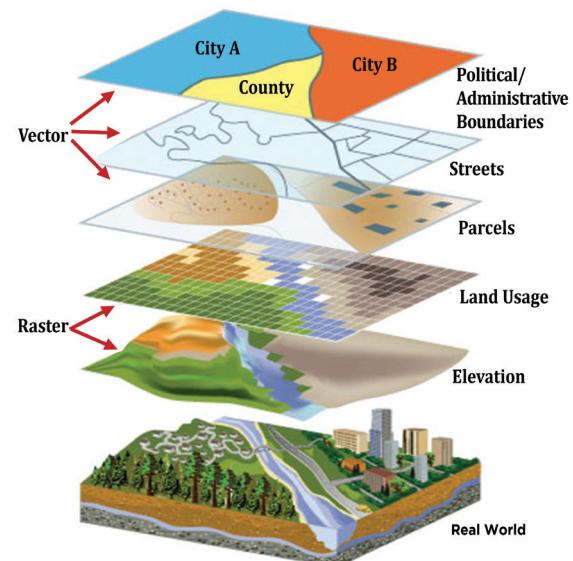
From the moment we reach for our smartphones to navigate through traffic using GPS-based applications, to checking the weather forecast with real-time GIS data, we are interacting with GIS technology. Such everyday utility underscores the profound impact of GIS on contemporary life.

Figure-1: The Importance of Geographic Data Visualization



Source: <https://dataexpertise.in/geographic-data-maps-geospatial-visualization/>

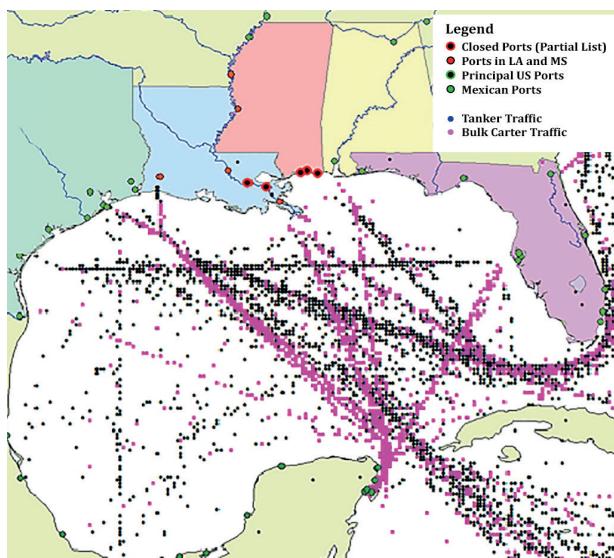
Figure-2: Representations of Spatial Data in GIS



Source: Mierzejowska and Pomykół (2019)

Navigational aids like Google Maps and Waze are prime examples of how GIS simplify our lives. These applications utilise geospatial data to provide us with the most efficient routes, real-time traffic updates and even suggest nearby points of interest. The ability to make data-driven decisions while on the move has become a hallmark of modern living, all thanks to GIS.⁹

Figure-3: GIS Map of Normal Ship Traffic in US Gulf Coasts



Source: <https://www1.udel.edu/PR/UDaily/2005/mar/katrina090705.html>

GIS in Warfare and Military Exercises

Military leaders have understood the value of precise maps for strategic planning and decision-making since the early days of mapping. The capacity to assess the terrain, find enemy locations and track army movements has frequently made the difference between victory and defeat during conflict.¹⁰ GIS plays a vital part in war gaming and simulation in modern military drills. In these drills, military forces can prepare for everything from asymmetric warfare to traditional battles. GIS offers the digital battlefield on which these simulations take place, allowing soldiers to practice coordination, test plans and hone their abilities without the inherent financial hazards of live exercises.⁹

GIS assists image intelligence analysis and decision-making in the age of information warfare and cyber threats by giving a thorough overview of both the physical and virtual frontlines. Its ability to combine geospatial and digital data is crucial for comprehending

the intricate interactions between physical and digital environments in contemporary conflicts.⁸

The Arsenal: Tools of the GIS Trade

- **GIS Software**

GIS relies on specialised software programs that are created to collect, store, analyse and show geographical data.

ArcGIS, created by Esri, is one of the most used GIS software suites. A complete set of tools for map development, spatial analysis and data display are available through ArcGIS. It is now widely used in fields including urban planning, environmental management and epidemiology in addition to military applications.⁹

- **Quantum GIS (QGIS)**

QGIS is an open-source GIS software that has gained popularity for its versatility and extensive plugin support. It allows users to harness GIS capabilities without the costs associated with proprietary software.⁹



- **Google Earth Pro**

Google Earth Pro stands out as a user-friendly GIS tool accessible to both professionals and the public. While it offers impressive geospatial visualisation capabilities, it may not possess the depth of analytical features found in specialised GIS software.⁹



• **Remote Sensing**

Military GIS applications have been transformed by remote sensing technologies. High-resolution photography and other sorts of data are captured by satellites, aircrafts and drones outfitted with cutting-edge sensors. These technologies provide mission planning tools including trend analysis and historical data in addition to real-time observation.

Aerial photography, often conducted by military aircrafts, complements satellite data by offering higher resolution and the flexibility to capture imagery on demand. The advent of unmanned aerial vehicles (UAVs) or drones, has increased the potential of remote sensing. Specialised sensors on drones allow them to fly into hazardous or inaccessible locations and provide real-time data for intelligence collection and reconnaissance. Military forces are better equipped to respond quickly to new threats and adjust to changing circumstances due to the integration of GIS and drone technologies.

• **Global Positioning System (GPS)**

GIS relies heavily on GPS technology, which provides the accurate position data necessary for military operations. GPS is a constellation of satellites created and managed by the US Department of Defence that sends signals to receivers on Earth. Users can utilise these signals to pinpoint their precise position, speed and time. GPS is a key piece of equipment for armed forces, helping everything from precision munitions

targeting to troop and vehicle tracking. High accuracy location knowledge improves situational awareness and operational performance.

Furthermore, GPS technology is becoming essential in supply chain and logistics management. The accurate tracking of supplies, tools and other items enables effective distribution and lowers the possibility of resource shortages on the job site. Long-term military campaigns or humanitarian missions particularly benefit from this skill.⁵

• **Geospatial Intelligence (GEOINT)**

The combination of geographical data with other types of intelligence, such as human intelligence (HUMINT) and signals intelligence (SIGINT) is known as GEOINT. A force multiplier, GEOINT gives military decision-makers a thorough understanding of the battlespace. It is used in military applications to support everything from operational planning and humanitarian aid to target identification and threat assessment. It assists in comprehending the objectives and capabilities of enemies, offering insightful information for making strategic decisions.⁴

The Capabilities: GIS Analysis in Military Operations

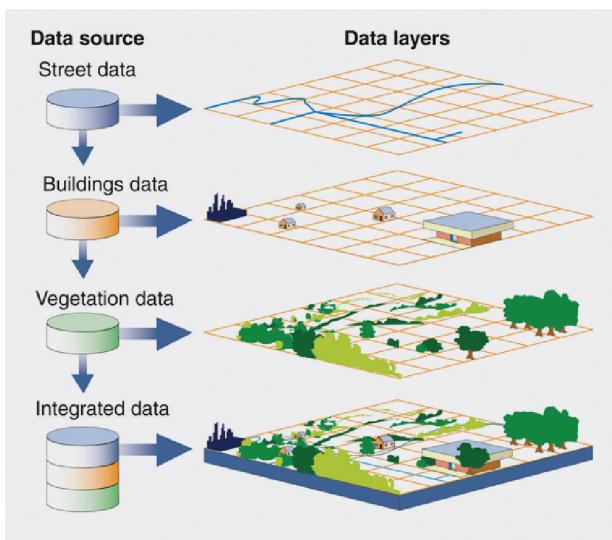
• **Terrain Analysis**

Most important uses of GIS in military operations is terrain analysis. The movement of soldiers and equipment, as well as the effective range of weapon systems, are all greatly impacted by the geography of a battlefield. GIS offers resources for the in-depth analysis of topographical features, enabling military strategists to pinpoint strategic advantages and difficulties.

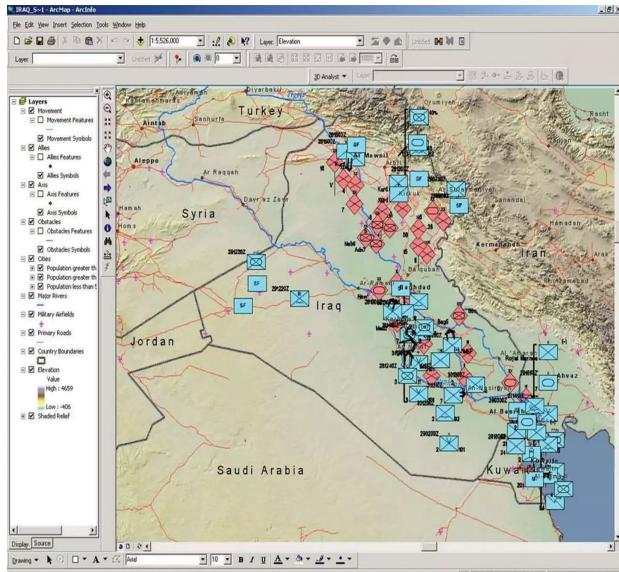
GIS, for instance, may evaluate elevation data to identify the ideal locations for artillery or observation vantage points. It can also simulate how geography affects movement, assisting in route planning by reducing vulnerability to hostile fire or natural impediments.⁹

• **Threat Assessment**

Military strategy's cornerstone is accurate



threat assessment. By including information on adversary movements, troop deployments and previous battle patterns, GIS aids in this process. Military analysts can identify prospective threats and evaluate their likelihood and impact by superimposing this knowledge with geographic data. For precise planning and execution of activities, this predictive power is essential.⁵



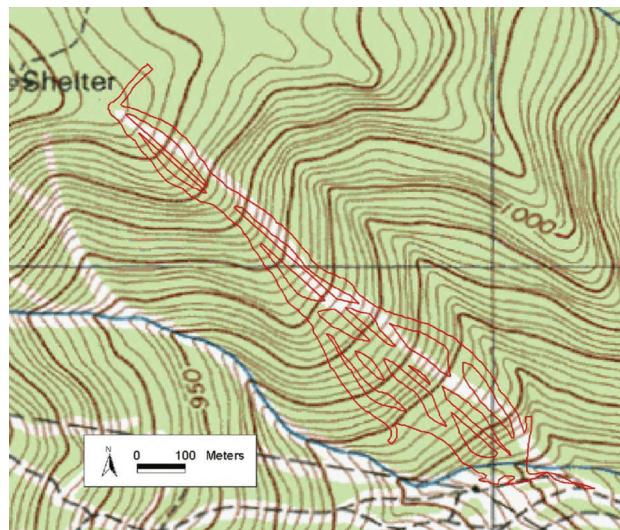
• Logistics Optimisation

Logistics, or the movement and supply of personnel and equipment, is a challenging task. By providing real-time information on the location of assets, supply depots and operational units, GIS plays a crucial part in logistics optimisation.

In essence, GIS serves as a logistical command center, enabling decision-makers to monitor the flow of goods and employees, foresee bottlenecks and make necessary adjustments to routes and schedules. This degree of coordination makes sure that troops get the resources they need exactly when and where they are needed, which improves operational effectiveness.⁶

• Situational Awareness

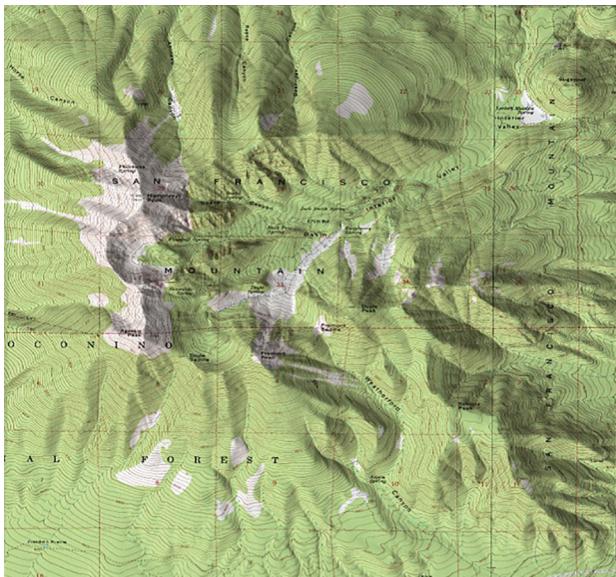
Knowing where friendly and hostile forces are located, the state of the terrain and current happenings on the battlefield is known as situational awareness. Real-time situational awareness is made possible by GIS technology, which unifies several data sources into a single, spatially referenced presentation.



GIS-based maps and dashboards that offer a live feed of data are accessible to military leaders and soldiers. Troops positions, sensor data, meteorological information and even social media feeds for gauging public opinion in combat zones are all included in this data. A thorough understanding of the issue allows for quick decision-making and the capacity to adapt to shifting conditions.³

• Target Identification

Precision in military operations is a critical factor in minimising collateral damage and achieving mission objectives. GIS aids in target identification by providing the spatial context needed to ensure that strikes are accurate and effective especially aerial forces and UAVs.



Military analysts can overlay various data layers to assess potential targets, layers may include infrastructure maps, civilian population densities and information on protected sites such as hospitals and schools. By cross-referencing this data, military forces can identify valid targets while avoiding areas where collateral damage must be minimised.⁴

Top Armies and GIS

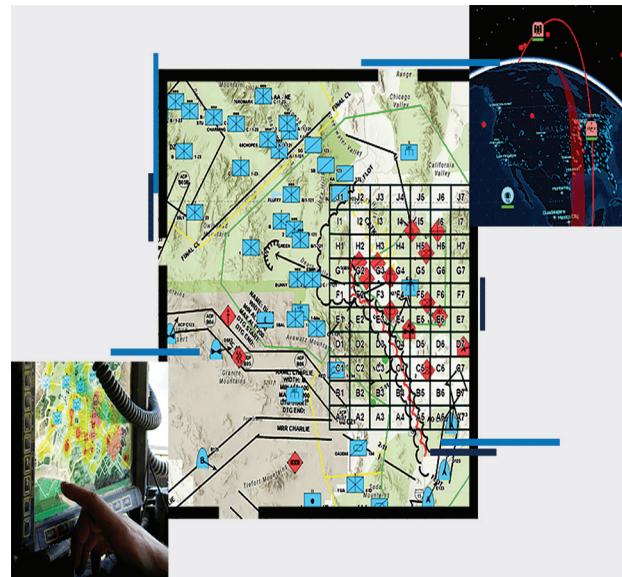
As we delve deeper into the significance of GIS in modern military operations, it's essential to appreciate the global landscape of GIS adoption. Different countries and their respective armed forces have

varying approaches to GIS integration, often shaped by their unique geographical, geopolitical and strategic contexts.

- Strategic Planning and Geospatial Intelligence
- Logistics and Supply Chain Management
- Tactical Operations and Decision Support

United States (US) Military

The US military stands as one of the pioneers in adopting and extensively utilising GIS for various purposes. The military branches, including the US Army, Navy, Air Force and Marines, have integrated GIS into their operations, establishing dedicated units and centers for GEOINT.



The National Geospatial-Intelligence Agency (NGA) is crucial in helping the US military forces with GEOINT. The US military's GIS applications extend to global surveillance, remote sensing and navigation. This comprehensive approach aligns with the famous quote by Dwight D. Eisenhower, "The plan is nothing; planning is everything," emphasising the importance of continuous preparation and adaptation.^{16,17}

The 2023 US National Defence Strategy identifies geospatial information as a critical capability for the US military. The strategy states that the US military must "have the capability to collect, exploit and integrate geospatial information to enable warfighters to make

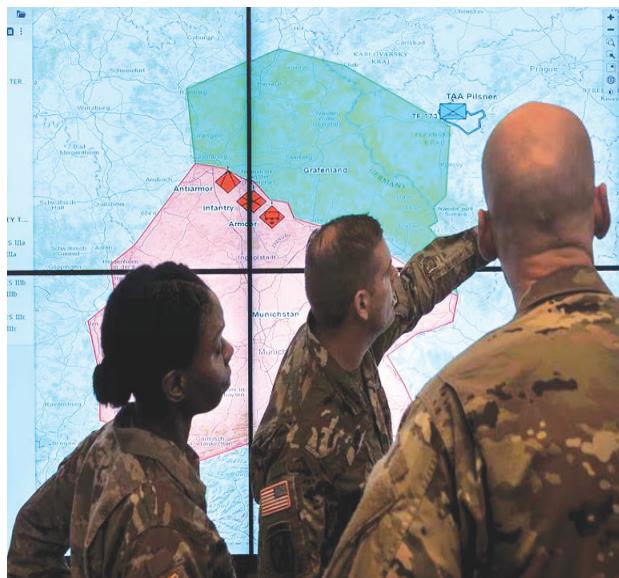
faster, better decisions in all domains". The strategy also identifies several key geospatial priorities, including:-

- **Creating and Implementing Cutting-Edge Geospatial Technologies**

To assist warfighters on the front lines, the US military must continue to create and implement cutting-edge geospatial technologies. Investing in new sensors, data processing systems and visualisation tools falls under this category.

- **Increasing Geospatial Intelligence (GEOINT)**

The US military must enhance its capacity for gathering, processing and disseminating GEOINT. This entails creating fresh GEOINT collecting



and analysis technologies and strengthening the connection between GEOINT and other intelligence fields.²⁰

Chinese People's Liberation Army (PLA)

GIS is used by the Chinese People's Liberation Army (PLA) to organise and carry out operations along its vast frontiers. Due to China's varied geography and climate, border monitoring and resource allocation must be exact.

The PLA employs GIS for resource management, intelligence analysis and border security. GIS technology helps in determining the best deployment areas, evaluating the compatibility of the terrain and

keeping an eye on potential dangers. The Chinese proverb "Opportunity only knocks on the door once" fits with this.

The PLA's emphasis on GIS demonstrates its dedication to upholding national interests and safeguarding territorial integrity, particularly in border regions.³²

Israeli Defence Forces (IDF)

To meet the difficulties presented by the nation's geopolitical environment, the Israeli Defence Forces (IDF) have adapted their GIS applications. Israel uses GIS because of its emphasis on urban security and the requirement for real-time intelligence.

The IDF emphasises real-time geospatial intelligence while using GIS in urban warfare scenarios. GIS makes it easier to move across complicated, densely populated terrain, spot hostile positions and protect friendly forces. The notion that "Adaptability is about the powerful distinction between adapting to cope and adapting to win" is in line with this strategy (Max McKeown).

The IDF also uses GIS to improve situational awareness in battle zones and for border security and intelligence gathering. To combat asymmetric threats, GIS applications for tactical decision-making have proven essential.³⁰

Indian Armed Forces

The Indian Armed Forces have recognised the significance of GIS for their diverse operational environments. India's vast and varied geography, ranging from the Himalayan mountains to coastal regions, necessitates precise geospatial information.

GIS technology is integral to India's strategic planning, especially in border regions. It aids in understanding the topography, optimising deployment strategies and conducting risk assessments. This approach aligns with the wisdom of Sun Tzu, who emphasised that "The terrain is to be contended for; this is the first principle of war."

In addition to military operations, the Indian Armed Forces employ GIS in disaster management and humanitarian missions. GIS applications help coordinate relief efforts, assess damage and plan efficient routes for aid delivery, underscoring



the military's dual role in national security and humanitarian relief.³¹

Russian Military

In a variety of operational settings, including the harsh Arctic environment, Russia's military personnel use GIS technology. Operations in remote and difficult terrain are made possible by GIS, which supports mapping, navigation and tactical decision-making.

The preservation of Arctic resources, monitoring and disaster response are all addressed by GIS applications used by the Russian military. The military can make wise decisions in isolated and frequently harsh environments by combining GIS data with satellite photos and environmental data.

The famous statement by Charles Darwin that "It is not the strongest of the species that survives, nor is it the most clever; it is the one most responsive to change" is in line with this adaptability. Russian GIS skills demonstrate its capacity to adapt to changing operational difficulties.³³

British Armed Forces

The significance of GIS technology in boosting their operational capabilities has been acknowledged by the British Military Forces, which include the British Army, Royal Navy and Royal Air Force. Applications for GIS are essential for planning missions, analysing intelligence and providing logistical support.

A key player in GIS integration is the Joint Forces Command (JFC) of the United Kingdom, which places a strong emphasis on interoperability between all branches. For situational awareness, mapping and geospatial intelligence, the British Armed Forces use GIS. They use GIS applications for deployments abroad, where accurate mapping and current geospatial data are essential. Collaboration with NATO and other allies further enhances their GIS capabilities.³⁶

Republic of Korea Armed Forces

South Korea's Republic of Korea Armed Forces employ GIS technology to address security challenges stemming from the unique geopolitical context of the Korean Peninsula. GIS supports the country's defence strategy, intelligence gathering and crisis management.

GIS applications aid in the surveillance of the Korean Demilitarised Zone (DMZ), which is one of the most heavily fortified borders globally. Real-time monitoring of this border is essential for national security. The Republic of Korea Armed Forces also leverage GIS for terrain analysis and military simulations, ensuring preparedness for various scenarios.³⁷

In an environment where rapid response is vital, GIS technology enables South Korea to maintain a strong defence posture. This aligns with the principle articulated by Sun Tzu, "Opportunities multiply as they are seized."

Australian Defence Force (ADF)

The Australian Defence Force (ADF) recognises the significance of GIS in modern military operations. ADF employs GIS for diverse applications, including strategic planning, environmental monitoring and disaster relief.

Strategically, GIS assists in understanding the vast Australian terrain, optimising troop deployments and assessing potential operational areas. In addition, the ADF employs GIS in disaster management and humanitarian missions, responding effectively to natural disasters, such as bushfires and floods.³⁸

Collaboration with regional partners in the Asia-Pacific region enhances the ADF's GIS capabilities, aligning with the famous quote by Sir Winston Churchill, "We are all worms. But I believe that I am a glow-worm."

GIS Applications Beyond Military Operations

GIS have been studied extensively in relation to their crucial role in military operations, but it's important to note that GIS technology is relevant in several other fields and applications. These examples demonstrate how versatile and adaptable GIS is in dealing with complex problems by going beyond the battlefield.^{43,44,45,46}

- Security of the Environment and Climate Change
- Natural Disaster Response
- Resource Management
- Border Security and Immigration Control
- Situational Awareness
- Infrastructure Protection
- Crisis Mapping

- Peacekeeping and International Missions
- Conflict Monitoring
- Logistics and Aid Distribution
- Protection of Cultural Heritage

The Future of GIS in Military Operations: Fields to Explore

A game-changer in military operations has been the inclusion of GIS. Even more promise lies in the future. Military forces should investigate the following options to maximise the potential of GIS:-

- **Combination of Machine Learning and AI Predictive**

Skills may be improved by the integration of GIS with AI and machine learning. AI-driven GIS systems may predict adversary movements, weather patterns and logistical needs by evaluating past data and current information, enabling proactive decision-making.

- **Data Protection and Cybersecurity**

Military forces must give cybersecurity and data protection priority as GIS systems grow increasingly linked and data driven. To preserve an operational advantage, geographical data integrity and security must be guaranteed.

- **Space-Based Technologies**

The integration of GIS with space-based technologies, such as advanced satellite systems and global positioning systems (GPS), can provide more precise and real-time data for military applications. This includes enhanced navigation, communication and surveillance capabilities.

- **Urban Warfare and Counterinsurgency**

Military forces should invest in GIS tools designed for urban warfare and counterinsurgency operations because of the growing urbanisation of conflicts. This entails mapping intricate urban landscapes, monitoring insurgent networks and perfecting strategies in crowded places. The Pakistan Army is aware of the value of GIS in urban warfare scenarios given their growing complexity. Beyond standard mapping and navigation, GIS is used in urban warfare to provide real-time intelligence, which is essential for operations in heavily inhabited regions.

- **Data Fusion and Visualisation**

It is essential that GIS technology be able to combine and visualise various data sources. For total situational awareness, military forces are increasingly combining GIS with data from sensors, drones and social media.

- **Network-Centric Warfare**

Using GIS to link military assets, network-centric warfare enables real-time data exchange and group decision-making. The coalition's efforts and cooperative operations are improved by this strategy.

- **Environmental Protection**

GIS assists with environmental protection initiatives in military training and operations zones, in addition to resource management. It adheres to the "leave no trace" maxim and helps monitor and reduce environmental impact.

- **Precision Strike Capabilities**

GIS is essential for assuring precise target identification, avoiding collateral damage and efficient engagement in both symmetric and conventional warfare.

- **Multi-domain Operations**

Which involve coordinated actions spanning land, sea, air, space and cyberspace are made possible by GIS technology. GIS makes integration between various sectors easier, allowing for coordinated military operations.⁴⁵

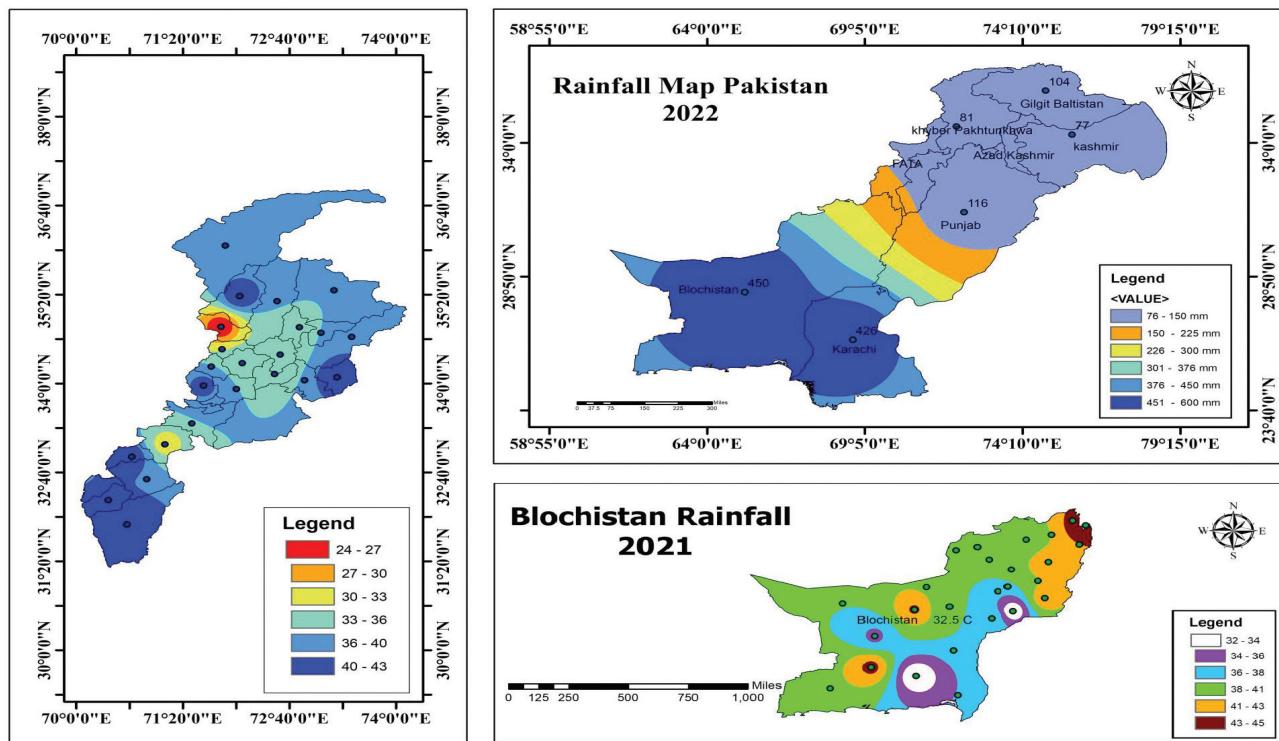
The Pakistan Army's GIS Capabilities and Suggestion for Future Enhancement

The Pakistan Army recognises the significance of GIS in modern military operations. It has developed its GIS capabilities to navigate the complex operational environment in the region. Emphasising GIS in military training and decision-making with enhanced situational awareness, optimised resource allocation and respond effectively to emerging threats.

Pakistan Army's GIS Capabilities as of Today

The Pakistan Army uses GIS for a variety of purposes in its operations, including:-





- **Preparing Strategically**

Strategic planning now incorporates GIS technologies in comprehending the geographical intricacies of Pakistan's varied landscape, which ranges from the Northern highlands to the Southern wide deserts. Military planners use GIS to evaluate possible operational regions, comprehend the geography and make wise personnel placement and resource allocation decisions.

- **Terrain Analysis**

Terrain analysis is carried out on regular basis to record terrain changes in order to prepare for hostilities during peace time.

- **Border Management (Surveillance & Security)**

As a result of Pakistan's vast borders, GIS is essential for border monitoring. The Pakistan Army monitors border region, follows activities along the boundaries and acts quickly in the event of threats, thanks to near real-time data from GIS systems.

- **Low Intensity Conflicts (LIC)**

During war against terrorism and LIC, Pakistan Army has effectively been using GIS for operational

planning, finding terrorist hide outs, eliminating No-Go areas and effectively targeting miscreants alongwith guarding civilian population from collateral damages.

- **Resource Allocation**

GIS aids in logistical planning and resource allocation. To ensure that soldiers stationed in varied terrains get the supplies and support they need, Pakistan Army distributes resources as efficiently as possible. To handle logistics effectively, GIS also helps track the movement of people and equipment.

Disaster Management

GIS is essential for both disaster relief efforts and disaster management. Natural disasters like earthquakes, floods and landslides are common in Pakistan. GIS technology is utilised to assist in assessing the impact of disasters, coordinating relief efforts and planning efficient routes for aid delivery.

- **Environmental Security and Climate Change Preparedness**

Considering Pakistan's susceptibility to climate change, Pakistan Army ought to include GIS into its plans for mitigating its effects. Assessing how

climate change will affect military infrastructure, managing resources in climate-vulnerable areas and taking part in national initiatives to reduce environmental hazards are all such examples.

Abilities to Accrue

- **Investment in AI Integration**

Combining GIS and AI can provide Pakistan Army the ability to predict future events. A GIS powered by AI can assess area security dynamics, analyse past data and suggest proactive measures to counter new threats.

- **Space-Based Technology**

Increasing the use of space-based technology, such as cutting-edge satellite systems, can give border surveillance and local security access to real-time data. To improve its GIS capabilities, Pakistan Army can go into joint ventures with commercial satellite providers or space agencies.

- **Urban and LIC Warfare Training**

Pakistan Army can invest in GIS applications designed for urban areas given the complexities of urban warfare in the area. GIS-based simulations of realistic urban combat can help soldiers be more prepared for challenging situations.

- **Urban Warfare Simulations.** Using GIS data to create accurate urban combat simulations can provide priceless training possibilities. These simulations can accurately reflect the difficulties of urban settings, such as the design of buildings, potential ambush locations and the presence of civilians.

- **Geospatial Intelligence for Urban Warfare.** Urban warfare requires the use of geospatial intelligence wherein real-time geospatial intelligence is essential. Pakistan Army can make investments in GIS technologies that give commanders immediate insights into urban areas allowing them to act quickly and wisely.

- **Protection of Civilians and Infrastructure.** GIS can help to reduce collateral damage during urban combat. Pakistan Army can create policies that

prioritise the safety of non-combatants and minimise damage to crucial facilities by mapping civilian sites and important infrastructure.

- **Cooperation for Cybersecurity**

Pakistan Army should work with cybersecurity professionals to protect GIS infrastructure given the constantly evolving nature of cyber threats. Collaborative efforts can help to find weaknesses and create defences against cyberattacks.

- **Humanitarian and Disaster Response Relief**

GIS can also be employed in humanitarian missions and disaster relief efforts. Military forces can use GIS to coordinate relief operations, assess damage and plan efficient routes for aid delivery. GIS may be quite useful in disaster response initiatives in Pakistan and its surrounding areas. Humanitarian activities can benefit from improving GIS capabilities for catastrophe assessment, relief coordination and resource allocation.

Conclusion

GIS has emerged as a powerful and indispensable tool in modern military operations and tactics. Its multifaceted capabilities, spanning strategic planning, logistics and real-time decision support, provide a significant advantage to armed forces worldwide. By comparing the utilisation of GIS by different armies, we discern unique approaches tailored to specific operational contexts.

In a world where information is paramount, GIS equips military forces with the tools needed to understand and manipulate the complex spatial dimensions of modern warfare. As GIS continues to evolve, it will undoubtedly remain a cornerstone of military strategy and operational success. Looking ahead, the future of GIS in military operations holds promise. By exploring fields such as AI integration, cybersecurity, space-based technologies, urban warfare applications and humanitarian missions, military forces can further enhance their strategic capabilities.

Pakistan Army is on the right track to meet the future challenges but a need exists to channel the effort as this domain can be the future warhead of the world.



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