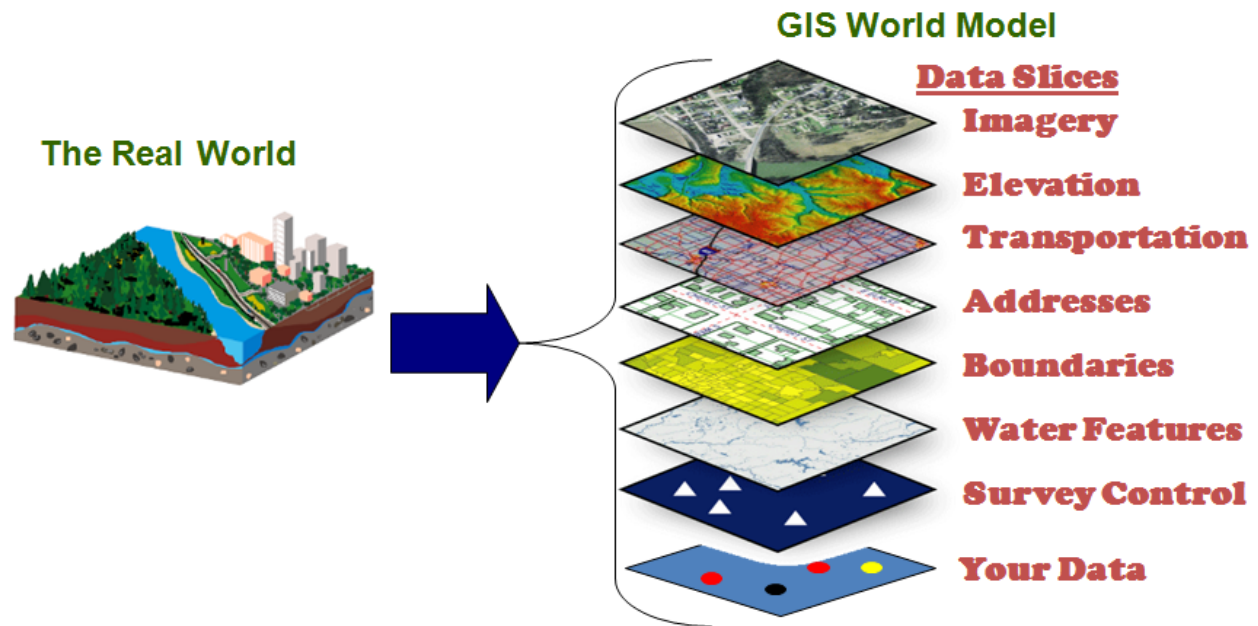


Unlocking the Power of GIS: How Geospatial Data is Paving the Way for Sustainable Development

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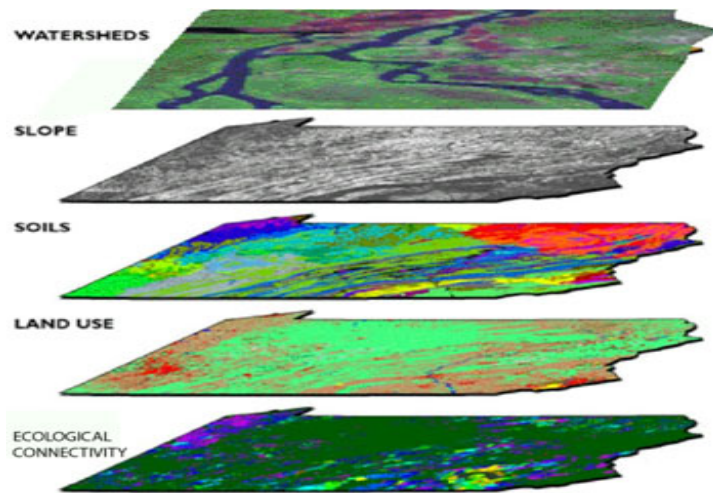
(State of Indiana,2023)

The way we collect, study, and display geospatial data and interpret its patterns, has been transformed by Geographic Information Systems (GIS). Lately, sustainability mapping, which entails pinpointing and studying areas with the most significant potential for sustainable development, has emerged among the most exciting topics related to GIS application. As we seek to balance economic growth with protecting the environment and promoting social equity, this has become a significant development.

The role of GIS in sustainability mapping cannot be overstated. With its versatility and precision, it has become an indispensable asset in identifying vulnerable areas that require environmental protection or suitable ones with enormous potential for sustainable development. By highlighting regions particularly susceptible to environmental hazards or mapping areas with elevated water pollution levels, we can focus on conservation and remediation strategies, where they are mainly required. Identifying areas with high potential for solar or wind energy development assists in placing renewable energy infrastructure in optimal locations where they can most effectively

meet our sustainable energy needs in an environmentally friendly way. In essence, GIS indirectly enables us to create a certain balance between economic development goals with the responsibility to protect the environment and promote sustainability. By leveraging the available tools, we can make more informed and effective decisions about using and conserving natural resources to benefit present and future generations. Here are some examples of how GIS can be applied to sustainability assessment:

Environmental Monitoring



(Nusayba MJ, 2012)

Biodiversity assessment through identifying areas with diverse fauna and flora or that provide essential ecosystem services is a primary application of GIS for environmental sustainability. By integrating data on species distribution, habitat characteristics, and human activities, we can identify critical areas that need intervention for wildlife conservation using many tools like ArcGIS, QGIS, GRASS GIS, Google Earth Engine, ENVI IDL, and ERDAS IMAGINE. These areas can be targeted for conservation initiatives, such as creating protected areas or restoring a degraded ecosystem. Therefore, maps showing the distribution of wildlife habitats and migration routes can be beneficial for developing management plans and conservation strategies to sustain biodiversity in vulnerable ecosystems.

Resource Management

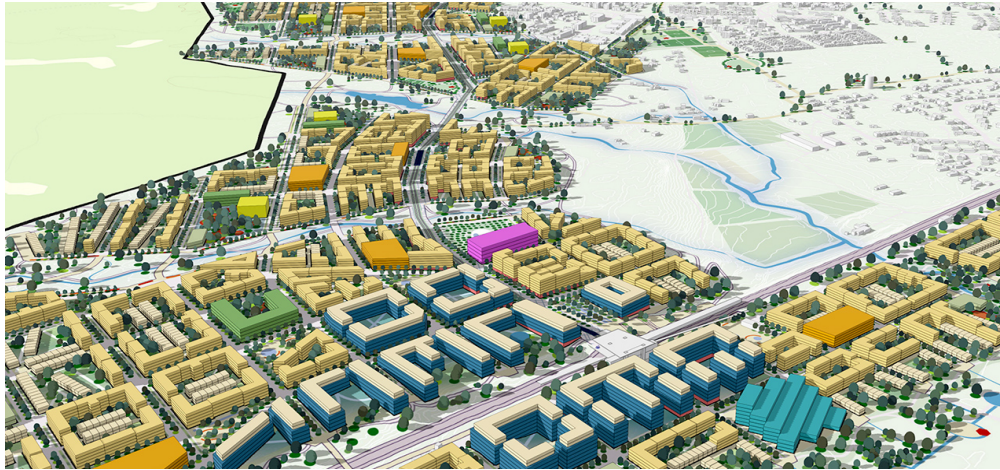


(Michael Gigante,2019)

GIS offers tools for analysing spatial data on land use, vegetation cover, and water resources for natural resource management. Detecting intense land-use changes over time and space allows for better decision-making regarding land-use planning and management. By integrating data on soil properties, climate, and vegetation, a suitability analysis to localise optimal areas for certain agricultural practices can be achieved while providing key information on developing sustainable agriculture practices to maximise crop yields in the future.

GIS also provides a platform for integrating and analysing spatial and non-spatial data. Thanks to it, stakeholders can better understand environmental issues and make informed decisions, such as in mitigation projects related to natural resource contamination. For instance, integrating data from air quality monitoring stations and remote sensing platforms like Sentinel-5P can help in mapping the spatial distribution of pollutants and identify areas with high pollution levels to assist policymakers in implementing the appropriate strategies. In this context, GIS tools and software that can be employed in such processes may include ArcGIS, QGIS, GRASS GIS, Google Earth Engine, ENVI IDL, and ERDAS IMAGINE.

Urban Planning



(ESRI, 2023)

Through analysing and visualising spatial data on land use, transportation networks, urban infrastructures, population density, housing, and employment, we can create maps that show the distribution of urban activities, which can be used to identify areas that require infrastructure development, such as sanitation systems. Further, analysing patterns in urban development and transportation infrastructure, which are critical drivers of socio-environmental sustainability, can be employed to assess the location and accessibility of public transportation systems or map areas with impervious surfaces, drastically contributing to urban heat islands and water pollution hazards.

Further, GIS has been used in transportation planning to process and analyse data on traffic flow, transit routes, and accessibility. Combining geospatial data on travel demand, population density, and transportation networks, for instance, we can detect areas with high congestion levels and identify potential solutions to improve accessibility. The following GIS tools can be integrated for the sustainable development of urban areas: ArcGIS Urban, QGIS, SketchUp, OpenStreetMap, CityEngine, GeoPlanner, and UrbanSim.

Renewables



(Ben knight, 2020)

GIS plays a key role in the sustainable development of the energy sector by helping to identify and evaluate potential sites for renewable energy projects, through land suitability analysis via ArcGIS, QGIS, and GRASS GIS, assessing their potential impact on the environment and communities, and managing related project operations.

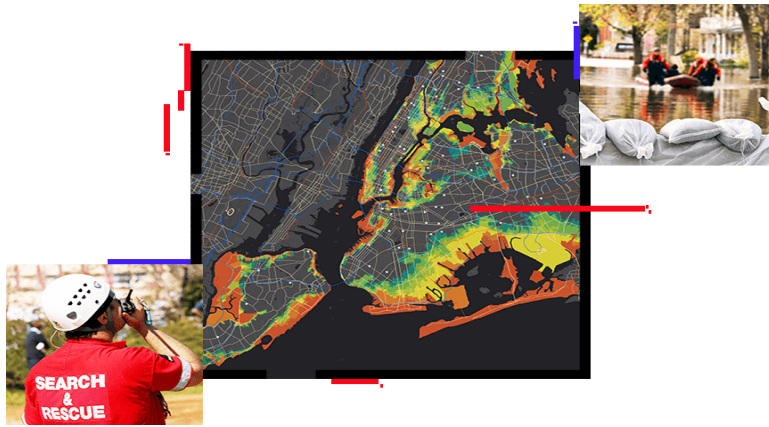
Moreover, it can be used to assess the availability and quality of renewable resources, such as solar energy. Tools like PVWatts, SAM (System Advisor Model), and Solargis can be utilised to estimate solar radiation, hence identifying areas with the highest potential for solar energy production and wind energy (WAsP, WindPRO, and OpenWind. This tool can also be employed to identify potential sites for renewable energy projects by analysing a range of data, including solar radiation, wind patterns, terrain properties, and land use. By analysing relevant geospatial data, GIS can assist in identifying the potential energy output of a renewable energy project, and its site's suitability and evaluate its feasibility whilst minimising its environmental footprint.

By mapping and analysing environmental data, such as sensitive habitats or water resources, GIS can help identify potential impacts and develop strategies to mitigate them. In this context, there are several examples of environmental impact assessment GIS tools that can be considered like ArcGIS Spatial Analyst, GRASS GIS, and Quantum GIS.

Interpreting data related to community demographics, land use, and other relevant information, GIS can aid in addressing community concerns such as noise pollution caused by wind farms. By ensuring that renewable energy projects are developed in a socially and culturally appropriate

manner, it can promote a balanced approach to economic development and environmental conservation as well.

Disaster Management



(ESRI, 2023)

Due to the rapid increase in geohazard magnitude encountered in recent months from earthquakes in Turkey and Syria and tropical cyclones in Malawi and Mozambique, we look into ways that GIS can be integrated to sustainably mitigate and manage natural disasters. GIS can play a crucial role in natural disaster management in several ways. For instance, it can be used to deal with the associated risks of natural disasters, such as floods, earthquakes, hurricanes, and wildfires, or by proposing emergency plans for evacuation during the occurrence of such events.

By mapping the areas that are susceptible to these disasters, emergency planners can identify the resources and actions required to mitigate the risks and prepare for a response. Its applications also extend to managing and coordinating emergency response efforts during natural disasters, by helping track the location of victims and direct resources to the most vulnerable areas.

GIS can be used to manage resources during a natural disaster, such as tracking the availability of food, water, and medical supplies, as well as identifying potential shelter locations. GIS can be used to assess the extent of damage caused by a natural disaster. By creating before-and-after maps of the affected areas, GIS can help emergency responders and recovery teams understand the full impact of the disaster and prioritise recovery efforts.

By mapping out evacuation routes, identifying vulnerable populations, and analysing potential risks, emergency planners can develop comprehensive disaster response plans that address the unique needs of each community. Among the GIS tools and software that can be used in risk management are ArcGIS, Google Earth, QGIS, GeoServer, Sentinel Hub, ERDAS IMAGINE, and InaSAFE which is the most widely employed tool to model the potential impact of disasters and support disaster precaution planning. The latter includes assets for risk analysis, vulnerability assessment, and scenario modelling.

Challenges and Considerations for GIS Application

Despite the diversity in GIS applications for sustainability mapping, some limitations exist, like the need for high-quality data to achieve specific goals or reach a certain accuracy level. GIS relies on accurate and up-to-date geospatial data, so it is often challenging to acquire, particularly in inaccessible areas with limited resources. Further, the need for specialised technical expertise is another challenge to address, particularly when establishing and applying complex analytical tools and prediction models like those based on machine learning, deep learning, or artificial intelligence.

There are also some ethical and social considerations to be aware of before applying GIS to sustainability-related projects. The potential for GIS to be used in ways that perpetuate or exacerbate social inequalities is minimal but not to be ignored. Among the many scenarios to state is the use of GIS to identify areas suitable for renewable energy development. If such a GIS approach is employed without taking into account the social impacts on the communities surrounding these areas, it could potentially result in the displacement or marginalisation of these communities.

To effectively tackle these challenges related to GIS in sustainability mapping, it is essential to adopt a comprehensive holistic perspective. This includes engaging with local communities and stakeholders throughout the planning and implementation process, ensuring their voices and perspectives are heard and incorporated into decision-making. This will raise awareness of the potential unintended negative impacts while proactively mitigating these side effects through ethical and socially responsible practices.

Summary

GIS application for sustainability mapping has emerged as an attractive option for promoting sustainable development. Once appropriate methodologies are accordingly adopted, GIS can offer a set of powerful tools for achieving sustainability and supporting the transition to a more resilient future. By identifying suitable areas for green energy development, mapping areas with high biodiversity or key ecosystem services, or analysing urban development and transportation infrastructure patterns, GIS helps support the development of spatially targeted policies and interventions that promote sustainable development goals (SDGs). Nevertheless, to fully understand its reliability, it is fundamental to address the above-mentioned challenges and limitations with an inclusive perspective that considers the ethical and social implications.

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