

SUSTAINABLE MINING AND GEOINFORMATION

Prof. Mukunda Dev Behera

Centre for Ocean, River, Atmosphere and Land Sciences (CORAL)

Indian Institute of Technology Kharagpur

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Lecture 36: SDG 11

Welcome, let us discuss on today's talk number 36 on Sustainable Cities and Communities. So, this is the SDG goal number 11 and we are going to discuss on the sustainable cities particularly how they are resilient as far as the mining industry is concerned as far as the town and cities are concerned. Second we will be discussing on different monitoring protocols as far as the urban sprawl is concerned in general and also how to manage various social impacts as far as the mining industries is concerned and with respect to mining areas. We will also see a few case studies that is benefited by the use of geo information technologies for urban sustainability in terms of enhancing the resilience and monitoring the social and environmental impacts. So, the SDG goal number 11 commits to make the cities and human settlements inclusive, safe, resilient and sustainable.

CONCEPTS COVERED

11 SUSTAINABLE CITIES AND COMMUNITIES

- **GeoINFO for Creating Sustainable & Resilient Mining Town and City (SDG 11)**
- **Monitoring Urban Sprawl and Managing the Social Impacts of Mining on Nearby Communities**
- **Case Study: GeoINFO Applications for Urban Sustainability: Enhancing Resilience and Monitoring the Social and Environmental Impacts**

Goal 11 Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable

- High-resolution satellite imagery (e.g., Landsat, Sentinel, WorldView) aids in Urban Sprawl Detection, Monitoring Land-Use changes, and Analysing Impervious Surface Growth
- Spatial Analysis helps Model Urban expansion, Identify Suitable zones for Development, and assess Infrastructure needs
- Mining activities near urban areas Impact Land Use, Air Quality, and Water Resources
- GeoINFO Can Track these Changes and Mitigate their Effects on Urban Sustainability

Applications

- Mapping Urban Growth and its Encroachment on Natural Habitats
- Monitoring Land Subsidence in Mining-Affected Urban Areas using InSAR
- Identifying Potential Zones for Urban Development that avoid Conflict with Mining Areas

So, four important characteristics all the human settlement and the cities has to be inclusive, safe, resilient and sustainable. So, in this context, high resolution satellite imageries which are coming relatively from WorldView, Sentinel and many other sensors like that, they help in urban sprawl detection, monitoring various land use, land cover categories. And also in turn helps in analyzing some of the impervious growth in terms of the land cover or land use or a particular the land use. The various types of spatial analysis through the geoinformation tools helps in modeling the herbal expansion and also in identifying suitable zones for development and access as far as the infrastructural needs are concerned. So, in mining sectors, particularly the activities nearby the urban areas, they impact the land use, the air quality, the water resources.

So, geo information can help in terms of tracking all the changes and thereby help in mitigating their effects on urban sustainability. So, the various applications mapping urban growth and its encroachment on natural habitats, monitoring land subsidence in mining affected urban areas using SAR interferometry tools, then identifying the potential zones for urban development that avoid conflict with mining areas. So, these three important these three applications importantly which is coming through the geo information tools are useful in terms of achieving sustainable goal sustainable development goal number 11 so as to realize sustainable mining objectives. As far as the section 11.1 is concerned, it deals with safe and affordable housing in mining areas or its surrounding. So, use of high resolution data is helpful to detect and classify informal settlements that can be done using various texture analysis, the variations in the spectral signature and different kinds of spatial configurations.

11.1: Safe and Affordable Housing

Objective: Ensure Access to adequate, Safe & Affordable Housing & Basic Services, Addressing Slum Upgrading

- Use of High-Resolution imagery (e.g., WorldView-3, GeoEye) to detect and classify informal Settlements based on Texture, Spectral Signatures, & Spatial Configurations
- Multi-temporal analysis for tracking Slum expansion over Time and Spatial Modeling of Housing Distribution relative to essential Urban amenities
- Heatmaps to identify areas with housing deficits or high population densities
- Monitoring Structural Stability and Ground Deformation in Urban areas impacted by underground mining using InSAR and LIDAR

Infrastructure mapping tool (source maps.london.gov.uk)

Multi-temporal analysis is also utilized for tracking slum expansion over time and space, which is how it is also analyzed in the form of various spatial modeling of housing distribution relative to essential urban amenities over or within industrial areas or their nearby surroundings. Similarly, the heat maps generated are useful or are used to identify areas with housing deficits or high population densities. So, monitoring the structural stability and ground deformation in urban areas impacted by underground mining is done using InSAR and LiDAR tools. So, sustainable transport systems are earmarked as SDG goal 11 in subsection 2. So, subsection 11.2 is attributed to sustainable transport systems with an objective to provide safe, affordable, and sustainable transport systems, particularly for vulnerable populations.

11.2: Sustainable Transport Systems

Objective: Provide Safe, Affordable, and Sustainable Transport Systems, Particularly for Vulnerable Populations

- Satellite Imagery to extract road networks using feature detection algorithms (e.g., CNN-based edge detection)
- Use of SAR data for monitoring Road Stability in Mining-affected Regions
- Network analysis to optimize public transport routes and ensure equitable access to Transit Systems
- Spatial modeling to assess transport infrastructure's impact on Urban Growth Patterns
- Evaluate Heavy mining vehicle traffic impact on Urban Transport Networks using Road Degradation Model

So, how is the geoinformation tool useful in achieving or realizing this objective? Satellite imagery is useful to extract road networks, particularly high-resolution data, which is very regularly used to extract road networks using feature detection algorithms or digital or DL-based algorithms such as CNN for edge detection, conventional neural networks. So, the use of SAR data for monitoring road stability in mining-affected

regions. SAR Western has a good property in terms of edge detection. So, edge detection is relatively good and safe to do using SAR data.

So, road stability and also deformation-related studies in mining-affected regions can be very well done using synthetic aperture radar data. Now, the use of network analysis is helpful to optimize public transport routes and ensure equitable access to various kinds of transit systems. Similarly, spatial modeling is helpful in assessing transport infrastructure's impact on various urban growth patterns. It is also useful in evaluating heavy mining vehicle traffic and its impact on urban transport using various kinds of road degradation models. Now, as far as the next subsection, 11.3, is concerned, it aims at providing inclusive and sustainable urbanization.

11.3: Inclusive and Sustainable Urbanization

Objective: Enhance Inclusive and Sustainable Urbanization and Participatory Planning

- **Multispectral and Hyperspectral Imagery to classify urban land use, including Commercial, Residential, and Industrial Zones**
- **Temporal Analysis of Urban Sprawl using Indices like Normalized Difference Built-Up Index (NDBI)**
- **Urban Growth Modeling using Cellular Automata (CA) and Agent-Based Models (ABM) to simulate future scenarios**
- **Land Suitability Analysis for Sustainable Urban expansion**
- **Map Land-Use Transitions from Mining to Urban Areas, assessing reclaimed sites for Urban Development**

The slide features a speaker's photo on the right side and logos for IIT Bombay and NPTEL at the bottom left.

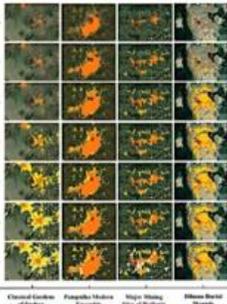
So, the objective aims at enhancing inclusive and sustainable urbanization and participatory planning. So multispectral and hyperspectral imagery is useful to classify urban land use, including commercial, residential and industrial zones. Temporal analysis of urban sprawl using indices like NDBI normalized difference built up index is very very useful in achieving this objective. Urban growth modeling using various tools or algorithms such as cellular automata, agent based models are you are very regularly used to simulate future or immediate future scenarios based on the past pattern. The land suitability analysis for sustainable urban expansion can study or assessment can benefit from the geo information tools.

So, mapping the land use transitions from mining to urban areas assessing reclaimed sites for urban development are also are also they can take or benefit from the geo information technology or tools. Now coming to the subsection 11.4 that aims that deals with cultural and natural heritage protection. So, the objective is to strengthen the efforts that can lead to safeguarding the cultural and natural heritage. On the left hand side, we have the

process by which cultural heritage sites are incorporated in towns, you see, gradually over time and space. So, this needs to be, this can be very well monitored, detected using various satellite data sets.

11.4: Cultural and Natural Heritage Protection

Objective: Strengthen Efforts To Safeguard Cultural and Natural Heritage



- Thermal IR Imaging for detecting structural degradation in heritage buildings
- LiDAR for detailed 3D-Modeling of cultural sites and their surrounding landscapes
- Heritage Site vulnerability assessment using Proximity analysis to Urban/Mining activities
- Conservation zoning to buffer heritage sites from Urban and Industrial encroachments
- Impact assessment of Blasting, Subsidence, and Vibration on nearby Heritage structures using Geo-Mechanical Models

The process by which Cultural Heritage sites are incorporated into Towns
(Xie et al., 2022)





So, such as the thermal infrared imaging is useful in detecting structural degradation in heritage buildings. LiDAR is useful for detailed 3D modelling of cultural sites and their surrounding landscapes. Heritage site vulnerability assessment can be done using proximity analysis to urban and mining activities. The conservation zoning to buffer heritage sites from urban and industrial encroachments are also done using the geoinformation tools. Finally, the impact assessment of various kind of blasting activities, subsidence and vibration on nearby heritage structures can be done using various geomechanical models.

So, we have the the geoinformation tools that gives or enables in terms of analyzing this in a spatial framework. So, the next section 11.5 that talks about disaster risk reduction has the objective in order to reduce the disaster related losses especially for the vulnerable population they are inhabited near and around the mining industries. So, real time hazard detection can be done using SAR and optical satellites for example, Sentinel-1 for floods Landsat for the landslide analysis or zone or what you say post analysis. Elevation models which are coming from the data set such as SRTM, ALOS PALSAR can be useful to map the terrain vulnerability to landslides in urban mining interfaces. MCDA multi-criteria decision analysis is useful or can be useful to integrate hazard maps, land use data and socioeconomic vulnerability indices generation thereby.

11.5: Disaster Risk Reduction

Objective: Reduce Disaster-related Losses, Especially for Vulnerable Populations

- Real-Time Hazard Detection using SAR and Optical Satellites (e.g., Sentinel-1 for Floods, Landsat for Landslides)
- Elevation Models (e.g., SRTM, ALOS PALSAR) to map Terrain Vulnerability to Landslides in Urban-Mining Interfaces
- Multi-Criteria Decision Analysis (MCDA) to integrate Hazard maps, Land-Use data, and Socio-economic vulnerability indices
- Flood Inundation Models combining Precipitation data, Urban Topography, and Drainage Networks
- Monitoring Tailing Dam Stability and the Risk of failures using InSAR and Time-Series Analysis of Surface Deformation



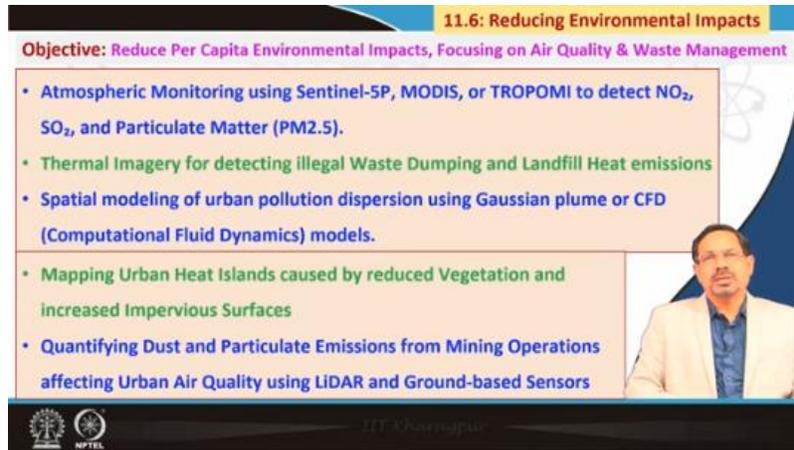

The flood inundation models various flood inundation models are available which combines the precipitation data over the mining region or the or its surrounding region or particularly the water set that accommodates one or two one or more than one water sets that accommodate the mining area. So, can benefit in terms of flood inundation models by combining the precipitation data with that of the topography and the drainage network. And also the geoinformation tool helps in terms of monitoring the tailing, dam stability and the risk of failures using InSAR that means SAR interferometry and time series analysis. We have already discussed these are very useful tools as far as the soil deformation studies are concerned. So, in a sense this soil deformation studies will will be will be intelligently used to monitor the tailing dam stability and also the risk failures that could arise from various may various processes and system in general.

The next section as far as SDG goal number 11 is concerned. So, section 11.6 deals with reduction as far as the environmental impacts is concerned. So, this section has a has an objective that aims at reduction of per capita environmental impacts and mostly focusing on air quality and waste management. So, this is the lot of certain a lot of sensors from different satellite platform such as MODIS, Sentinel 5P that is TROPOMI gives a lot of useful information to detect various greenhouse gases particulate matters such as nitrous oxide, sulfur dioxide, PM 2.5. These data sets are very very useful in monitoring and the air quality parameters.

11.6: Reducing Environmental Impacts

Objective: Reduce Per Capita Environmental Impacts, Focusing on Air Quality & Waste Management

- Atmospheric Monitoring using Sentinel-5P, MODIS, or TROPOMI to detect NO₂, SO₂, and Particulate Matter (PM_{2.5}).
- Thermal Imagery for detecting illegal Waste Dumping and Landfill Heat emissions
- Spatial modeling of urban pollution dispersion using Gaussian plume or CFD (Computational Fluid Dynamics) models.
- Mapping Urban Heat Islands caused by reduced Vegetation and increased Impervious Surfaces
- Quantifying Dust and Particulate Emissions from Mining Operations affecting Urban Air Quality using LIDAR and Ground-based Sensors



Thermal imagery is also available that helps in terms of detecting the illegal waste dumping and the landfill heat emission. We already know use of thermal infrared imagery benefits us in terms of what in terms of discriminating features based on their temp the based on their temperature difference or the thermal difference property. So, this has an application particularly in terms of illegal waste dumping and landfill heat emissions. So, spatial modeling of urban pollution dispersion is done or can be done can very well be done using gaussian plume or CFD computational fluid dynamics based models. these are little bit these have started practicing in terms of the spread and their spatial modeling particularly the dispersion behavior.

The fourth one is is dealing with the mapping of urban heat islands caused by reduced vegetation and increased impervious surfaces. Various optical and other data sets coming from satellite remote sensing platform, remotely sent satellite platform are useful in terms of mapping the land use land cover. In a sense, we can always characterize one that we can say that yes, this is a urban heat island which has a different differential behavior as far as the heat content as far as their near around or surrounding vegetated area or the previously it was a vegetated area and now lot of the vegetation has gone or converted to urban means urban built up. So, this kind of change detection studies can qualify or can can help us in urban island related studies. Now quantifying the dust and particulate emissions from mining operations that affect urban air quality using LiDAR and ground based sensors.

So, SMURBS smart urban solutions for air quality disasters and city growth a project initiated under the European H2020 framework funded by the ERA-PLANET program. So, this project that deals with that is abbreviated as SMURBS as you say SMURBS it is aimed in terms of monitoring or providing solutions as far as the air quality disasters and

the city growth is concerned. So, came from European H2020 framework under ERA-PLANET program. So, this particular package or the solution is a coming in a bundled way bundled solution aimed to leverage the earth observation to address urban environmental challenges and thereby support the sustainable urban development. The project also aligns with the objectives of creating smart urban solutions to tackle the following.

SMURBS

"Smart Urban Solutions for Air Quality, Disasters and City Growth"

A project initiated under the European H2020 framework, funded by the ERA-PLANET program.

- Aimed to leverage EO to address urban env.al challenges and support sustainable urban development. The project aligns with the objectives of creating "smart" urban solutions to tackle the followings:

- Air Quality Management:** Implementing EO-based tools to monitor and mitigate urban air pollution for healthier cities
- Disaster Preparedness and Management:** Developing solutions for better disaster risk reduction, response, & recovery in Urban settings
- City Growth Monitoring:** Addressing urban sprawl and its env.al and social implications
- Migration Aspects:** Exploring EO-driven methodologies to understand and manage urban pressures arising from migration

URBAN RESILIENCE INDICATORS
A SMURBS project solution in support of migration

EO data

Essential variables

Indicators

- Monitoring of settlements
- Monitoring of migrant population and flows over time
- affordable housing
- basic services
- air quality

POTENTIAL IMPACTS

- ✓ Better knowledge of local migration aspects
- ✓ Combining migration
- ✓ Identify some general criteria to choose suitable short long-term host sites
- ✓ Planning services
- ✓ Improving living conditions and resilience of both host cities and migrants

(Aquilino et al., 2022)

Number one is air quality management. So, implementing Earth observation-based tools to monitor and mitigate urban air pollution for healthier cities. Disaster preparedness and management: developing solutions for better disaster risk reduction, response, and recovery in urban settings. City growth monitoring: addressing urban sprawl and its environmental and social implications. Then, migration aspects: exploring Earth observation-driven methodologies to understand and manage urban pressures arising from migration-related activities.

So, SMURBS provides a good platform or window in terms of offering bundled solutions as far as air quality, disasters, and city growth are concerned. So, these kinds of packages are useful in terms of managing air quality, disaster preparation as far as disasters are concerned, city growth, and different migration-related aspects as far as the mining industry is concerned. Now, let us move on to the next section as far as SDG goal number 11 is concerned—that is, section 11.7. So, here it deals with public and green spaces. The objective is to provide universal access to safe, inclusive, and accessible green and public spaces.

The slide features a blue header with the text '11.7: Public and Green Spaces'. Below the header, a pink bar contains the objective: 'Objective: Provide Universal Access to Safe, Inclusive, and Accessible Green and Public Spaces'. The main content consists of five blue rectangular boxes, each containing a white text item. To the right of these boxes is a faint graphic of a stylized atom. At the bottom left, there are logos for NPTEL and a tree. At the bottom center, the text 'Dr. Shweta' is visible.

11.7: Public and Green Spaces

Objective: Provide Universal Access to Safe, Inclusive, and Accessible Green and Public Spaces

- Vegetation Mapping using NDVI or EVI derived from Sentinel-2 or Landsat data
- Identifying Urban Green Cover using Object-based Image Analysis (OBIA)
- Spatial equity analysis to Identify underserved areas lacking Green Spaces
- Planning Urban Afforestation Initiatives using Predictive Spatial Models
- Evaluating the Suitability of Reclaimed Mining Sites for Green Spaces or Public Infrastructure

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Dr. Shweta

So, how can it be done or benefited from satellites or geo-information technologies? Vegetation mapping using NDVI or EVI can be derived from Sentinel or many other satellites or optical sensors. So, they can be useful in terms of identifying urban green cover using various tools such as object-based image analysis, abbreviated as OBIA. Then, spatial equity analysis can be done to identify various underserved areas that lack green spaces. So, in this sense, these are the areas which can undergo plantation or be brought under plantation to increase the green cover or green space.

Planning urban afforestation initiatives using various predictive spatial models. Evaluating the suitability of reclaimed mining sites for green space development or various kinds of public infrastructure development. In an area such as the mining industry or mining sector, we need to have public and green spaces for various activities. Using satellite remote sensing, we can map the areas where green space exists. Alternatively, we can identify where green space should or ought to be, which can also be done using a bit of modeling analysis under the geospatial framework. This helps in providing universal access to safe, inclusive, and public spaces.

Coming to an example regarding the point of interest. So, the section or subsection 11 point A, as far as SDG goal number 11 is concerned, deals with strengthening urban-rural linkages. It can be achieved with the objective of supporting economic, social, and environmental links between urban, peri-urban, and rural activities. So, how can this be strengthened? If we support all these activities in terms of social, economic, and environmental aspects, then the link is very well established.

11.a: Strengthening Urban-Rural Linkages

Objective: Support Economic, Social, and Environmental Links Between Urban, Peri-urban, and Rural Areas

- Monitoring land-use change and agricultural encroachment due to urbanization using time-series
- Mapping resource flows, such as water or biomass, using spatially explicit data
- Urban-rural interaction modeling using flow networks and spatial econometrics
- Planning transport corridors that balance development and conservation
- Assessing the socio-economic impact of resource extraction on rural livelihoods & urban demands

The geographic distribution of the Point of Interest (POI) data (Tu et al., 2024)

City boundary
Density of POI
Low High

Look at the map over there, where the geographical distribution of various points of interest has been mapped. If we know these are the various points of interest regarding the interface supporting economic, social, and environmental aspects in urban, peri-urban, and rural areas around the mining industry or its surroundings, then this particular objective will benefit from geo-information tools. The five points mentioned on the left-hand side are: monitoring land use change and agricultural encroachment due to urbanization using time-series data, mapping resource flows such as water or biomass using spatially explicit data. The interaction between urban and rural areas can be modeled using various flow networks and spatial econometric models. Planning transport corridors among and between urban, peri-urban, and rural areas can lead to balanced development and conservation among these three built-up spaces in mining areas or their surroundings.

So, assessing the socio-economic impact of resource extraction on rural livelihoods and urban demands also benefits from geo-information tools. Let us go to the next subsection, 11.b, which deals with integrated policies for disaster resilience. So, the objective is to achieve or implement integrated policies for climate adaptation and resilience for this purpose in the mining sector or mining industry areas. So, climate modeling using various datasets—we have a lot of climate variables, data coming from various satellites, reanalysis products, and things like that. As far as temperature, precipitation, and soil moisture are concerned, the ecosystem services around the mining areas or the townships or cities around the mining areas can be derived from various analyses regarding their ecosystem services.

11.b: Integrated Policies for Disaster Resilience

Objective: Implement Integrated Policies for Climate adaptation and Resilience

- Climate Modeling using Satellite Data for Temperature, Precipitation, and Soil Moisture Anomalies (e.g., CHIRPS, SMAP)
- Mapping Ecosystem Services that buffer Urban Disaster, like Wetlands Flood Risk Redⁿ
- Climate Vulnerability Assessments combining Socio-Economic, Physical, & Env.a.l Parameters
- Scenario-based Disaster Resilience Planning integrating Urban Growth Models and Climate Data
- Developing Policies for Integrating Post-Mining Landscapes into Urban Disaster Planning

So, climate environmental assessment combines socio-economic, physical, and environmental parameters. Scenario-based disaster resilience planning can be done by integrating urban growth models and climate data. So, finally, all these analyses can be useful in developing various policies for integration regarding the post-mining landscape for different kinds of urban disaster planning or mitigation-related activities. Section 11.c of the SDG or Sustainable Development Goals deals with sustainable building in least developed countries. The objective is to support least developed countries in terms of sustainable, resilient building using local materials or materials available locally.

11.c: Sustainable Building in Least Developed Countries

Objective: Support Least Developed Countries In Sustainable, Resilient Building Using Local Materials

- Identifying natural material sources like clay or stone using hyperspectral imagery
- Monitoring construction trends in developing regions to track material use
- Optimizing material transport networks for low-carbon construction
- Identifying regions prone to building failure due to subsidence or unstable geology
- Ensuring sustainable practices in material extraction to reduce ecological footprints and support urban construction

So, identifying natural material sources like clay or stone using hyperspectral data is very well done or can very well be done. Monitoring construction trends in developing regions to track the use of materials and optimizing material transport networks for low-carbon construction. Identifying regions prone to building failure due to subsidence or unstable geology, ensuring sustainable practices in material extraction to reduce ecological footprints and support urban construction. So, all these five points, whatever has been marked here and I just mentioned, benefit from geoinformation or the use of

geoinformation tools and aim at achieving sustainable building in the least developed countries, particularly here. The least developed mining sectors are the areas where these buildings and sustainable building are very underdeveloped.

A kind of case study that deals with geo-information utility as far as urban sprawl mapping and monitoring is concerned. Various satellite datasets and statistics can be used as far as land use interventions are concerned. The data processing, classification, chain detection, ground truthing, and GIS integration are the various steps as far as the methodology is concerned. The key findings could be a kind of change detection—change from one type of vegetation or land cover class to another—and our purpose of interest here is urban sprawl monitoring or the trend. So, you can see the linear expansion across certain regions, particularly the interface areas. As far as the roads and road network are concerned, it is expected that more and more of this built-up space will come up around or across the road or the connecting communication network.

Case Study: GeoINFO-Urban Sprawl

To analyze the magnitude, growth, and trends of urban sprawl in Udaipur. To identify the factors influencing urban expansion & its impact on LU, focusing on development along major transport arteries.

DATA USED

- Landsat satellite Imageries: MSS (1972), TM (1990), ETM+ (2000)
- Land use maps and field data
- Statistical land use inventories

METHODOLOGY

- **Data Preprocessing:** False-color composites, subsetting, and reprojection.
- **Classification:** Supervised classification into five categories (forest, built-up, water, cropland, barren land).
- **Change Detection:** Temporal analysis of 1972, 1990, and 2000 imagery.
- **Ground Truthing:** Validation with field data and maps.
- **GIS Integration:** Mapping urban expansion and analyzing trends.

KEY FINDINGS

Land Use Changes:

- Built-up areas rose from 6.93% (1972) to 11.55% (2000).
- Forests decreased from 29.86% to 25.07%, while cropland declined from 38.43% to 14.51%.
- Barren land expanded from 23.73% to 48.38%.

Urban Sprawl Trends:

- Linear expansion along NH-8 and NH-76.
- Eastern industrial growth and rising land prices near transport routes.
- Rapid urbanization post-1990 due to economic reforms.

Impacts:

- Loss of open spaces, farmlands, and forests.
- Increased traffic, Env.al degradation, Human-Wildlife conflicts

Expansion of Built-Up Area (Jain, 2008)

Also, rapid urbanization may happen beyond certain years just to cope with faster economic reforms. So, the impact can be seen in terms of loss of open spaces, farmlands, and forests; increased traffic; environmental degradation; and human-wildlife conflicts—some of the negative impacts that can also be realized. Another case study deals with monitoring urban sprawl in a fast-growing urban center. So, many places where urban or built-up activities are growing fast can also benefit from satellite-based observations or geoinformation tools. So, here, importantly, you use various types of satellite data, pre- and post-analysis, and the change detection can be done.

Case Study: Monitoring Urban Sprawl in a Fast Growing Urban Centre

Objective: To assess and quantify urban sprawl in the fast-growing twin cities of Hyderabad-Secunderabad using remote sensing and GIS techniques, with Shannon's entropy model for spatial analysis.

Data Used:
 Satellite Data: IRS P-6 LISS-III (2005), topographic sheets (1971)
 Maps: Land use/land cover and ward maps
 Census Data: Population records

METHODOLOGY
Classification: Land use maps created
Shannon's Entropy: Used to assess spatial dispersion and urban sprawl
Change Detection: Compared land use transitions from 1971 to 2005

KEY FINDINGS

- Urban Growth:** Built-up area rose from 179 km² to 370 km²; 76.63% of agricultural land and 71.4% of water bodies converted to urban use
- Entropy Analysis:** Values increased from 0.627 (1971) to 0.918 (2005), showing significant sprawl, especially in the northwest due to high-tech development
- Impact:** Population grew by 124%, built-up area by 174%, with increasing land consumption driven by economic growth

(Rahman et al., 2011)




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But one important methodology followed here by Rehman et al., in a study published in 2011, talks about Shannon's entropy. So, this is used to assess the spatial dispersion and urban sprawl. So, entropy analysis values increased from 0.627 to 0.918 between 1971 and 2005. So, what does it show? It shows significant sprawl, especially in some directions, such as the northwest, due to high technological development.

So, similar kind of attributes can be or cause can be attached to the urban sprawl growth and somewhere we can also attribute in terms of magnitude and the direction to which direction it is going and the rate also is calculated. So, these kind of study are useful and very well can be done using the geoinformation that has implications over the mining industry areas or its surrounding. So, these references were used as far as the study is concerned. So, we need to conclude with these 5-6 points. First is geoinformation enabled balanced land use and infrastructure development thereby mitigating conflicts between mining activities and urbanization while protecting the natural ecosystems which are expected around the mining areas.

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CONCLUSION

- GeoINFOenable balanced land use and infrastructure development, mitigating conflicts between mining activities and urbanization while protecting natural ecosystems.
- High-resolution satellite imagery tracks urban sprawl and resource use, ensuring sustainable land management and monitoring conversions of forests, agricultural lands, and water bodies.
- Remote sensing tools like InSAR and LiDAR monitor environmental issues such as land subsidence, air quality, and water contamination, reducing mining-related disturbances and promoting sustainability.
- GIS and EO technologies support disaster preparedness through hazard mapping and resilience planning, reducing vulnerabilities in mining-affected urban areas.
- Platforms like Sentinel-5P and MODIS provide air quality and climate data, assisting in pollution control, urban heat island mitigation, and enhancing climate resilience.
- GIS ensures inclusive growth by identifying underserved areas, supporting planning for housing, transport, and public spaces, and addressing the social impacts of mining for equitable development.



High resolution satellite imagery tracks urban sprawl and resource use, ensuring sustainable land management and monitoring conversion of forest, agriculture, lands and water bodies. Geo-information tools and particularly the remote sensing data sets such as SAR interferometry, LiDAR, they help in terms of monitoring environmental issues such as subsidence, air quality, water contamination, thereby reducing the mining related disturbances and promoting sustainability. And, GIS and earth observation technologies support disaster preparedness. Platforms like Sentinel-5P and MODIS provide good quality data as far as air quality data is concerned. So, in conclusion the geo information ensures inclusive growth by identifying underserved areas that is more or less expected around the mining industries, thereby supporting planning for housing, transport and public spaces and in turn addresses the social impacts of mining for equitable development. Thank you very much.