HEXAGON

Air, water and soil pollution management using geospatial technologies

A concept note for the Pollution Control Board

Contents

Significance of pollution management **3**

Air pollution management **4**

Integrating with automatic weather station data 4

Inventorying toxic releases 5

Extrapolating data with satellite data processing 5

Understanding air quality distribution using geostatistics 5

Water pollution management **6**

Integrating the hydrological network with a toxic release inventory and creating spatial databases 6

Monitoring water quality using satellite-based water indexes and change detection 7

Identifying thermal plumes in water bodies using satellite data 8

Soil pollution management **8**

Creating zonation of solid waste dumping grounds and garbage dumps 8

Understanding impacts using land use zones and satellite imagery 8

Geotagging solid waste incinerators to understand the network coverage area 9

Creating waste management plans with population distribution maps 9

NOC management **10**

Creating an inventory with NOC details for industries 10

Generating NOC with the spatial database and land base inventory 10

Contact us **10**

About Hexagon **11**

Significance of pollution management

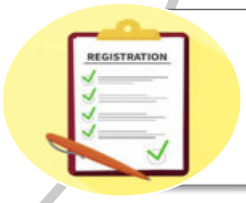
India is a country whose states are undergoing rapid industrialisation and urbanisation, leading to natural consequences of air, water and soil pollution. This has created an urgent need for the state to effectively monitor and manage the pollution and create a control mechanism. Unregulated pollution leads to biomagnification and negatively affects human health.

Biomagnification is the accumulation of a chemical by an organism from water and food exposure that results in a concentration that is greater than would have resulted from water exposure only and thus greater than expected from equilibrium. A variety of processes could help improve the situation:

Air pollution
Integrate with automatic weather station data
Inventory toxic releases
Extrapolate data with satellite data processing
Understand air quality distribution using geostatistics

Water pollution
Integrate the hydrological network with a toxic release inventory
Create spatial databases
Monitor water quality using satellite-based water indexes and change detection
Identify thermal plumes in water bodies using satellite data

Soil pollution
Create zonation of solid waste dumping grounds and garbage dumps
Understand impacts with land use zones and satellite imagery
Geotag solid waste incinerators to understand the network coverage area
Create waste management plans with population distribution maps



No Objection Certificate management
Create an inventory with NOC details for industries
Generate NOC with the spatial database and land base inventory

Air pollution is especially severe in some of the world's fastest-growing urban regions, where greater economic activity is contributing to higher levels of emissions. But air pollution is also a problem outside cities. Air pollution is not just a health risk, but also a drag on development. By causing illness and premature death, air pollution reduces the quality of life.

Point source water pollution is a major challenge, as sometimes industrial wastes are allowed to flow untreated and unregulated into water channels or rivulets. The rise in the human population requires the use of more natural resources, which leads to the growth of industries - specifically chemicals and petrochemicals - along with urbanisation, deforestation and intensive agricultural practices. The industries and urban sprawl discharge waste into bodies of water, leading to major contamination and reduced water quality and adversely affecting the ecosystem.

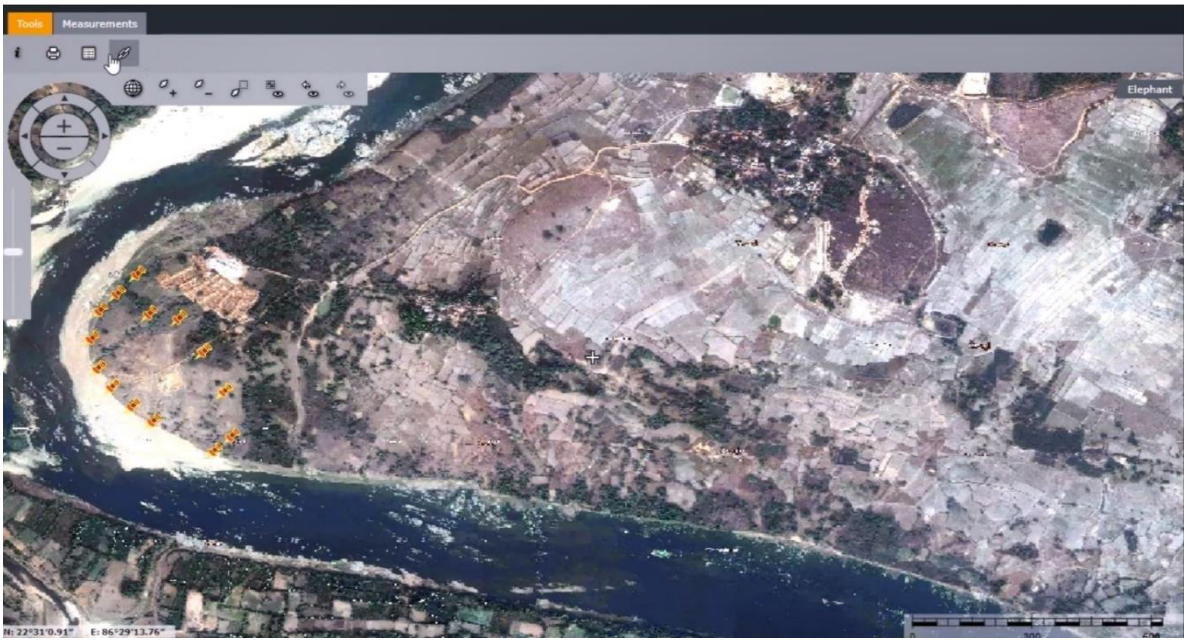
Soil pollution results primarily from the disposal of solid or liquid waste on land surface without treatment. Liquid waste and leachates generated from solid waste percolate into the ground and cause problems like ground water contamination, degradation of vegetation and modification of soil properties. It can also cause foundation failures in buildings by leading to land subsidence and landslides.

GIS and remote sensing techniques can help industries at several levels with managing pollution and NOC generation.

Air pollution management

Integrating with automatic weather station data

With GeoMedia Desktop, users can integrate GIS systems with tabular datasets from automatic weather station data loggers to create historical archives. The created databases are converted into GIS formats and stored in relational databases to create an archive and repository accepted by GIS software. The historical data can then be used by decision-makers to understand changes in the pollution pattern.



Inventorying toxic releases

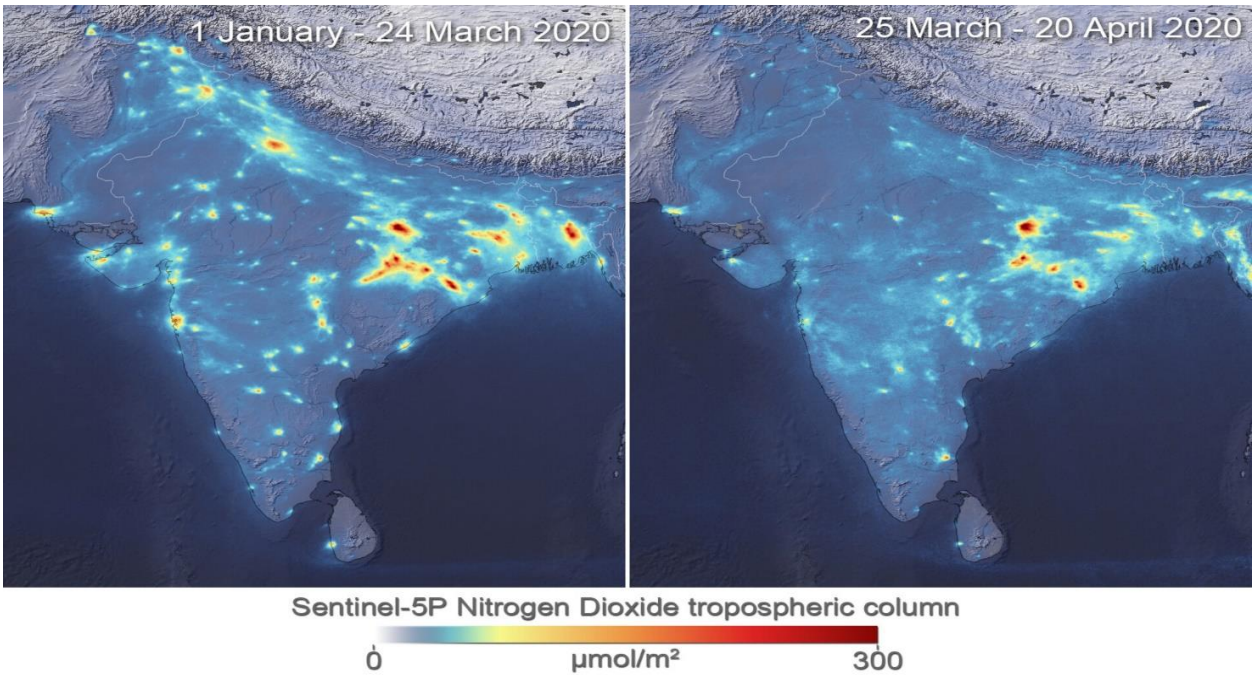
All NOC-provided industries are required to be geotagged; a repository must then be created based on the categorisation of aerial discharges along with NOC expiry dates. This allows the government to keep track of all the industries nearing their NOC expiry dates, and it allows departmental officials to track site visits.

Together, this information acts a spatial database that, when merged with other spatial layers, can provide a clear picture of the environmental impacts a particular industry might cause or is already causing.

Extrapolating data with satellite data processing

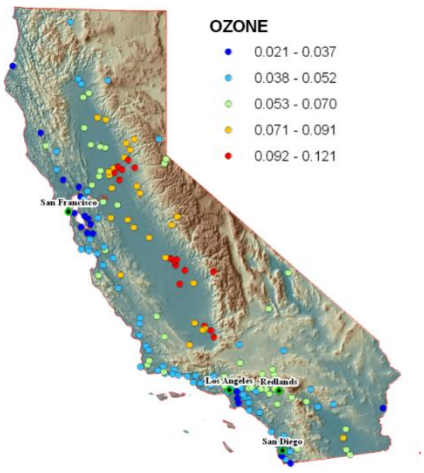
Setting up a huge network of on-demand cloud computing platforms is not an economically viable solution for most agencies. The best alternative currently available is satellite-based information. Remote sensing technologies can help create extrapolated data at a minimal cost using ERDAS IMAGINE. Satellite imagery is available from NASA and ESA, and it provides nearly real-time data for monitoring particulate matters and pollutants suspended in our planet's atmosphere using reflectance patterns from the electromagnetic spectrum. Among the datasets available for download are Sentinel P5, MODIS and VIIRS.

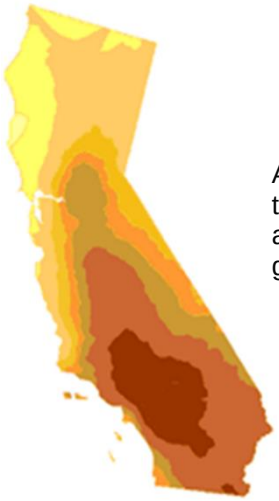
These datasets can be used in concert with data loggers to create a complete picture and allow scientists to perform analysis while also providing necessary information to decision-makers.



Understanding air quality distribution using geostatistics

Using the available point information and satellite reference, GeoMedia Desktop can create a distribution pattern of particulate matters with geostatistical tools like kriging and interpolation techniques like IDW or spline. These surfaces can help department officials understand pollution patterns and take a note of new hotspots that might indicate the growth of particular plants or industrial emissions. This can help officials make plans, decide which areas need inspection and maintain scientific proofs.





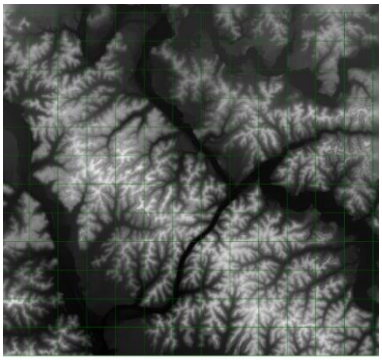
A representation surface showing the distribution of ozone over an administrative boundary using geostatistical tools

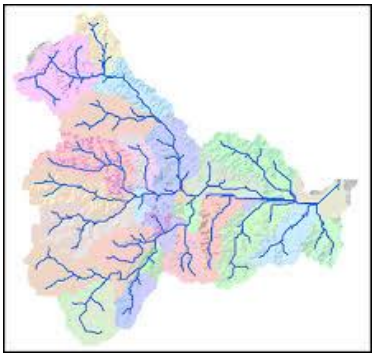
Water pollution management

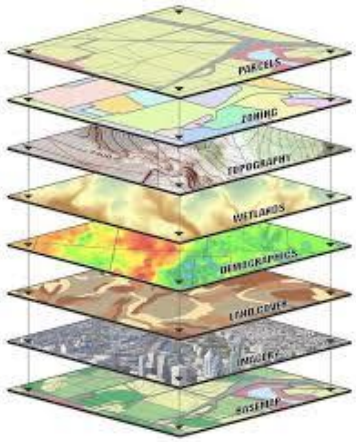
Integrating the hydrological network with a toxic release inventory and creating spatial databases

GeoMedia Desktop can be used in conjunction with ERDAS IMAGINE to extract a hydrological network from available digital elevation models. That network along other available river layers can be used to understand the proximity of pollution point sources. When these layers are overlaid with point data regarding industries and plants, departments can assess and understand risks and plan effective mitigation measures. It also enables decision-makers to build treatment plans for the discharges created by industry.

The layers can be stored in a relational database management system (RDBMS) for archival and update in the future. Also, once the layers are in the RDBMS, a defined GIS database with defined schemas is created for use alongside other management information system (MIS) information sets that might be available within the department.







Utilising DEM to extract hydrological network information, create a spatial database and overlay it with industry layers

Monitoring water quality using satellite-based water indexes and change detection

Remote sensing with wide coverage and multitemporal monitoring is the best solution for tracking surface water quality. Chlorophyll a, dissolved oxygen, total suspended solids, Secchi disk depth, total dissolved substance and pH were the parameters selected for surface water quality analysis in the example below. High spectral resolution of L8 OLI/S2A images were used with a suite of data mining models to provide more reliable images with both high spatial and temporal resolutions to extract important parameters.

ERDAS IMAGINE has several water quality indices built in as NDWI, WI and MNDWI that allow for water quality extraction. Also, NDVI can be used to understand water quality and eutrophication parameters.

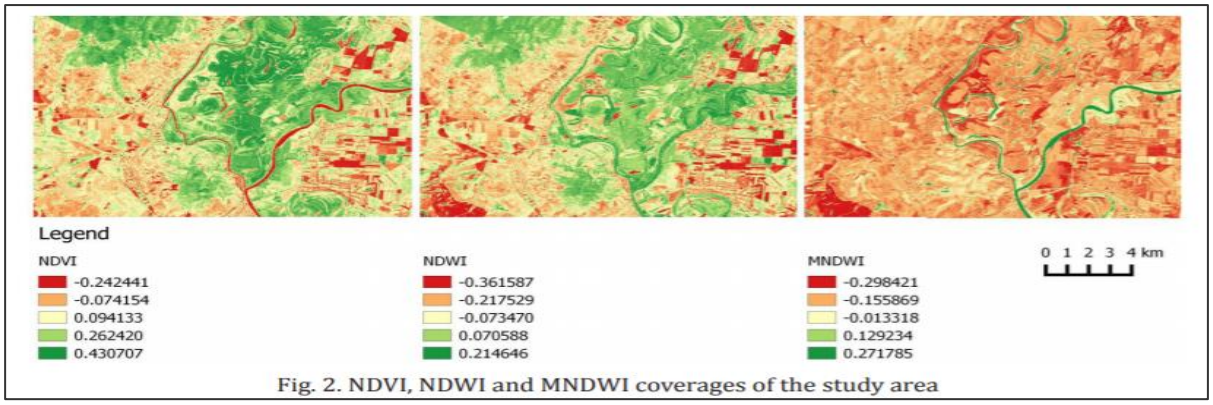
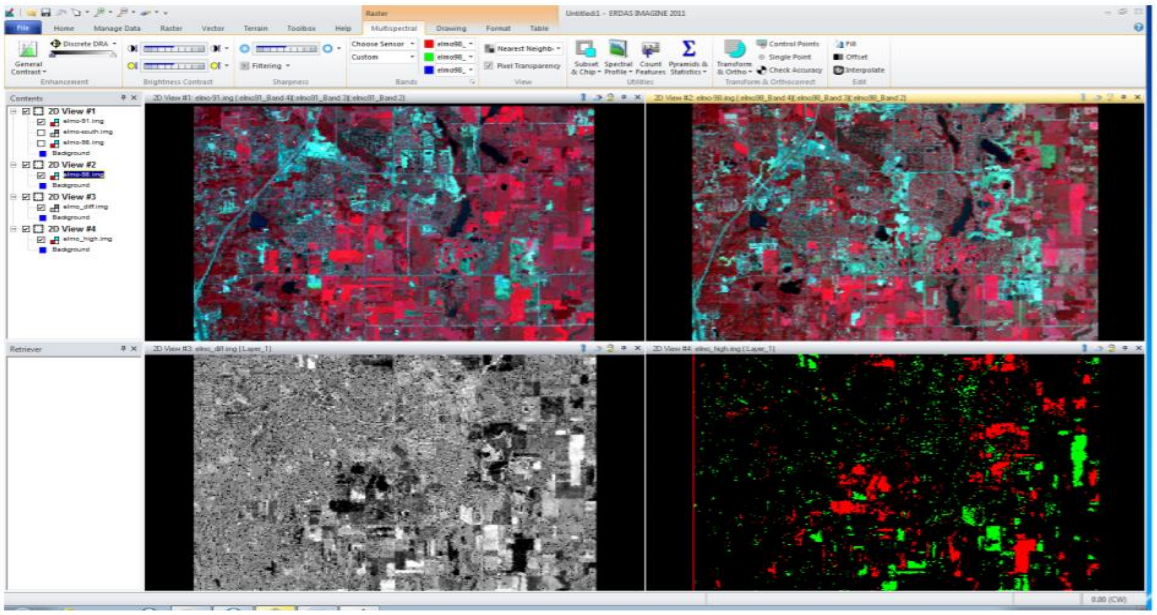


Fig. 2. NDVI, NDWI and MNDWI coverages of the study area

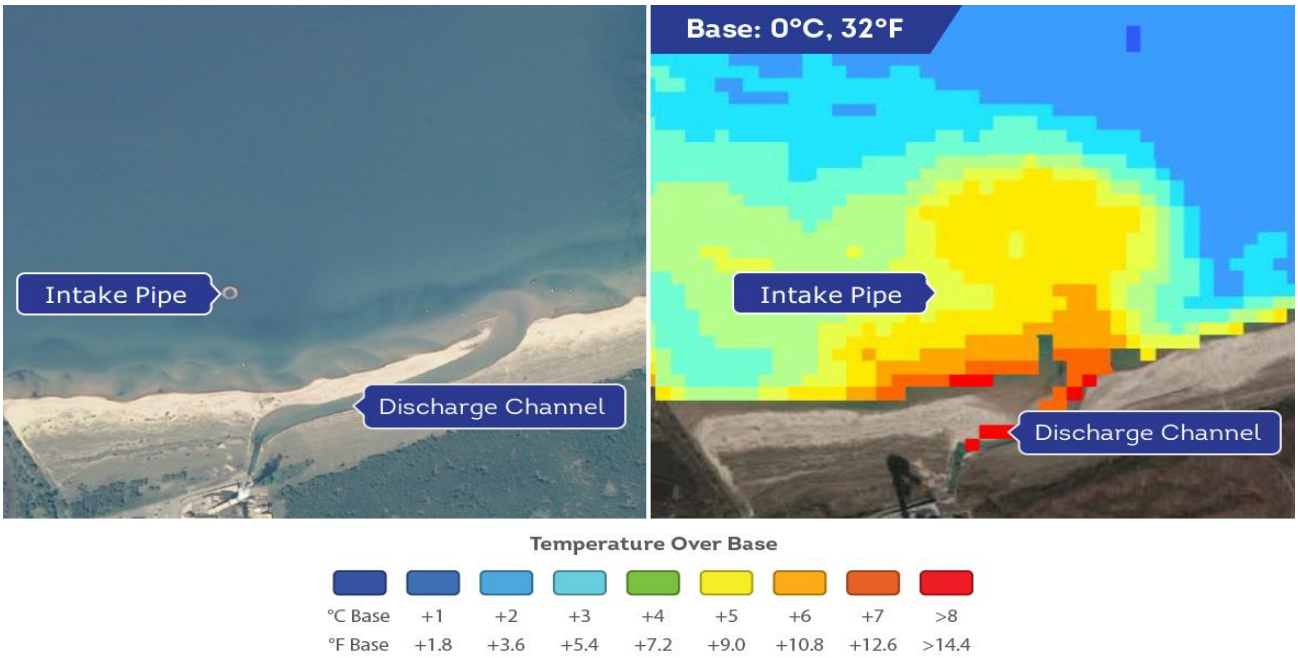
Machine learning-based change detection techniques can be used with multitemporal datasets, allowing users to pinpoint areas where industries are violating the norms of effluent discharge into bodies of water. Understanding this from a single image is very difficult, but comparing two different images taken by the same sensor on different dates can reveal very important datasets.



This dataset represents multiple-timeline LANDSAT 8 imagery being used to understand the effects of urbanisation and industrialisation

Identifying thermal plumes in water bodies using satellite data

The image chain functionalities in ERDAS IMAGINE can be used to identify thermal plumes originating in water bodies and help officials determine the point sources. This can also act as proof of illegal activity.
It can be done with LANDSAT thermal bands that are freely available for download; drone-based datasets can be used for analysis.



Soil pollution management

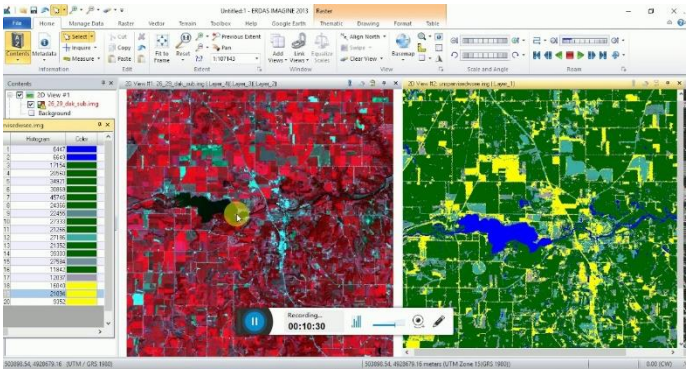
Creating zonation of solid waste dumping grounds and garbage dumps

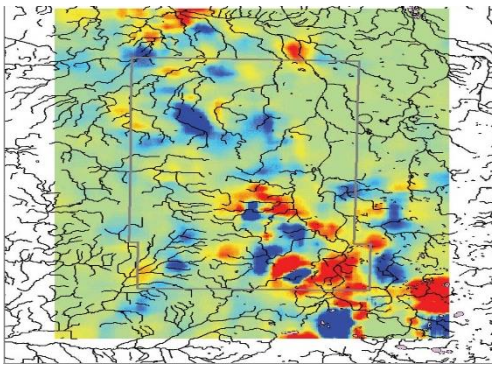
GPS-based survey or polygon creation using satellite imagery should be performed to create zonation of dumping grounds. This will allow officials to effectively monitor how much area is affected by waste dumping activities and make action plans. During the process, a significant geospatial layer is created and stored in the RDBMS. It can act as an important overlay for understanding the ecological effects of dumping. GeoMedia Desktop can provide additional layers and facilitate the overlay.

Understanding impacts using land use zones and satellite imagery

Land use classification can be performed with ERDAS IMAGINE. Once land use zones are available and overlaid with land parcel data, they can be used to understand the effects of soil pollution and contamination. Identifying soil contamination zones is helpful in reducing groundwater contamination and can help personnel understand chemical discharges and increases in soil salinity. ERDAS IMAGINE also displays polluted zones that are in close proximity to aquifers and agricultural lands so that necessary actions can be taken.

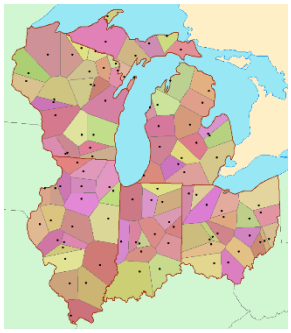
In GeoMedia Professional, this information can also help with site suitability analysis for dumping zones based on several parameters, like effective distance from bodies of water.





Land use classification in ERDAS IMAGINE and aquifers mapped along with dumping zones

Geotagging solid waste incinerators to understand the network coverage area



Another useful layer can be created using GeoMedia Desktop - the locations of solid waste incinerators installed throughout cities. There is also a beautiful tool available in GeoMedia Desktop called Thiessan Polygon.

Thiessan Polygon can be used to create a coverage area for incinerators to give departmental personnel an effective idea of the available resources, which is useful for estimating how much area a department can handle.

Creating waste management plans with population distribution maps

All solid waste management planning is dependent on the accurate representation of population distribution over spatial layers.

GeoMedia Desktop can be used to create joins and extract census layer information in boundary layers, which results in the creation of an important layer constituting population distribution. This can give officials and decision-makers a strong basis for policymaking.

NOC management

Once all the above-mentioned different layers are available in a spatial database residing in an RDBMS, departments can use GeoMedia Professional to create a scientific workflow backed by geospatial technologies for providing No Objection Certificates to industries. It also facilitates monitoring over time.

Creating an inventory with NOC details for industries

GIS-based point layers should be available for all industries that are provided with NOC. GeoMedia Desktop can be used to create an inventory containing GIS and MIS data related to the industries, and it allows spatial analysis and pollution tracking via satellite imagery and provides up-to-date information regarding NOC expiries.

Generating NOC with the spatial database and land base inventory

GeoMedia Desktop can be used to maintain land base information in GIS layers in an RDBMS. When it is overlaid with land use classification, officials can understand the risks associated with providing a specific type of industry with NOC. Also, if overlaid with population density maps, it can help officials understand the proximity of industry to human settlements and can be checked in coherence to hydrological networks to understand effects.

Land base information overlaid over satellite basemap created in GeoMedia Desktop

Contact us

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Our technologies are shaping urban and production ecosystems to become increasingly connected and autonomous — ensuring a scalable, sustainable future.

Hexagon's Safety, Infrastructure & Geospatial division improves the performance, efficiency and resilience of vital services. Its Safety & Infrastructure solutions enable smart and safe cities. Its Geospatial software leverages the power of location intelligence.

Hexagon (Nasdaq Stockholm: HEXA B) has approximately 21,000 employees in 50 countries and net sales of approximately 3.8bn EUR. Learn more at hexagon.com and follow us @HexagonAB.