

“NMRDSS (Nigerian Mineral Resources Decision Support System)”

AJAY YADAV¹, YYYYYYY²

¹Technical Specialist, RMSI Private Limited

²Position in the Org, Name of Organization

A-8 Sector 16, Noida 201 301, India.

Email: india@rmsi.com Phone: +91 120 4040500, 2511102

Abstract:

Mineral resource of a country (like Nigeria) is one of the most essential driving forces to the country's development and in improvement of quality of life. However, exploration and mining of mineral resources, especially from feasible mines is difficult without support from allied sectors e.g. infrastructure, water resources, man power etc. and physical infrastructure including roads, rail, ports, power which increases the cost. Furthermore, it is important to identify the areas where mineral occurrences are high as per their economic importance and their interaction with other natural resources such as forest, water etc. To identify an area for mining development purpose it is also necessary to understand various aspects of that area to consider geology, hydrology, land use and land cover, existing mining activities, environmental, socio-economic relationship etc.

NMRDSS is a web based decision support system which facilitates users to analyze mineral resource occurrences and mineral resource corridors. Based on incorporated fifteen (15) minerals (coal, iron, gold, baryte, bitumen etc.) availability and existing parameters (i.e. infrastructure, land use/cover, mining lease holding, population, water resources, socio economic etc.) of the surrounding area, various analysis to be done for developments of locals with less efforts and to utilize maximum resources.

Main factors/parameters used in this system is to get the weightage/priority of the mineral corridors are Mineral Occurrence (Resources, Production), Infrastructure (Airport, Roadways, Railways, Waterways, Power Network, Industry, Ports), Water Resource, Land Use/Cover (Water Body, Habitation,

About the Author:



Mr. AJAY YADAV

My passion in GIS brought me closer to ESRI technologies. I have developed widespread GIS applications for ArcGIS Desktop (ArcObjects and Python) and ArcGIS Server Application (Web ADF, ArcGIS Server JavaScript API, GP Services using Python etc.). I wish to convey my gratitude to ESRI for the entire journey which made me a hard-core ESRI expert and successful professional.

E mail ID: ajay.yadav@rmsi.com

Contact: +919999039028

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Protected Land, Low Forest Land, Agriculture, Barren Land), Mining Lease Holding (Exploration, Mining, Small Scale Mining, Quarry), Population Density, Socio-Economic (Poverty, Unemployment, Literacy, Skilled Man Power, Social Sensitive Zone) etc.

ArcGIS geo-processing tools helped us in geo-processing services created (using ArcPy) to process the heavy geo-databases with thousands of complex business rules depending upon multiple critical factors. User has options to create/draw the proposed/new infrastructure features to check the priority of any specific mineral pockets. This is a complete dynamic decision support system where user can update the data/parameters and gets results as per defined criteria in the form of corridor priority (high, medium, low) and to view or generate reports in moments as require.

Introduction

NMRDSS (Nigerian Mineral Resources-Decision Support System) is a web based decision support system which would facilitate users to analyse mineral resources occurrences and mineral resource corridors. Based on mineral availability and existing parameters such as infrastructure, land-uses, socio-economic condition etc. of the surrounding area, various analyses can be done for developments of locals with less efforts and maximum utilization of resources. User can create/draw the proposed/new infrastructure features and can check the priority of mineral pockets accordingly based on what if analysis.

The primary objective of the solution was to develop a Decision Support System (DSS) that is capable of performing the GIS data analysis and helps in deciding the weightage of the mineral corridor generated. Cumulative Analysis can be performed on particular group of parameters. Final Corridor Analysis can be performed on all the groups selected in generating the mineral corridor. Any time corridor editor will be allowed to add/delete/update the mineral features, other data, business rules. Following this, user runs the analysis and gets the updated results immediately. A number of different kinds of reports (In PDF) can also be generated through this application containing the calculated priority (High/Medium/Low) for different parameters, group of parameters, cumulative reports etc. it helps in doing analysis & prioritizing (High, Medium or Low) the mineral occurrence pockets for overall growth & development of the country.

RMSI had collected and studied the data sets extensively and designed thousands of effective business rules to make the analysis and output more precise and effective in planning and decision making.

The analysis is based on Mineral Occurrence, Infrastructure, Land Use/Land Cover, Mining Lease Holding, Population Density, Water Resources, and Socio Economic factors.

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It incorporates the mineral and mining geo-database created using the data collected from various departments of Government of Nigeria.

It analyzes the spatial and attribute data based on complex business rules.

Use of ESRI capabilities in NMRDSS:

In today's world, nothing can be so realistic, effective and user friendly without GIS. When we talk about Web GIS, ESRI ArcGIS JavaScript API, the first thing which comes to our mind. So, in this case also, this whole analysis couldn't be performed without GIS. We can't get the intersection of different parameters/features. A lot of spatial analysis was performed the data to get the final result in the form of priority of the generated mineral corridors by implementing thousands of business rules. We have used a number of ArcGIS inbuilt tools as following but not limited to.

- (i) SearchCursor
- (ii) CreateFeatureclass_management
- (iii) InsertCursor
- (iv) MakeFeatureLayer_management
- (v) SelectLayerByLocation_management
- (vi) CopyFeatures_management
- (vii) UpdateCursor
- (viii) CalculateField_management
- (ix) FeatureClassToFeatureClass_conversion
- (x) AddField_management
- (xi) Describe
- (xii) Buffer_analysis
- (xiii) Append_management
- (xiv) MultipartToSinglepart_management
- (xv) Intersect_analysis
- (xvi) Erase_analysis
- (xvii) AddJoin_management
- (xviii) TabulateIntersection_analysis
- (xix) Dissolve_management
- (xx) Delete_management
- (xxi) MakeTableView_managemen
- (xxii) DeleteRows_management
- (xxiii) SelectLayerByAttribute_management
- (xxiv) Exists
- (xxv) Field Info

All the GIS data consumed in the application is coming from the map/feature/image services publish in ArcGIS Server. As we all know the ArcGIS Geo-Processing tools are very much faster to analyse the GIS data of very big size. All the above geospatial tools are used in for Geo-Processing Services created (by using ArcPy) to process the spatial and attribute data by implementing thousands of complex business rules. In this way, by using these tools, we are capable to generate the mineral corridors by processing the different parameters.

Consistently improvements and enhancements carried out by ESRI, encourages us to use ESRI products for all kind of GIS application development.

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NMRDSS Facilitates:

- (i) Navigation tools to navigate through map (like Zoom In, Zoom Out, Zoom Previous, Zoom Next, Full Extent, Pan, Identify, Zoom to Location)
- (ii) Drawing tools to create & edit new (proposed) features (Port, Industry, Railway, Roadway, Power Network)
- (iii) User friendly tools like Identify, Search (Search by Attribute, Spatial Search), Measure and Print etc. to help user accomplish various tasks.
- (iv) Dynamic mineral corridor analysis & generation based on factors like socio-economic, population, infrastructure, resources, lease holdings, land use/land cover, water resources etc.
- (v) User friendly tools like Search, Measure and Print etc. to help user accomplish various tasks.
- (vi) The application incorporates analysis on 15 minerals (Coal, Iron, Limestone, Gold, Base metal, Baryte, Bitumen, Bauxite, Columbite-Tantalite, Feldspar, Gemstones, Gypsum, Kaolin, Phosphate, Tin).

NMRDSS Analysis Groups/Parameters:

Main group and their parameters used in this decision support system to get the priority of the mineral corridors are as following.

- (i) Mineral Occurrence (Occurrence, Resources, Production)
- (ii) Infrastructure (Airport, Roadways, Railways, Waterways, Power Network, Industry, Ports)
- (iii) Water Resource
- (iv) Land Use/Land Cover (Water Body, Habitation, Protected Land, Low Forest Land, Agriculture, Barren/Waster Land)
- (v) Mining Lease Holding (Exploration Lease, Mining Lease, Small Scale Mining Lease, Quarry Lease)
- (vi) Population Density
- (vii) Socio-Economic (Poverty, Unemployment, Literacy, Skilled Man Power, Social Sensitive Zone)

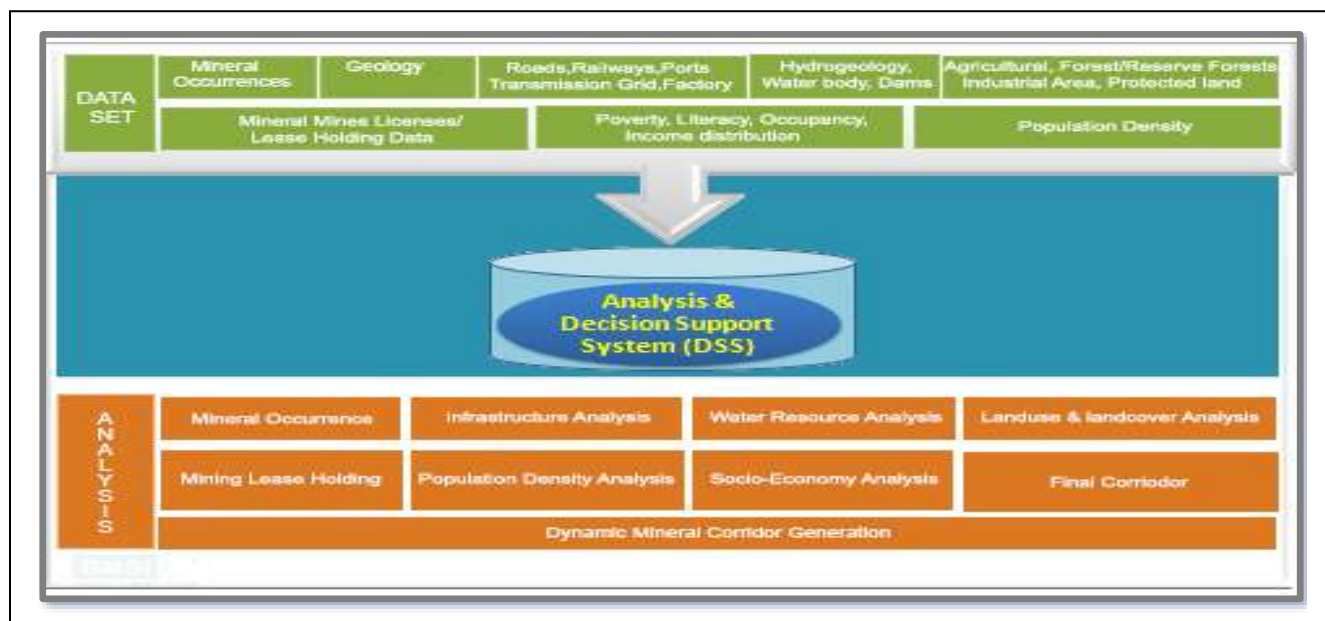


Fig: 1 – Mineral Analysis Dataset and Groups/Parameters



Fig: 2 – Application Functionalities

NMRDSS Map Viewer Interface:

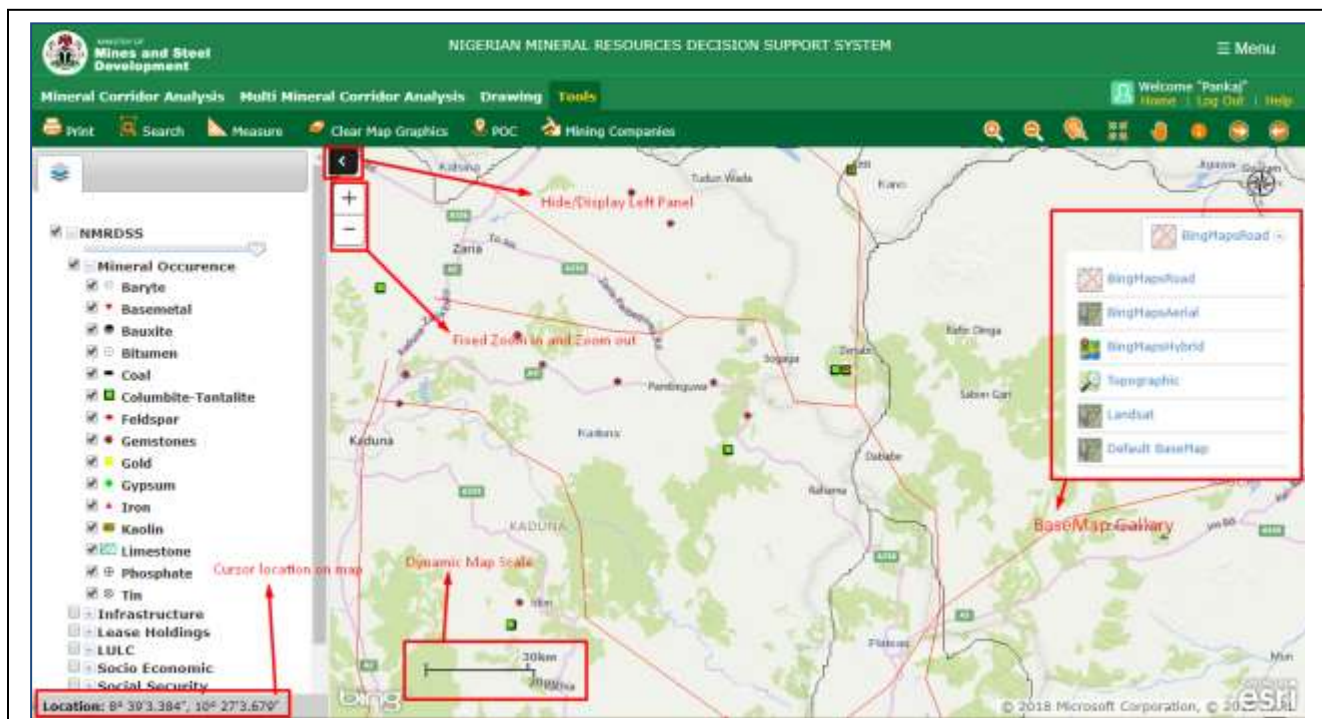


Fig: 3 – Map Viewer Interface

Mineral Corridor Analysis

Mineral Corridor Analysis functionality allows users to analyse mineral like Coal, Iron, Limestone, Gold, Base metal, Baryte, Bitumen, Tin, Phosphate, Gypsum, Kaolin, Bauxite, Feldspar, Gemstones and Columbite-Tantalite etc. against different factors and parameters like their occurrence, production, infrastructure around

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the occurrence, population and social economical etc. and generate cumulative reports for individual parameter or all parameters.

- (i) Select Corridor: To select one of already created corridor for selected mineral

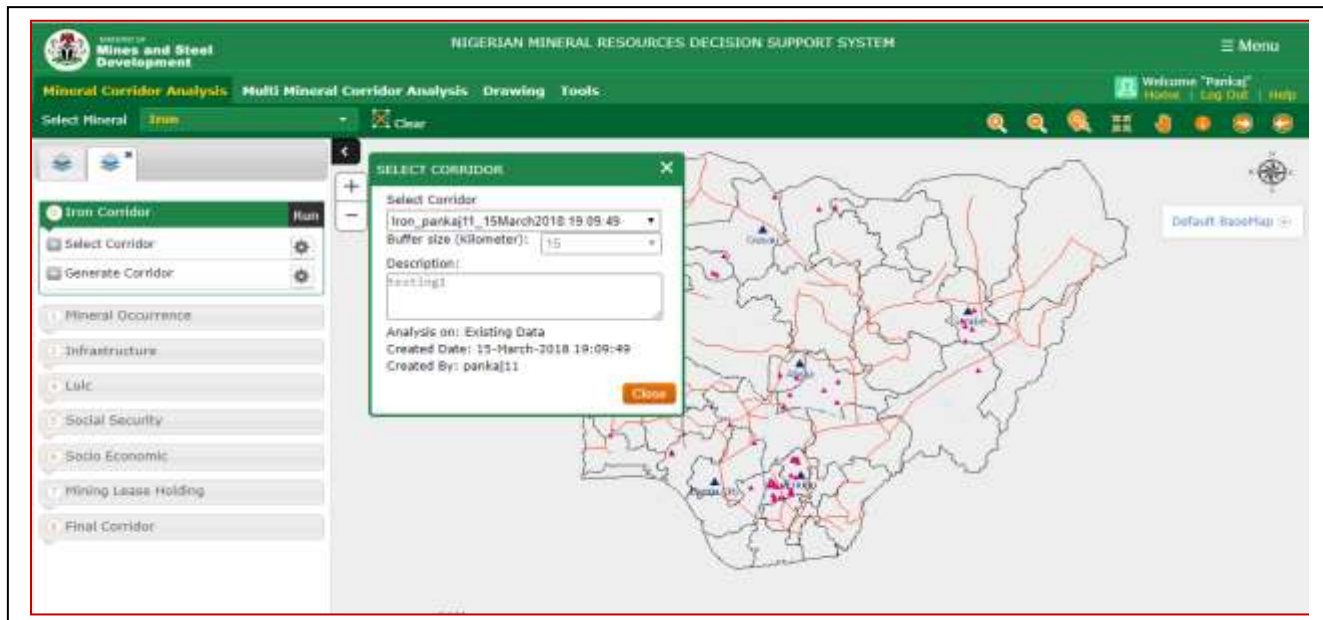


Fig: 4 – Select Corridor option for Mineral Corridor Analysis

- (ii) Generate Corridor: This functionality allows user (Administrator and Corridor Editor) to generate corridor for selected mineral by specifying buffer size and analysis criteria. Corridor can be generated for entire Nigeria and also can be generated for a specific area or state.

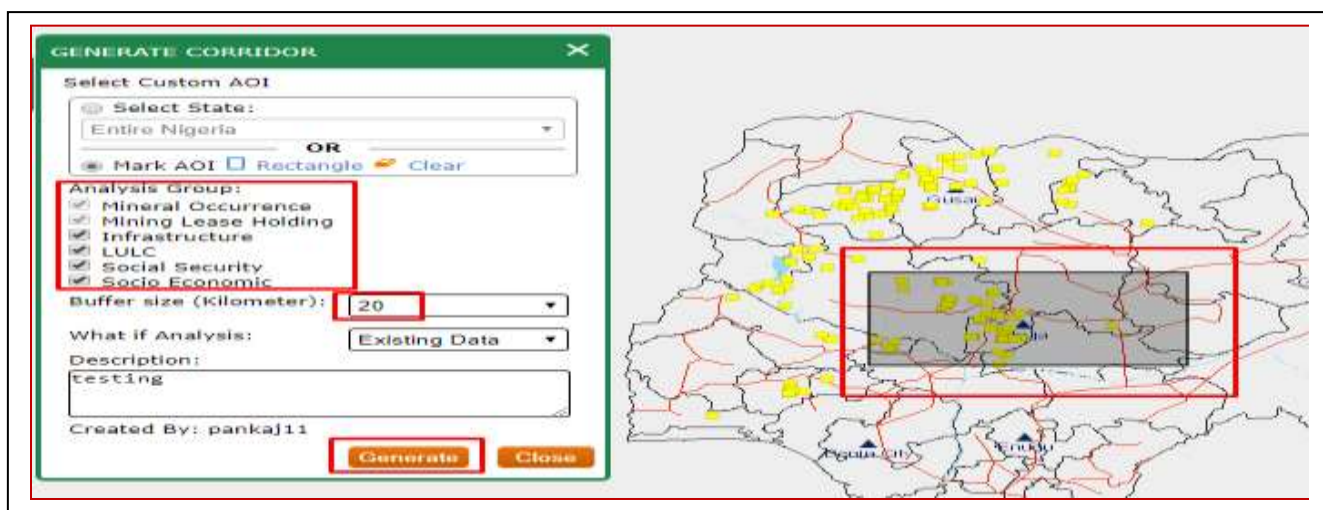


Fig: 5 – Drawing rectangle and specifying criteria for corridor generation

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- (iii) Mineral Occurrence: Under this section user will able to run analysis on individual Mineral occurrence parameters like Occurrence, Resources, and Production etc. Or user can run cumulative analysis for all parameters and generate report.

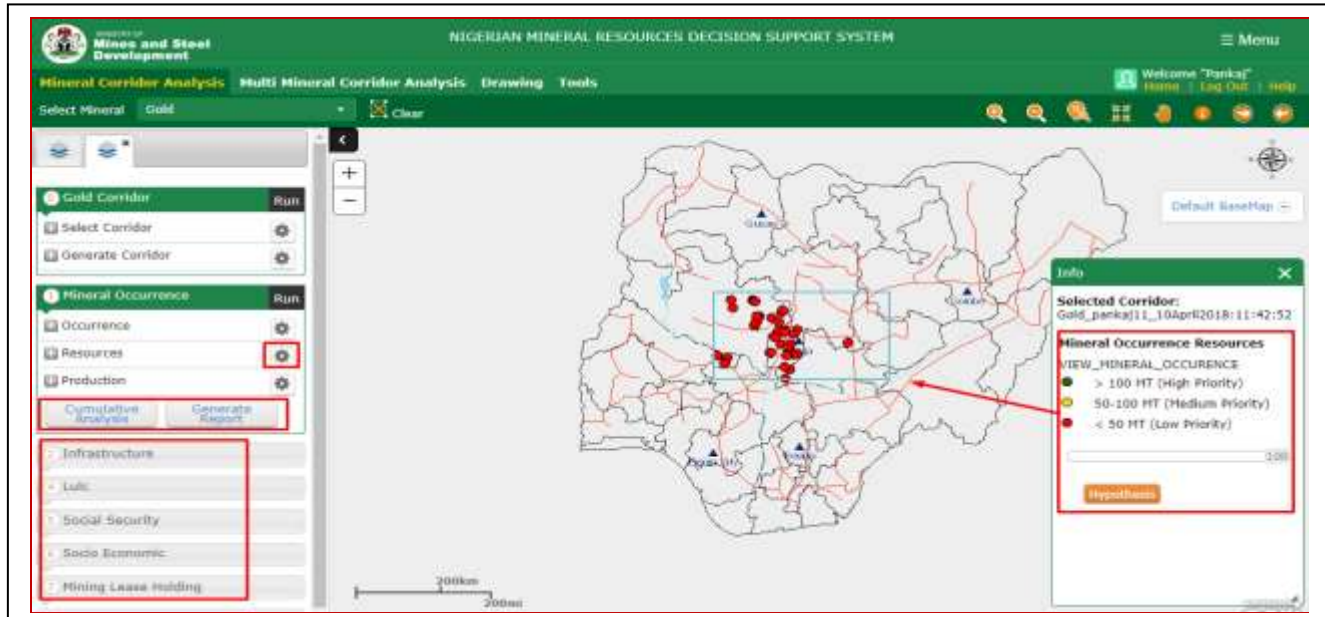


Fig: 6 – Analysis of Gold as per Resources under Mineral Occurrence

- (iv) Infrastructure: Under this section user will able to run analysis on sub-parameters of Infrastructure like Airport, Roadways, Railway, Waterway, Power Network, Industry and Ports or user can run cumulative analysis for all parameters and generate reports. Analysis of Infrastructure will be based on distance of mineral occurrence from infrastructure and priority is set according to pre-defined rules.
- (v) LULC: Land use & Land cover (LULC) is one of the important parameters to be considered for identifying mining corridor. Land use and Land cover module analysis would help user to identify the mineral pockets on the basis of land use in which a particular pocket is falling in. Under LULC user can run individual analysis for parameters like Water Body, Habitation, Protected Land, Low Forest land, Agriculture and Barren/Waste Land.
- (vi) Social Security: Social Security is one of the major factors while taking decision on Mining.
- (vii) Socio Economic: Social Economical factors will also affect mining work around mineral zone as for poor and unemployed zone mining will help for job and development.
- (viii) Mining Lease Holdings: Using this functionality, user will be able to check availability of lease type for mining.

Below Figures 7 & 8 are for examples to show the cumulative analysis on Gold mineral on Infrastructure and LULC.

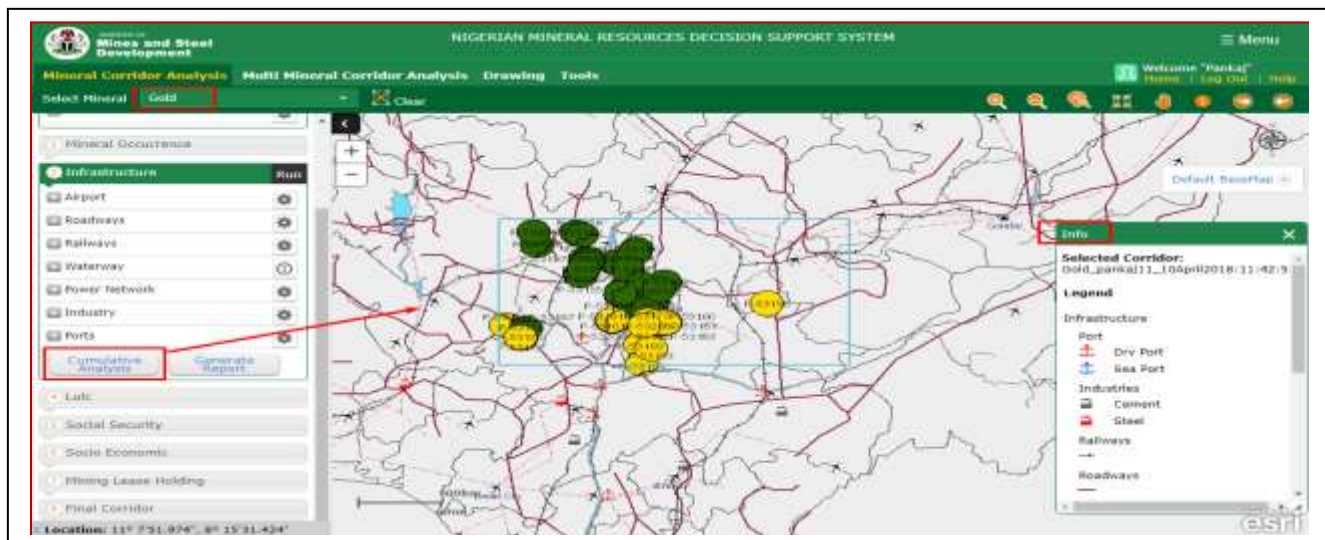


Fig: 7 – Cumulative Analysis for Gold for Infrastructure

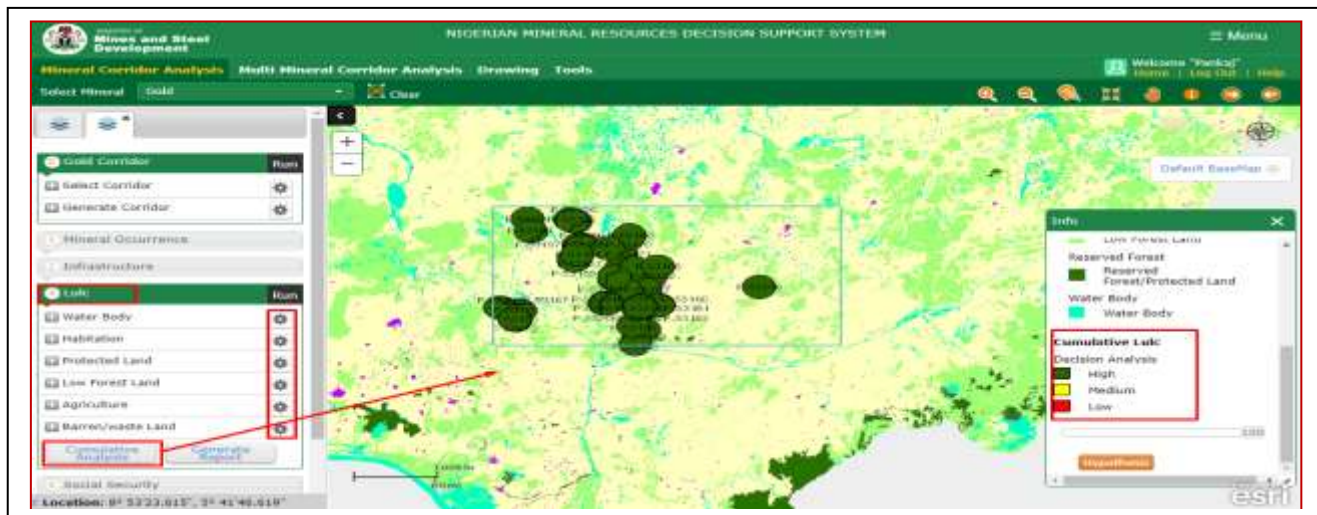


Fig: 8 – Cumulative Analysis for Gold for LULC

Below Figures 9 & 10 are for examples to show the cumulative analysis reports for LeadAndZinc on Socio-Economic.

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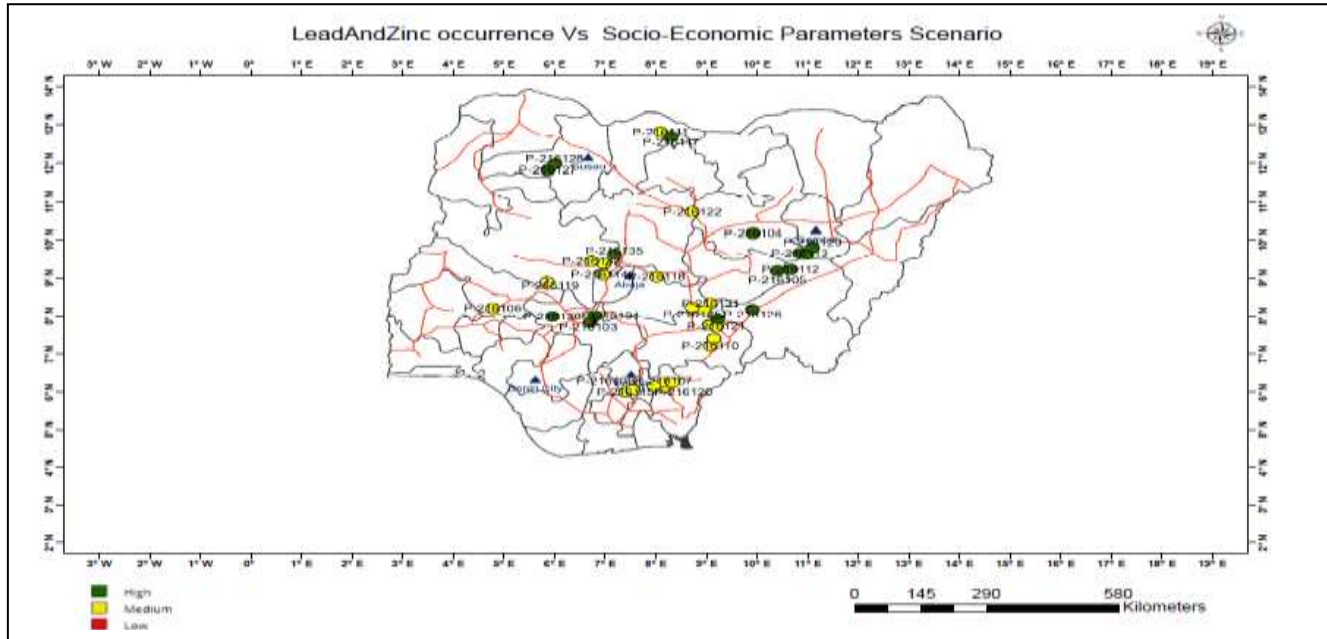


Fig: 9 – LeadAndZinc Occurrence Vs Mineral Socio-Economic Parameters Scenario

Cumulative Analysis of Socio-Economic Parameters for LeadAndZinc

Sl.no	Lat	Long	State	Location	Mineral pocket	Poverty	Poverty weights analysis	Poverty priority	Unemployment	Unemployment weights analysis	Unemployment priority	Literacy	Literacy weights analysis	Literacy priority	Electric power	Electric power weights analysis	Electric power priority	Soz	Soz weights analysis	Soz priority	Cumulative weighted analysis	Final cumulative priority
1	8.2844	8.3328	Odisha	Angal	Angal	Value <10%	1	Low	Value <10%	1	Low	Value <10%	1	Low	0	0	0	High	1	High	9	High
2	7.2044	8.7218	Odisha	Angal	Angal	Value <10%	1	High	Value <10%	1	Medium	Value <10%	1	Medium	0	0	0	High	1	High	10	High
3	10.1734	8.3442	Bihar	Angal	Angal	Value <10%	1	High	Value <10%	1	High	Value <10%	1	Low	0	0	0	High	1	High	8	High
4	9.1718	10.2028	Rajasthan	Angal	Angal	Value <10%	2	Medium	Value <10%	2	Medium	Value <10%	2	Medium	0	0	0	High	1	Low	7	Medium
5	8.1124	7.7931	Haryana	Angal	Angal	Value <10%	1	High	Value <10%	1	Low	Value <10%	1	Medium	0	0	0	High	1	High	9	High
6	8.2278	8.1929	Odisha	Angal	Angal	Value <10%	1	Low	Value <10%	1	High	Value <10%	1	Medium	0	0	0	High	1	High	9	High
7	7.9949	8.1817	Bihar	Angal	Angal	Value <10%	1	Medium	Value <10%	1	Medium	Value <10%	1	Medium	0	0	0	High	1	High	9	High
8	8.0428	7.5482	Bihar	Angal	Angal	Value <10%	1	Low	Value <10%	1	High	Value <10%	1	Medium	0	0	0	High	1	High	9	High
9	7.2028	8.3728	Bihar	Angal	Angal	Value <10%	2	Medium	Value <10%	2	Medium	Value <10%	2	Medium	0	0	0	High	1	High	9	High
10	12.3184	8.0428	Kerala	Angal	Angal	Value <10%	1	High	Value <10%	1	Medium	Value <10%	1	Low	0	0	0	High	1	Medium	8	High
11	8.2124	10.2028	Tamil Nadu	Angal	Angal	Value <10%	2	Medium	Value <10%	2	High	Value <10%	2	Medium	0	0	0	High	1	Low	8	High
12	8.0428	10.2028	Bihar	Angal	Angal	Value <10%	1	High	Value <10%	1	High	Value <10%	1	Low	0	0	0	High	1	Low	8	High
13	8.0428	8.3728	Andhra Pradesh	Angal	Angal	Value <10%	1	Low	Value <10%	1	Medium	Value <10%	1	Medium	0	0	0	High	1	Low	8	Medium
14	8.3728	7.4028	Andhra Pradesh	Angal	Angal	Value <10%	1	Low	Value <10%	1	High	Value <10%	1	Medium	0	0	0	High	1	High	9	High
15	7.4028	8.3728	Andhra Pradesh	Angal	Angal	Value <10%	1	Medium	Value <10%	1	High	Value <10%	1	Medium	0	0	0	High	1	High	10	High
16	12.3184	8.3728	Andhra Pradesh	Angal	Angal	Value <10%	1	High	Value <10%	1	Medium	Value <10%	1	Medium	0	0	0	High	1	Medium	8	High
17	8.3728	8.3728	Kerala	Angal	Angal	Value <10%	2	Medium	Value <10%	2	Low	Value <10%	2	Medium	0	0	0	High	1	High	8	High
18	8.3728	8.3728	Andhra Pradesh	Angal	Angal	Value <10%	2	Medium	Value <10%	2	Medium	Value <10%	2	Medium	0	0	0	High	1	Low	7	Medium
19	8.3728	8.3728	Andhra Pradesh	Angal	Angal	Value <10%	1	Low	Value <10%	1	High	Value <10%	1	Medium	0	0	0	High	1	High	9	High
20	7.4028	8.3728	Bihar	Angal	Angal	Value <10%	2	Medium	Value <10%	2	Medium	Value <10%	2	Medium	0	0	0	High	1	High	9	High
21	10.2028	8.3728	Andhra Pradesh	Angal	Angal	Value <10%	2	Medium	Value <10%	2	Medium	Value <10%	2	Medium	0	0	0	High	1	Low	7	Medium
22	8.3728	10.2028	Andhra Pradesh	Angal	Angal	Value <10%	1	High	Value <10%	1	High	Value <10%	1	Medium	0	0	0	High	1	Medium	10	High

Fig: 10 – Cumulative Analysis for LeadAndZinc of Mineral Occurrence Parameter

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(ix) Final Corridor Analysis: Final Corridor functionality allows user to display created corridor on map with pre-defined symbology and run analysis on these against all criteria and parameters as per defined business rules also to generated report of analysis.

After corridor generation you can do final analysis for selected mineral where all parameters and their sub-parameters of selected/generated corridors are considered. All priority rankings of different parameters/sub-parameters are summed and final overall ranking is calculated. Final ranking is compared with set rules and accordingly each pockets of selected mineral is highlighted on map with priority colors.

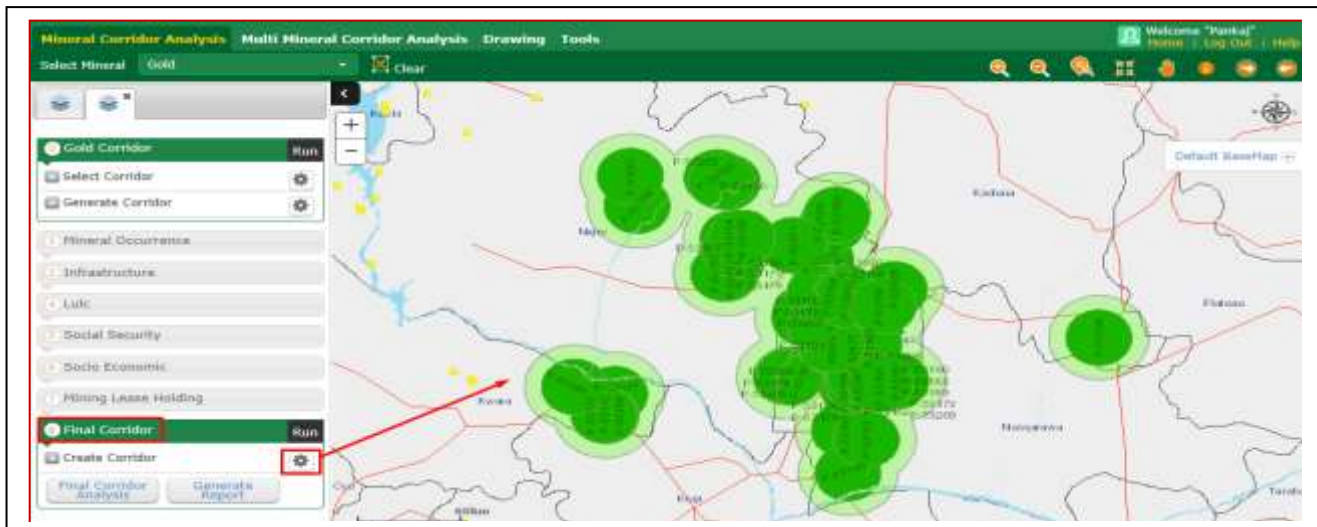


Fig: 11 – Create Corridor shown under Mineral Corridor Analysis

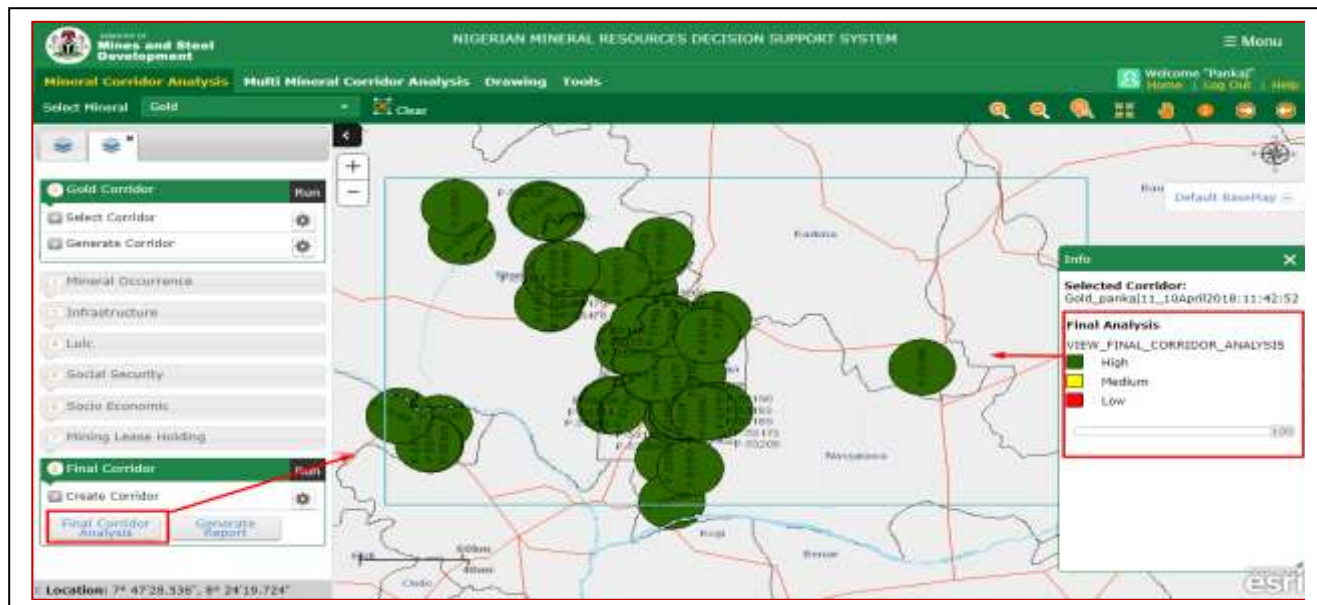


Fig: 12 – Cumulative Analysis of Corridor shown under Mineral Corridor Analysis

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Multi Mineral Corridor Analysis

Multi Mineral Corridor analysis functionality allows users to create corridors for multiple minerals together by selecting already generated corridors for individual minerals and generate report for same.

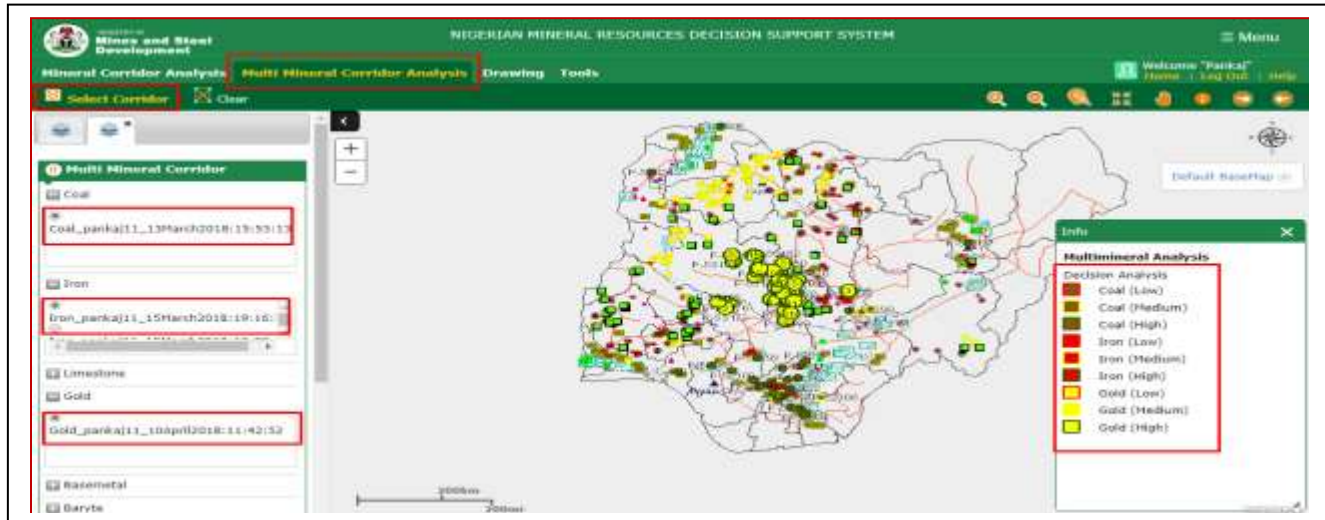


Fig: 13 – Multi Mineral Corridor Analysis Selection

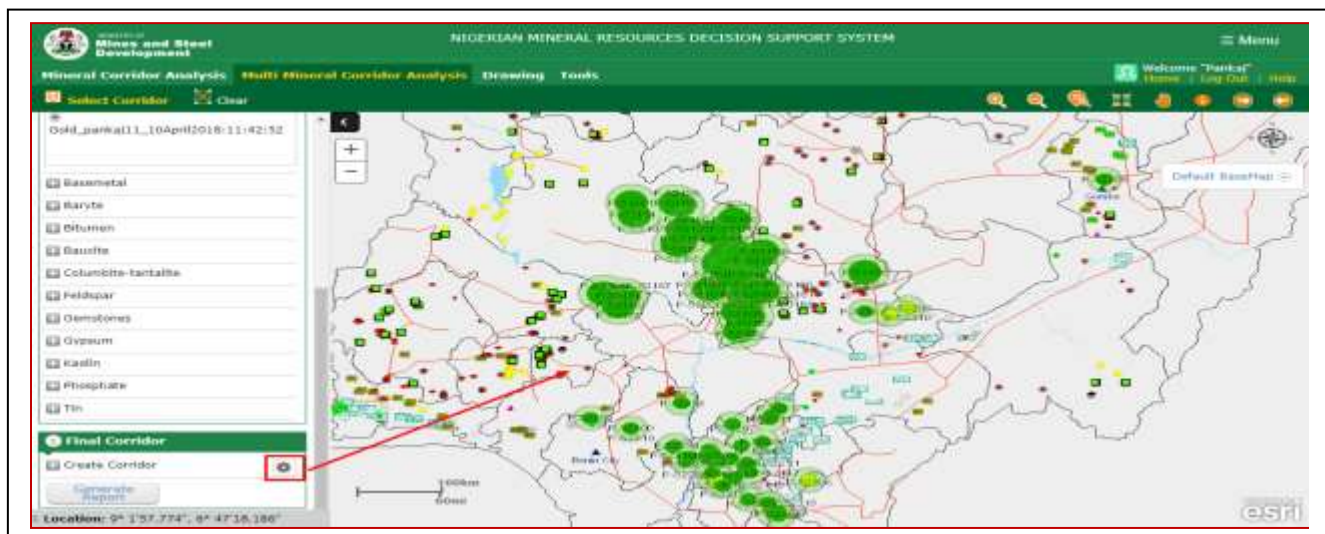


Fig: 14 – Corridor generated with Multi Mineral Corridor Analysis

Conclusion

NMRDSS application will give a better idea to the audience to develop the Decision Support System based on a number of parameters/layers/features/business rules in a way that how to utilize the ESRI inbuilt tools available with ArcGIS. It also tells about how to process the heavy spatial data in seconds and helps in take future decisions in terms of developing infrastructure. Have the data, build the business rule, process the data and get the desired result.

References

1. <http://resources.arcgis.com/EN/HELP/MAIN/10.2/index.html>
2. <https://developers.arcgis.com/javascript/3/>