SUSTAINABLE MINING AND GEOINFORMATION

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Week – 07

Lecture 31: Fundamental: Geoinformation and SDGs in Mining

Welcome, in today's lecture let us discuss about the fundamentals that connects three things one is sustainable mining the second one is geo information as the technology and the third one is how this is targeted towards achieving the sustainable development goals. So, it is like a triangle connecting three things, geo information, sustainable development goal and applicable in mining sector. So, we will be discussing on these three concepts, particularly the role of geo information in achieving sustainable development goals. Introduction to sustainable mining practices will also take an overview of the global initiatives that are available to promote sustainability in mining.

And also we will see how the mining operations that align with the environmental and social responsibility goals using the geo information technology. So, this and the subsequent 2 weeks (week 7 and week 8) we will be discussing the applications of geo information tools or geo information techniques in order to achieve the sustainable development goals we have 17 sustainable development goals but in this we will see how the application of geo information is suitable to which of the sustainable development goals and how they can be achieved. So, let us see we in terms of introduction yes this

sustainable development goals and particularly in mining sector is emerged only in 21st century. So, when the UN 2030 agenda this particular decade we are in the decade of executing this 2030 agenda UN agenda.

So, this sustainable development goal implementation or is given in mining sector is as fresh as this particular decade or this particular century. And let us see the United Nations 17 Sustainable Development Goals. They provide a framework for sustainable development, thereby emphasizing issues such as poverty, clean energy, responsible production, climate and things like that. So, this geospatial technology can bridge the knowledge gaps by integrating tools such as we have the UAV or the drone based image capturing protocol. the AI machine learning deep learning all this form under the or fall under this AI series or AI family and the blockchain with traditional and modern method.

So, all these things can be integrated together using geospatial technologies. This technology comprises improvements in monitoring, decision-making, and thereby aligns mining practices with sustainable development goals. So, it is a kind of triangle: sustainable development goals, the mining sector, and geo-information technology. In weeks 3 and 4, we discussed the applications of geo-information technologies to the mining industry or mining sector, but in this and the next week—that is, weeks 7 and 8—lectures, we will discuss how different sustainable development goals aligned with the mining sector have or do benefit from the applications of geospatial technology.

So, connecting these three main frameworks is key with respect to the seventh and eighth week lectures. So, friends, all of us know these 17 sustainable development goals: no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy. Then we have decent work and economic growth. Then we also have industry, innovation, and infrastructure; reduced

inequalities; sustainable cities and communities; and responsible consumption and production. The 13th one is climate action; the 14th and 15th are life below water and life on land.

And the 16th one is peace, justice, and strong institutions, and the 17th one is partnership for the goals. So, all these 17 sustainable development goals that fall under Agenda 2030 have been earmarked to be achieved by the end of this decade, that is, 2030. So, the sustainable development goals are measurable by Earth observation data that are adapted by the Group on Earth Observations. So, on the left-hand side, in terms of the rows, all 17 sustainable development goals have been mentioned. And, in terms of the columns, we have mentioned 10 different applications as far as the broader applications of Earth observation and geo-information techniques are concerned.

Let us say the 'no poverty' goal can be benefited in terms of population distribution studies, in terms of cities and infrastructure mapping studies, in terms of land cover and land use studies, and also agricultural monitoring studies. So, what we essentially aim to

understand are the different applications of Technology is valid here, but we need to link how many of them are applicable as far as the mining industries are concerned, and again they are linked to the sustainable development goals. Let us have the sixth one: clean water and sanitation. Here, it is taking benefit from all these applications like population distribution, cities, and infrastructure mapping. We have elevation and topographical applications coming from geo-information technology.

Land use and land cover mapping, even from oceanographic observations, hydrological and water quality observations, atmospheric and air quality observations. The eighth one is biodiversity and ecosystem observations, even if the ninth one is agricultural monitoring, and the tenth one is hazard disasters and environmental impact. So, in terms of clean water and sanitation, which is applicable in a mining industry or mining sector, can take benefit from all these aspects as far as geo-information technology is concerned. So, sustainable mining—and we also know this in terms of the involvement—as far as the definition goes, sustainable mining involves minimizing the environmental damage, thereby optimizing the resource use and ensuring the well-being of affected communities. Through advanced geoinformation tools, mining operations can achieve these objectives by addressing challenges such as land degradation, water management, biodiversity conservation, and so on. So, all these you can see—you can visualize—that this becomes part of various mining sectors or mining industries. Thereby, if we practice sustainable mining, they are useful in terms of enhancing transparency in environmental reporting, also helping in the reduction of exploration and operational costs by optimizing resource utilization.

They are helpful in terms of facilitating compliance with environmental regulations through predictive and real-time monitoring. So, mining is both a driver of development

and a source of significant environmental risk. So, on the one hand, it leads to socio-economic development, but on the other hand, it poses significant risks as far as the environment or environmental pollution are concerned. So, the dual impact—that means both positive and negative—makes it critical to adopt a kind of balanced strategy which is compatible or complies as far as the sustainable development goals are concerned. So, thereby, what does sustainable mining wish to achieve?

Sustainable mining wish to achieve in terms of maximizing the economic and the social benefits at the cost of minimizing the negative environmental impact that's what we say the optimization principle we optimize in terms of more or maximum economic and social benefit at the cost of very lesser minimal environmental risk or impacts so mining directly and indirectly influences numerous sustainable development goals we have 17 listed making it pivotal to global sustainability discussions So, the three vital pillars of sustainable mining from which are which have a which have which derive benefits as far as the geoinformation tools is concerned. The first pillar is under demand analysis. The second is integrated decision making and the third one is the technological advancement.

As far as the demand analysis is concerned, evaluating current and future mining requirements to ensure long term sustainability. Whereas the integrated decision making, it aligns the operations with the various sustainable development goals through community collaboration and comprehensive planning. As far as the technological advancement is concerned, here the innovating in terms of metal recycling, resource recovery and thereby help in terms of environmental monitoring. So, look at this particular depiction here this group Janikowska and Kulczycka in 2021 have put it in this way all those all these 17 sustainable development goals. they put in terms of mitigation

and enhancement so see on that basis they are divided this 6 they put it in terms of enhancement and other 11 they put under the mitigation category and out of that they put this in terms of indirect moderately direct and very direct

So, in the vertical axis that means the environment versus mitigation in terms of enhancement it indicates what you mean by this enhancement as far as the 17 the 6 out of 17 sustainable development goals are concerned. It indicates the positive impacts that mining can or the mining industrial mining sector can contribute in terms of achieving specific sustainable development goals and in that the SDG number 1, 11, 17, 4, 8, 7, 9 these all fall in terms of the enhancement category as far as the mitigation category is concerned. the rest of the 11 out of 17 fall under the mitigation category. They are the number 13, 14, 2, 5 and 10, 16, 3, 12 and 6 and 15. So, as far as the horizontal line is concerned where it goes from indirect to moderate to very direct impact.

So, indirectly they have put it in terms of mining. So, mining has less direct influence on these sustainable development goals. So, what are they? They are numbers 2, 6, 14, and 13. Whereas, in terms of moderately direct impact is concerned.

So, SDGs where mining has significant, but not exclusively or dominant influence. They are numbers 3, 10, 12, and 16, and a very direct impact is 6 and 15, that is the clean water and life on land. So, 6 and 15 have a very direct impact as far as mitigation is concerned, and as far as enhancement is concerned, numbers 7, 8, and 9 have a very direct impact as far as enhancement is concerned. And 4 and 17 have moderately direct impact, whereas 1 and 11 have indirect impact.

So, this gives a very clear division as far as different sustainable development goals are concerned in the mining industry sector. So, let us see the socio-economic impacts of

mining. We have both negative and positive, as we have seen. In terms of negative, it is the environmental liabilities, and as far as positive is concerned, these are the social and economic contributions. So, the negative impacts we can have are air pollution, water contamination, deforestation, soil erosion, and also with this, the sustainable development goals number 6, that is clean water and sanitation, 13 the climate action, and 15 the life on land are concerned. As far as the positive impacts are taken care of or considered, which involves the social and economic contribution, here the employment generation and economic growth are considered, so as far as the contributing sustainable development goals number one, that means no poverty, job creation reduces poverty in mining regions. In SDG 2, zero hunger, economic benefits improve access to food and resources.

The Sustainable Development Goal 8 focuses on decent work and economic growth, whereas Goal 9 pertains to industry, innovation, and infrastructure. So, these have positive impacts as far as mining is concerned. Now, let us see the different global initiatives that promote sustainability in mining, and then we will subsequently see how many of them have benefited from the geoinformation technologies. The UN Sustainable Development Goals (SDGs) show that mining practices are increasingly aligned with sustainable development goals. Environmental and social assessments integrate geo-information to achieve these goals.

So, it is very clear that to integrate social and environmental assessments, we need the help of geo-information tools. In terms of the Paris Agreement, it encourages the mining sector to align with global climate goals. The mining sector has to align with global climate goals by reducing carbon footprints, thereby adopting renewable energy sources and similar measures. This also benefits from the use of geo-information technologies. Next are the voluntary standards and certification programs, such as the Responsible Mining Index (RMI) and the Extractive Industries Transparency Initiative (EITI).

They all promote accountability, environmental stewardship, and community well-being. Certifications like Fair Trade and Gold Standard ensure ethical sourcing and production. Another one is the MAPx platform, a UN-supported initiative for visualizing data on mining, economic, social, and environmental performance. The MAPx platform aligns with SDG 16, which focuses on peace, justice, and strong institutions. What we mean to say is that there are several global initiatives in place that promote sustainable mining, which benefit from using geo-information tools, whose key strength is integration—integration of various different variables.

Let us see as far as the geo is concerned group of earth observations. global network of 105 member countries and 127 participating organization. They implement the global earth observation systems of system called GEOSS in terms of abbreviation. They have clearly mentioned that let us take as much as benefit as possible from the earth observation platform under the broad category of geo information. So, the Digital Earth Africa and Africa Regional Data Cube ARDC, these initiatives they facilitate accessibility of the geospatial data for monitoring mining in Africa.

So, we can also find out lot of similar examples from different countries and continents. As far as the global networks for earth observation and geospatial applications are concerned, The US EPA so United Nations Environmental Protection Agency initiative so they have commissioned the NRC National Research Council to integrate the sustainability performance indicators as far as the SDI or the development of sustainable the development of spatial data infrastructure is concerned we also have in India spatial data infrastructure. So, this provide a platform as far as efficient geospatial data management is concerned. So, increasingly the geospatial data management data the geospatial data platforms are emerging in all sectors including mining to to cater to these needs these objectives that are directly or indirectly linked to the various sustainable development goals.

The USGS United States Geological Survey and the Planets Lab, many of you may not have heard this planet gives different kind of images. So, this USGS and Planet Lab collaboration provide geospatial tools for sustainable mineral resources development across exploration, exploitation, closure, phases of mining. So, we must know this is a

piece of information useful for the people practicing the managers practicing mining. So, look at this the USGS and PlanetNav they are giving lot of information in terms of the geospatial tools for sustainable mineral resource development that help in terms of exploration, exploitation and even if the closer in terms of mining phases. And the next one is the Societal Benefits Areas, SBAs.

Regional SBAs prioritize decision-making and sustainable development with Earth observation information. As for the key legislative and policy frameworks governing mining in the Indian nation. So, we have a national policy and act—the Mines and Minerals Development and Regulation Act, framed in 1957—that talks about regulating the mining sector. It governs the process of granting mining leases, ensuring proper utilization and conservation of mineral resources. Now, in the next one, the National Mineral Policy in 2008 focuses on sustainable mining and conservation. In 2016, the National Mineral Exploration Policy emphasized comprehensive exploration of resources, deeper deposits, and the creation of a national geoscientific data repository.

This is very important because as we move from 1957's National Policies Act to 2008's National Mineral Policy and 2016's National Mineral Exploration Policy. In the third one, we say that we need to have a geoscientific data repository, which means all the data regarding the mining sector—the deposits, deeper deposits, exploration resources, or everything—has to be there in a geoscientific data repository that is solely based on geoinformation tools. We are increasingly relying on and depending on the utilization of geoinformation tools. The Mineral Conservation and Development Rules (MCDR) 1988 prescribe measures for sustainable mining and mandate a Sustainable Development Framework (SDF).

So, the 1988 one is also very important because it adheres to the Sustainable Development Framework. Now, coming to the prospects of geospatial techniques in sustainable mining. Exploration and site suitability analysis. We have discussed many of these during our third and fourth-week classes. So, exploration and site suitability analysis use a lot of different satellite datasets of various spatial and spectral resolutions, which are useful in terms of land-use change and monitoring activities.

In terms of monitoring disaster management. Real-time monitoring of disasters, like the tailing dam burst in Brazil, has benefited from using drone and satellite data with geospatial technology. So, that is how it has played a definite role as far as disaster risk assessment is concerned. So, it falls under or complies with Sustainable Development Goal number 3. About 70% of disaster management practitioners now employ geospatial tools or geoinformation tools for efficient management and response.

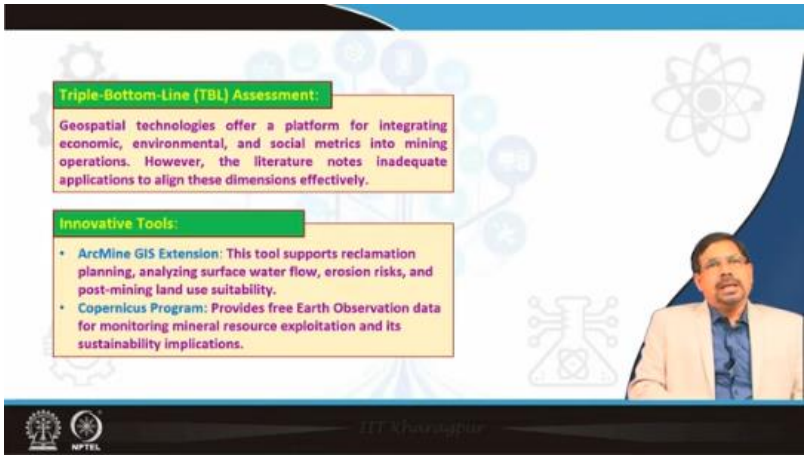
So, SDG 3 is well supported by geospatial technologies or geoinformation technologies. In terms of land degradation and habitat monitoring, Sustainable Development Goals 1, 2, 3, and 15 have relevant elements within them. So, land degradation and habitat monitoring assess impacts such as vegetation loss, wildlife displacement, forest fragmentation, and all these things. They link in terms of predicting land degradation, disease risk in new communities, and things like that, which have elements as far as these four Sustainable Development Goals are concerned: 1, 2, 3, and 15. So next is the waste management and water protection, which have elements as far as Sustainable Development Goals number 6 and 14 are concerned. Using geoinformation technology, the indiscriminate disposal of acid discharge waste affecting water bodies or agricultural productivity can be measured, monitored, managed, and protected.

Coming to illegal mining and law enforcement. Yes, satellites, because of their temporal repeatability and change detection, can track many things, including illegal mining activities and changes. So, that is how it is also useful in terms of applying to a few Sustainable Development Goals. Then, forest and ecosystem sustainability. So, concurrent analysis of mining activities and forest ecosystems has been achieved using geospatial technologies for SDG numbers 12 and 15.

So, there are a lot of prospects as far as sustainable geo-information technology is concerned in achieving sustainable mining. We also have emerging opportunities and under-explored areas as far as UAV is concerned—the integration of geospatial tools with emerging technologies, policy, and capacity building. Yes, in our initial classes, we have already discussed the potential of unmanned aerial vehicles: you can map anything or put a sensor on them and allow them to fly over certain areas to get good-quality, near real-time information, which may not be possible with satellites. So, UAVs are dominantly—and increasingly—becoming important as far as sustainable mining practices and integration are concerned. Using various latest technologies like IoT (Internet of Things), artificial intelligence, and even blockchain, they improve the management of mining data, stakeholder collaboration, and thereby increase transparency as far as information is concerned. It also leads to the generation of trust among communities and stakeholders.

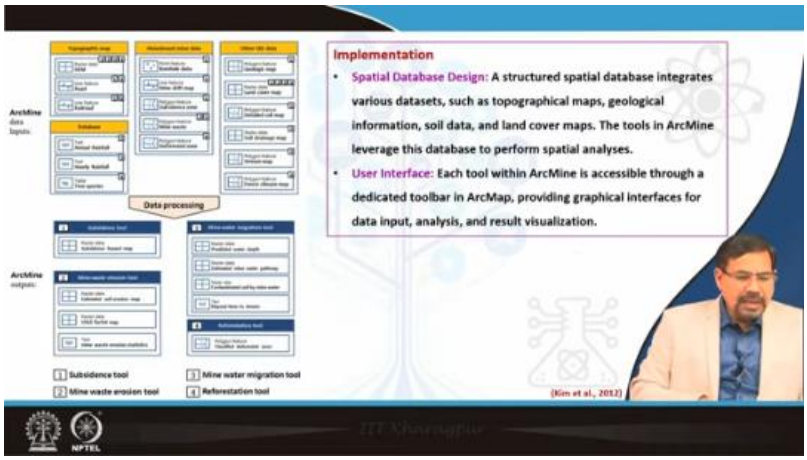
Policy and capacity building: expanding the use of geospatial technologies requires capacity building and policy support to empower governments and local stakeholders in sustainable mining. So, through this, geospatial technology helps in terms of linking capacity building and policy frameworks. Thereby, it helps the government, it helps local stakeholders, and finally, it helps in achieving sustainable mining. There are two concepts

we want to discuss here: one is the triple bottom line assessment (TBL). Geospatial technologies offer a platform for integrating economic, environmental, and social metrics into mining operations.



However, the background literature suggests that there are very inadequate applications. So, we need to work on this in terms of aligning these three things under the GIS platform or the geospatial information platform. Innovative tools: yes, in the mining sector, we have various software tools as far as geospatial technology is concerned. One of them is ArcMine, a GIS extension which acts as an extension. This tool supports reclamation planning, analyzing surface water flow, erosion risks, and post-mining land-use suitability. For those who want to use it, it is really interesting, and many of these built-in packages help in terms of customized applications.

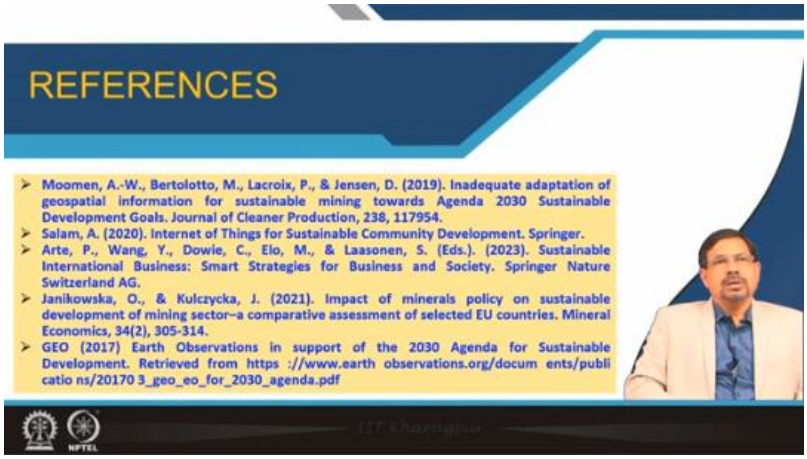
And we have various programs in India, Europe, and other places as far as they are concerned. And this particular ArcMine has this kind of architecture in terms of topographic maps, abundant mine data, other GIS data, and the database. And then once you process the data, you get the output in terms of the subsidence tools. You can use mine water migration tools, mine waste erosion tools, reforestation tools, and many other similar customized applications. So the implementation is spatial database design. It helps in the form of a structured spatial database. It integrates various datasets such as topographical maps, geological information, soil, land cover, and whatever else is needed. All these are customized and built into a graphical user interface, or GUI. The tools in ArcMine leverage this database to perform spatial analysis.



User interface: yes, each tool within ArcMine is accessible through a dedicated toolbar in ArcMap. Providing graphical interfaces for data input, analysis, and result visualization. You may refer to a key metal paper published in 2012 that gives more details about this ArcMine extension package. As far as mining operations with environmental and social responsibility goals are concerned, they benefit greatly from geoinformation tools. So, environmental responsibility through geoinformation, social responsibility through geoinformation, and geoinformation for compliance and reporting.

So, carbon emission tracking, wastewater management—all these fall under environmental responsibility. As far as social responsibility through geoinformation is concerned, community engagement and socio-economic impact all benefit from geoinformation technology. For regulatory compliance, GIS tracks environmental and social indicators to ensure legal adherence. Reporting on the SDGs: spatial data supports detailed, reliable reporting on progress toward sustainable goals. So, geoinformation is also useful in terms of complying with and reporting on many of these things.

So, we have used these references for the discussion in this particular lecture. So, let us conclude the five important points. Geoinformation plays a transformative role in aligning mining practices with the UN SDGs, offering advanced tools to minimize environmental damage, thereby optimizing resource utilization and promoting social well-being. By integrating GIS, remote sensing, and spatial analysis, geoinformation is becoming a powerful tool for mining operations, thereby addressing critical challenges like land degradation, water resources management, biodiversity conservation, and similar issues. It enhances transparency, facilitates compliance with regulations, and supports effective decision-making for sustainable mining outcomes.



As far as sustainable mining is concerned, it remains both a catalyst for development and a source of environmental risk. So, adopting geoinformation technology helps in following a balanced approach, which means maximizing economic and social benefits while minimizing ecological risk or harm. So, this integration underscores the pivotal role of innovative technologies in achieving global sustainability through responsible resource management in the mining sector. So, we discussed three things connecting geospatial or

geo-enabled technologies to achieving sustainable mining or the Sustainable Development Goals as far as the mining industry sector is concerned. Thank you very much.