SUSTAINABLE MINING AND GEOINFORMATION

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Lecture 40: Sustainability Performance Monitoring

Welcome, our 40th lecture today let us talk about Sustainable Performance Monitoring. So, there are various ratings you say star ratings in terms of the performance by the mining industries or by the miners. So, keeping that in mind we have different kind of rating system, it is a kind of certification system also and have a feedback mechanism in order to bring the sustainability in action. So, the concepts what we are going to cover today are star rating systems for mines, sustainable development framework and the Environment Performance Index abbreviated as EPI. Then we will also discuss about monitoring frameworks and technologies the broader sustainability practices in mining and we will also see a case study.

So, we can very well understand from here that in terms of the star rating system as far as the mining industry is concerned there will be the total activities are in totality the all gamuts of activity will be considered. so as to attain a sustainability certificate or sustainability goal. But through this also let us know that what are the different criteria parameters to achieve or to get this star rating and then out of them how many we can or can be directly or indirectly benefited from the application of geoinformation. In the first

two weeks, we have elaborately discussed about the potential of this geoinformation tools, various applications, its theoretical aspects, methodology and all this. In the third and fourth week, we already have discussed about the applications of geoinformation elaborately in different aspects of mining industry or mining sector. Here in this 7th and 8th week, we have been discussing how in totality the geoinformation is beneficial in terms of achieving the sustainable development goals.

We have 17 sustainable development goals. We covered almost 16 in past 8 lectures during week 7 and 8. In the 9th lecture or you can say the 39th lecture, we discussed about the sustainability matrices as far as the mining industry is concerned. Now, in this 40th talk or lecture, we are going to discuss the star rating systems, the developments or sustainable development framework and then where the geoinformation and how the geoinformation plays a role or contributes in this way to achieve a star rating system and can be practiced by the mining industries or by the miners. So, what are the pillars?

We already know that the social, environmental and economic development. These three are the three main pillars as far as the sustainable development is concerned. So, they are all valid as far as the mining sector or the mining industry is concerned. so in terms of the environmental we need to understand that how this is obeyed or respected as far as the mining industry so this needs involvement or preservation of natural capital ecosystem integrity carrying capacity biodiversity including the geodiversity as far as the social sector is concerned we need to understand and ensure that the preservation of social capital by incorporating concepts of equity, accessibility, cultural identity and institutional stability.

And at the third component which mostly the industry they are more or less little bit selfish in terms of this because ultimately they want to make as much profit as possible.

So, in terms of the third the economic aspect it involves in terms of building a capital implying financial feasibility while development moves towards environmental and social So, the economic sustainability has to come in parallel or together with the social and environmental sustainability. So, these are the three main pillars we know it already, but let us see how to respect or to comply to these three pillars of the sustainable development. what are the instruments we have here in this case let us be let us know about the sustainability performance monitoring what it is it is a comprehensive process which aims at evaluating and improving all three your economical social and economic impacts of mining activities while ensuring compliance with SDGs.
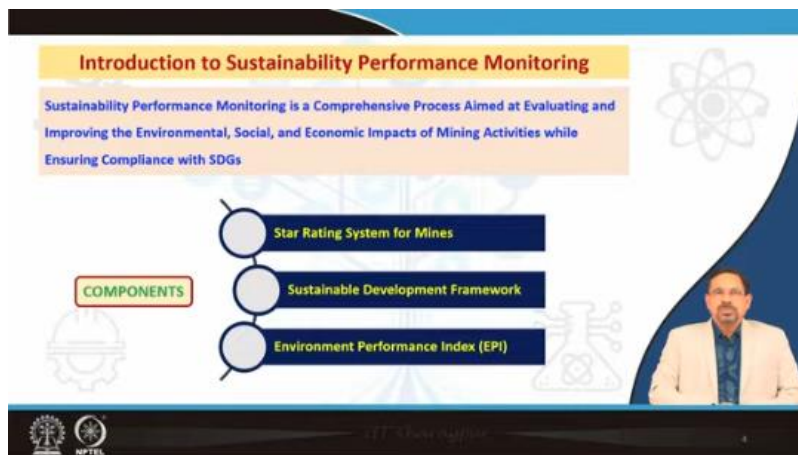
So, these three will be will be what you say will be there environmental social and economic aspects, but over mining industry or by the miners how this is complying or these three are complying in order to achieve or how they are following the different sustainable development goals that is that is what is the sustainability performance monitoring. And this sustainability performance monitoring is more or less becoming binding to all the mining industry and the sectors. So, the major components in terms of the sustainability performance monitoring are first star rating systems for the mines. So, one important component is that different countries and here we will be discussing about our own country Government of India has already introduced various kind of star rating systems for the mines. Then the sustainability development framework we will see the goals and the different parameters of this and also the EPI the Environment Performance Index.

So, let us know what the star rating system for mines is. A star rating system is an initiative by the Ministry of Mines, Government of India, aimed at promoting sustainable mining practices. Mining has to be sustainable. So, they have to comply with all three

parameters: social, environmental, and economic. They need to comply with all the sustainable development goals.

We have 17, having already discussed 16 as far as the geo-information applications are concerned. So, how does the mining sector promote sustainable practices? So, the star rating system is a web-enabled online system. So, the moment we say web-enabled, that means it is accessible to all who need it, and the data—whether spatial or non-spatial—must be available. There has to be some interaction between the data and information exchange.

So, these are the few important parameters that come by default when we talk about a web-enabled online system or a web-enabled online platform. So, this web-enabled online system is useful for evaluating measures undertaken for sustainable mining. So, the miners or the mining industry must have taken several measures to comply with sustainable mining. So, this web-enabled online system evaluates that. So, it is evaluated by the authority on behalf of the Government of India—in this case, the Ministry of Mines—and this web-enabled online system, which deals with the star rating system, has a two-layered system.

first layer is dealing with or deals with the application or the first layer provides self evaluation templates that is to be filled in by the main operators. So, one set there are there are already some self evaluation templates which needs to be filled the information against those parameters needs to be provided by the mine operators and then this information what has been provided that will be evaluated or validated by the bureau of mines on behalf of Government of India. So, it has a two layered system. So, whatever data you fill or you provide that will be again be verified and validated by the Bureau of Mines. Fourth it is a user friendly evaluation system which instantly awards the points

based on the information filled in by the mine operator and can be assessed by public as well.

So, the star rating system is a two layered system or two-layer web enabled platform or system where it is very very user friendly and it immediately you fill the data it is validated and you get how much hours are a rating is given. But, this is also accessible to the public. So, the public who wants to know about the sustainability status of the mine around their locality or what it is doing, so they will have an access. And the star rating system, it is designed to assess and incentivize sustainable mining practices. This system ensures that mining operations align with environmental and sustainable standards.

So, this star rating system is designed to assess and incentivize sustainable mining practices. So, the moment your rate or star rating is good, there will be incentives for that. So, as a promotion measure or encouragement measure. So, this system ensures that mining operations align with environmental and social standards. Now, let us see the various components.

So, the mines are rated on a scale of 1 to 5. So, 1 to 5, 5 where the score is more than 90 percent, 4 where the score is 80 to 90 percent, 3 where the score is 71 to 80 percent, 2 where the score is 61 to 70 percent and 1 where the score is 41 to 60 and below 40 there is no rating or no star rating. So, what are the evaluation criteria or parameters? The evaluation parameters consist of managing impacts through scientific and efficient mining, social impacts of resettlement and rehabilitation, local community engagement and welfare programs, progressive and final mining closure. So as far as when the mining activity is over, how it is closed, what are the scenarios that have been considered or what is the post closure mine scenario.

And then if the sustainable standard or the international standard have been practiced or adopted in this or not. So, these are the evaluation criteria or parameters as far as the star rating is concerned. Now, let us move on to sustainable development framework called SDF or abbreviated as SDF. So, here it is formulated as part of the national mineral policy as far as Government of India concerned by the ministry of mines. So, abbreviated as NMP 2008.

This SDF it aims to address ecological social and infrastructure challenges posed by mining while promoting sustainable development. Then the guiding principle shall be that a miner shall leave the mining area in better ecological shape than he found he or she found it or before or before he accepted or gone for this activity. So, here as we have already discussed we have the strength of remote sensing where we have the data satellite based data since last 52 years available now. So, using this data set we can very well go back and see what was the scenario 20 years back or 30 years back before the mining activity has undertaken. And then using several change detection techniques, we can see that what is the status now or what is the status after the post closure or what is the status post closure mining.

Then, the SDA framework was developed. It is aimed at development through extensive stakeholder consultations with academia, professionals, and state-level authorities. It is applicable to mining operations across sectors, including small-scale mines, captive mining, or large standalone mining operations. So now, let us see the core principles of the sustainable development framework. First is economic viability. Second is social responsibility.

And the third, importantly, the third aspect is environmental sustainability. So here, in terms of environmental sustainability, the satellite-based or geoinformation-based tool is

very useful to understand and can guide in minimizing ecological damage, thereby ensuring sustainable post-mine land use activities. The fourth one is technical and scientific soundness. Mining practices must adhere to higher technical and scientific standards for optimal resource utilization. So, efficient use of mineral resources ensures long-term benefits. So, these are the core principles of the sustainable development framework. I will repeat: economic, social, and environmental—we know the three pillars of sustainability.

But along with that, technical and scientific soundness and the optimal resource utilization protocol are also added to the core principles of the sustainable development framework. So, the framework principles for sustainable mining include environmental and social sensitivity in mining decisions. So here, remote sensing data—we already know optical, LiDAR, microwave, even thermal—are useful in classifying the mine areas or the mining sector, the areas, or the ecosystem around the mining based on social, environmental, logistical, and various other parameters such as technical. So, this has to be done in a continuous mode. So, continuation in terms of this classification, this change, and what the scenario is—this needs to be done. So here, we have—we already discussed—geo-information plays a very crucial role.

And the third is intensive engagement with state governments and central ministries such as the Ministry of Environment, Forest, MOTA, MOR, and UD. The second is strategic assessments in key mining regions. So, let us try to identify. So, through this principle, through the framework principles of sustainable mining, the strategic assessment in mining regions includes the identification of the thrust areas for environment, ecology, logistics, infrastructure, and socio-economic development. So, in all this, the thrust areas as felt out here—your geoinformation—do play a big role.

So, it also helps in terms of defining the carrying capacity when you put a lot of data into that and try to determine what the carrying capacity of a region is and what the current status is. Then, accordingly, you can see if you can add or remove something so that such decisions can be well taken, and accordingly, resource mobilization can happen—mining extent, production levels, and the pollution load. Yes, we have already discussed or known that the power of remote sensing, the power of geoinformation as the umbrella term, helps in understanding the extent of mining, as well as understanding the effect or the load as far as various pollutants are concerned, and then conducting social impact assessments and other necessary studies. So, here, GIS plays a very important role as far as the integration activities are concerned. Now, mining impacts at the mine level or managing the impacts at the mine level. It involves developing sustainable policies for each mine and establishing sustainable development units, setting goals in terms of conducting periodic reviews, and things like that.

Then, coming to the next point: addressing land resettlement and social impacts, protecting the rights of the project-affected persons, and conducting social impact assessments to monitor and address resettlement issues. These are extremely important and well benefited from the utility of geoinformation. Community engagement and benefit sharing. So, here also, different types of community engagements and benefit sharing involve the use of data through the GIS platform. Mining closure and post-closure.

The development of closure models aligned with local aspirations and sensitivity. So, various kind of closure models there may be mining specific or location specific needs to be developed and then create individualized closure plans for each mine and leach areas. So, here also geoinformation plays are as an important role to play with. Now, moving on

to monitoring the frameworks or what are the monitoring frameworks and technologies as far as the geoinformation is concerned. So, geoinformation technologies and framework play a critical role in ensuring effective sustainability performance monitoring.


Satellite data particularly remote sensing from various remote sensing platforms, I have been telling optical, LiDAR, microwave, thermal or even from UAV platforms. So, or even from other aerial platforms. So the data along with the GIS they used to monitor various aspects including land degradation, vegetation cover, water quality and many other environmental and pollution parameters over and around the mining areas. So, thereby geo-information helps in terms of tracking the progress on mining, reclamation, rehabilitation and many other things we have already discussed. So, these now can straight away play an important role in terms of bringing out the rating or the star rating system as far as mining is concerned.

The geoinformation role is going to be crucial as far as bringing out the information in a platform or a web enabled platform for star rating or that could be useful for evaluating the star rating as far as each mine is concerned. Coming to the IoT and other sensors, we know that this IoT, this internet of things through various sensors devices, they help in terms of real time monitoring of various parameters over the mining areas including air quality, water pollution, soil health etcetera. And, thereby they track the emissions and they and utilize the resources in mining operations. So, IoT and sensors that also make part of the broader geoinformation umbrella, they are really useful and in this way they can contribute or do play a role in terms of the star rating parameter is concerned. Then coming to the big data and analytics.

Here the big data and analytics they enable predictive analysis for environmental risks assist in identifying trends and correlations to optimize resource use and reduce the

waste. So, coming to the fourth one is the drones and the unmanned aerial vehicles abbreviated as UAV. So, aerial survey over mining area mining regions. So, whatever this platform either it could be aircraft or it could be a drone. So, whatever it is you put the sensors whatever we want to measure in terms of optical, lidar, thermal or emissivity based or columnar or average whatever we need to monitor or measure.

We can fly it over based on aerial survey over the mining region. And thereby we can monitor the compliance with safety standards and reclamation efforts. So, in this we very well understand and convince that yes the geoinformation has an important role to play as far as the monitoring framework is concerned. So, we have already discussed about different examples here is one given by Mhaske et al published in 2021, it is a case study that is as an example we have brought it before you that deals with the comprehensive assessment of soil environment in a mining site. So, this has implications as far as sustainable development is concerned management prospective is concerned.
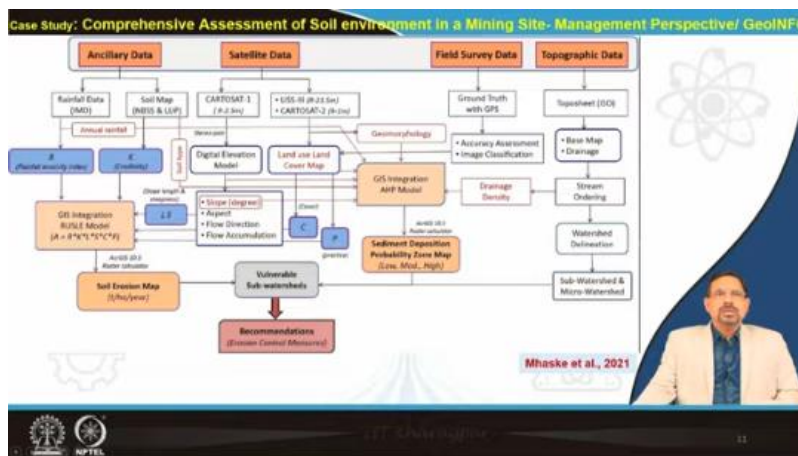
following the geoinformation based approach we can very well see that various various levels of data ancillary data coming from various other sources satellite data field survey data and the topography data the ancillary data may come from survey sources or from various indirect sources the topography data also may come from the satellite based based measurements satellite data here itself is giving you a lot of information as far as land use land cover change and the topographical analysis is concerned So, here this the authors they try to collect this data over a mining area and trying to assess the soil erosion potential or soil loss over different region over a mining area. So, this kind of study using geoinformation platform or using geoinformation technology on a geospatial platform helpful in terms of giving us various solutions. Here in this case, it is a solution as far as soil conservation is concerned.

So, similarly, these kinds of studies exist. We have discussed many examples, various methods and techniques, as well as different data utilities. So now, they need to be carefully and intelligently evaluated and considered when the star rating information is supplied. So, this contributes to the scientific and technical or technological basis of generating, proving, showcasing, and supplying information to the mining bureau for evaluation. Now, let us consider the broader sustainable practices in the mining sector.

So, we have CSR (Corporate Social Responsibility), climate change mitigation potential, transition to renewable energy sources for mining operations, and water and waste management. So, where the recycling and reuse of water within operations, safe disposal of mining waste, and tailing activities need to be done. Then we also discussed the conservation of biodiversity, flora, fauna, and microbes. So, that maintains the natural habitat and promotes afforestation in mining-affected areas. Sustainable supply chains.

So, ensuring raw materials sourced from mines must adhere to sustainable practices. So, these are the broader sustainability practices as far as geophysical technology is concerned, as it helps or has the strength to support climate change mitigation. Waste and water management is concerned; biodiversity conservation is concerned. And through the GIS, or dominantly through the GIS database, the other two—particularly CSR (Corporate Social Responsibility) and sustainable supply chain activities—can be monitored and well-regulated in the mining sector. These are the references used for discussing this 40th lecture.

So, let us conclude as far as the star rating system is concerned. So, initiatives like the star rating system, sustainable development framework, and environmental performance index promote sustainable mining practices while ensuring compliance with environmental and social standards. Rating systems encourage competition among mining companies to achieve operational excellence and align with global sustainability benchmarks. Emphasis on stakeholder consultations, socio-economic development, and benefit sharing ensures inclusive growth and addresses concerns of local communities.

Measures such as land reclamation, biodiversity conservation, water and wastewater management minimize environmental impacts and ensure responsible mining practices. So, towards the end, in a broader sense, the use of geo-information tools that comprise GIS, remote sensing, IoT, drones, and big data analytics enhances monitoring, compliance, and planning of sustainable mining operations, thereby helping in certification processes such as the star rating system. Thank you very much.