**SUSTAINABLE MINING AND GEOINFORMATION**

**Prof. Mukunda Dev Behera**

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

**Indian Institute of Technology Kharagpur**

**Week – 08**

**Lecture 37: SDG 12, 13**

Welcome, let us talk about SDG goals number 12 and 13. SDG 12 talks about Sustainable Consumption and Production, while Sustainable Development Goal number 13 talks about Climate Action. So, these two have a very important bearing on the mining industry or mining sector and benefit from geoinformation technology. In terms of the concepts covered, we will be discussing geoinformation technology for sustainable consumption and production in the mining sector. So, that is SDG goal number 12: sustainable consumption and production.

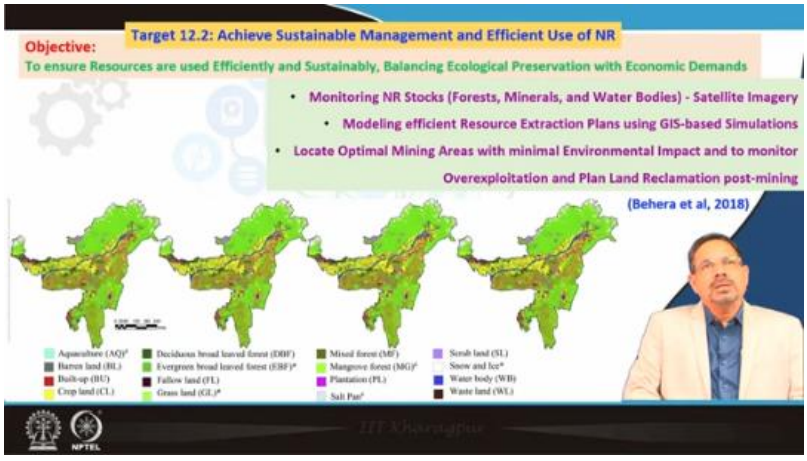

SDG 13 deals with climate or climate action. So, let us discuss geoinformation tools and their utility for assessing climate risk and promoting climate action in the mining sector. We will also have a few case studies that deal with the integration of geoinformation tools for promoting sustainable consumption, production, and climate action. As far as SDG goal number 12 is concerned, it ensures sustainable consumption and production patterns, focusing on Sustainable Consumption and Production (SCP), which are crucial in reducing environmental degradation, resource depletion, and waste generation. So,

these three are very important in terms of their impact reduction as far as degradation, resource depletion, and waste generation are concerned.


This sustainable consumption and production promotes resource efficiency, sustainable infrastructure, access to basic services, green jobs, and a better quality of life. Geoinformation tools provide spatial data and analytical tools that help in monitoring, managing, and optimizing the resources available for optimal use. And also in terms of less waste generation and lowering pollution levels. So, we need the help of this technology—geoinformation technology—that has its power in spatial data analytics, which in turn helps in monitoring, managing, and optimizing resource use, minimizing waste generation, and reducing pollution levels. So, geoinformation supports sustainable practices and decision-making by offering evidence-based insights.

As far as section 12.1 of this sustainable development goal target is concerned, it aims to implement a 10-year framework of programs on sustainable consumption and production patterns. So, it is a 10-year framework. So, here the main objective is to adopt sustainable consumption and production practices in order to balance economic growth with environmental stewardship. So, monitoring the global and regional patterns of natural resource extraction and land use changes helps in this. Mapping the hotspots in terms of unsustainable resource use, such as deforestation or mining activities, is very important and contributes to achieving target 12.1.


Assessing mining-induced land degradation and proposing sustainable extraction practices is also one of the sub-objectives that attains this. Promoting a framework for resource efficiency and environmental accountability in mining operations. Now, the subsection target 12.2 deals with achieving sustainable management and efficient use of natural resources. This aims to achieve the objective in order to ensure resource availability, resource efficiency, and their sustainable use to balance ecological preservation with economic demand. So, it is very important because we need to optimally and efficiently use our resources.




So, we need to maintain a difficult balance between ecological preservation and economic demand. So, in order to achieve this objective, monitoring various natural resource stocks, such as forest resources, mineral resources, and water bodies, can be done using geoinformation in the mining sector or over mining areas using satellite imagery and other geoinformation-based technologies. Modeling efficient resource extraction plans is very well possible or can be achieved over mining regions using GIS-based analysis and simulations in order to predict in terms of heat cast and forecast. Third

is to locate optimal mining areas with minimal environmental impacts and to monitor overexploitation of plants in terms of land reclamation and post-mining. So, what happens over the mining areas—we need to, or the objective should be, to cause minimal environmental damage or to minimize environmental impact.

So, to do this we need to monitor or to achieve this we need to monitor the if there is any kind of over exploitation in terms of the natural resources or we also need to address in terms of the land reclamation in order to achieve the pre mining status. So, this land reclamation is a must or we should do it very carefully and very sincerely after the mining activity or we say the post mining activities. So, satellite remote sensing is very well useful in terms of giving us a change in terms of the land cover, we can very well know what was before and what was after. So, in this particular four figures the sub figures you can see this is the North East India over Brahmaputra river basin as far as Indian continent goes Indian nation goes published in Behera et al in 2018 where 1985, 1995, 2005 and 2015 the land cover has been mapped. So, similar way satellite data is useful in terms of mapping various land use land cover over the mining region or mining areas.

This helps in order to understand what was the status before the mining and what so that all measures can be taken to restore the same land cover status post mining. The target 12.4 that deals with environmentally sound management of chemical wastes objective is to minimize the release of harmful chemical and wastes into the environment thereby ensuring their life cycle is managed sustainably. It is very important as far as the sound management of chemical and waste or any other hazards, chemical hazards or waste materials are concerned. So that we can ensure that their life cycle is managed sustainably and they are not causing any kind of harm to the environment. So, in this effort geoinformation technology provides detailed insights into resource consumption patterns and waste hotspots mapping such as tracking the urban sprawl areas, monitoring the deforestation activity where it is happening again and over time.


And, then also analyzing the industrial waste discharge locations. So, this is very well can be benefited using geoinformation technology from satellite data and some ground based reconnaissance or validation survey. And remote sensing helps in monitoring the resource extraction sites in order to quantify resources consumption and also helps in terms of contributing help in terms of analyzing the resources consumption pattern over the mining region. So, GIS the broad the geo-information technology pinpoints the areas where mining activities generate waste in a sense to help in terms of waste management over the mining locations or the mining in mining industry areas. Now, the next target target 12.5 deals with reduction of waste generation.

So, substantial reduction in terms of waste generation in order to focus on prevention reduction recycling and reuse of waste. So, three R's are we say as we say in terms of reduction, recycling and reuse of waste in order to focus the prevention as much as possible. So, this can be optimally done in terms of waste collection routes through GIS that reduces the fuel use and emission. One small help in terms of GIS here as an application in order to bring out with the waste collection route, optimal waste collection route so that the fuel utility or fuel efficiency or fuel use efficiency is optimum the second can be identifying the suitable locations for recycling centers or for bringing up bringing out or constructing the recycling centers and the landfill sites so depending on the load in terms of the waste collection and the distribution of the waste and their collection

GIS can be or geoinformation in general can be useful in terms of providing or identifying or suggesting the recycling centers and various landfill sites in order to support the economy or sometime we say circular economy. Tailing and other mining activities and their byproducts can be managed using geoinformation tools thereby

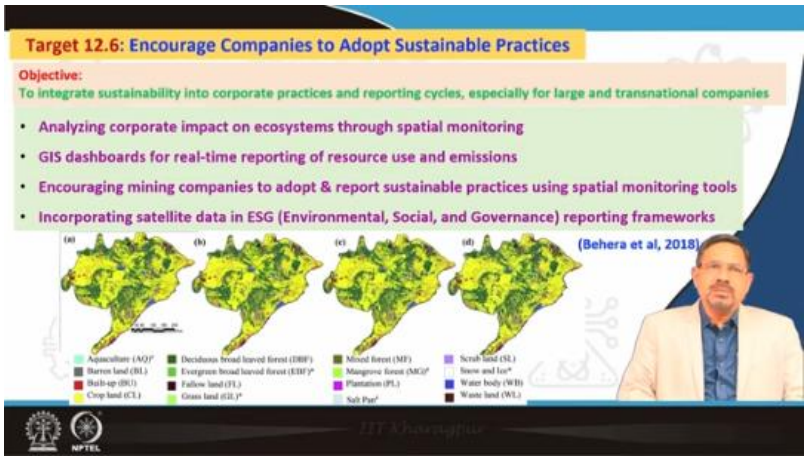
reducing their environmental footprint. Yes, remote sensing by virtue monitors the waste storage sites to prevent contamination. Contamination monitoring is very very important and remote sensing by its capability of periodic data providing the periodic data helps in terms of monitoring many other things including the waste storage sites so as to prevent from any contamination. A case study identifying and ranking landfill sites for municipal solid waste management.


Objective is to develop an integrated framework using remote sensing and GIS in order to identify and rank suitable landfill sites. Look at this particular example on the right hand side the map depicts the suitability of landfill sites given by Aslam et al published in 2022. They have used Landsat 8 OLI data and the thermal infrared sensor images that are that are available at 30 meter resolution. And, what they did they have derived a few indices based on normalized difference. So, the NDVI normalized difference vegetation index, normalized difference built-up index and normalized difference water index.

So, these respectively help in order to optimize the representation, availability, or strength of vegetation, built-up areas, and water bodies. GIS layers—yes, the other datasets in terms of the survey or the attribute data, such as population data, the road network, water bodies—were mapped and taken into account using the Thiessen polygon approach as far as spatial extrapolation is concerned. So, the methodology involved the creation of Thiessen polygons for dividing the study area, weighted overlay analysis of remote sensing indices and physical factors, assigning the highest weight to NDVI (up to 35 percent) as far as the built-up index is concerned. And a ranking and evaluation approach was followed using journal statistics. So, journal statistics were used to rank the polygons based on suitability for landfill development.

What are the key findings of this study? Yes, in the form of the spatial map, they could identify the suitable and unsuitable areas. About 70 percent of the areas were found suitable for landfill development. Polygon number 6 was ranked best due to low population, accessible roads, and minimal vegetation and water bodies, whereas 30 percent of the area was found unsuitable due to high population density and proximity to high-population-density zones. So, it was found that using the geo-information approach can effectively identify and rank suitable landfill sites that can be used for waste disposal or waste storage.

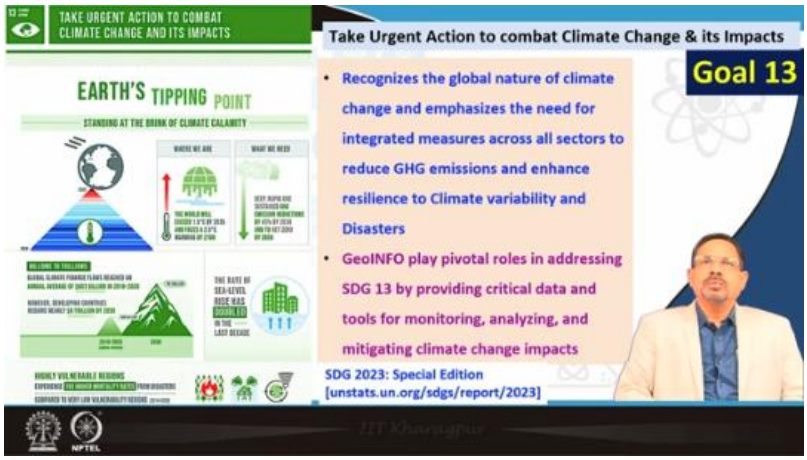
Next, let us move to Target 12.4, which deals with the environmentally sound management of chemical waste. The objective is to minimize the release of harmful chemicals and wastes into the environment, thereby ensuring that their life cycle is managed sustainably. Target 12.5 deals with the reduction of waste generation—substantial reduction of waste generation. So, now, in terms of Target 12.6, it encourages companies to adopt sustainable practices. So, the objective is to integrate sustainability into corporate practices and reporting cycles, especially for large and transnational companies.




So, how this can be achieved or this can be achieved using the geoinformation tool? Using geoinformation tool the corporate impact on ecosystems can be analyzed through spatial monitoring. And this geoinformation dashboards can be useful in terms of real-time reporting of the resource use and emissions. Also, encouraging mining companies to adapt and report sustainable practices using spatial monitoring tools, incorporating satellite data in ESG - Environmental, Social and Governance reporting framework. So, these four ways we can integrate sustainability into the corporate practices.

So, what we can do? We can do lot of analysis as far as analyzing the ecosystem through spatial monitoring. We can also generate GIS dashboards for real-time reporting. We can also adapt and report various sustainable practices using spatial monitoring tools. We can also incorporate certain data as far as the environmental, social and governance is concerned.

So, all this in totality or together gives us or encourage companies to adapt sustainable practices. Down below, we have again a land use land cover map of different at a decadal frequency that has been derived using the satellite data. So, it helps in terms of regular monitoring and thereby provides information for various planning using spatial monitoring approaches. Now, let us move on to the next goal number 13. So, SDG sustainable development goal number 13 deals with climate action.

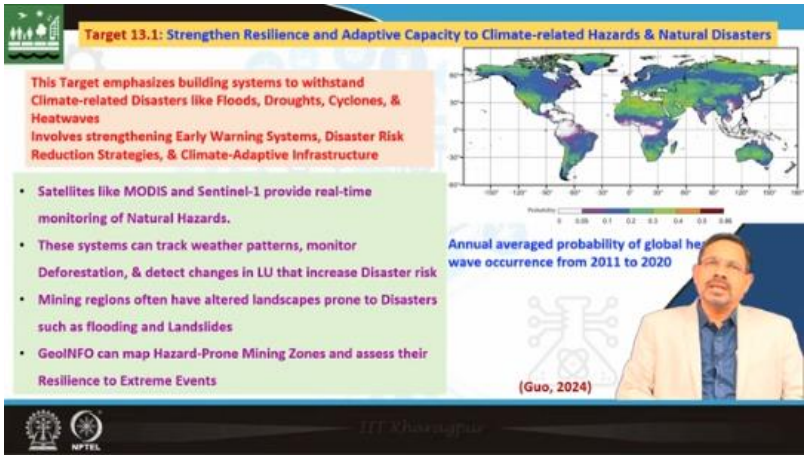



So, it talks about urgent action to combat climate change and its impact. So, thereby this particular SDG goal number 13 aims at recognizing the global nature of climate change. and thereby emphasizes the need for integrated measures across all sectors to reduce greenhouse gas emissions and enhance resilience to climate variability and disasters. So, two things one is the climate change is of global nature and this can be measured or should be measured across all sectors including mining, agriculture and many other industrial sectors. So, as to reduce the greenhouse gas emission.

So, as all of us understand the greenhouse gases like carbon dioxide, methane, nitrous oxide, water vapor all these are contributing to recent days rapid temperature rise or climate change is a warming effect. So, we have a responsibility to reduce the greenhouse gas emission in all sector including the mining industries, so that we can reduce and bring more resilience in terms of climate variability including the climate induced or extreme weather event induced disasters. So, geoinformation play pivotal roles in addressing SDG 13 by providing critical data and tools for monitoring, analyzing and mitigating climate change impacts. So, on the left hand side there is a good depiction that talks about take urgent action to combat climate change and its impact are stepping point. So, we all have been talking these days about restricting the temperature rise by or up to 1.5 or 2 degree centigrade in comparison to the last industrial era or the beginning of the industrial era that we usually mark between 1850 to 1900 average temperature.

So, we all need to be extremely careful and take urgent action. So, at every sphere, at every locality, at all sectors including our mining industry to combat the climate change and also mitigating or minimizing its impact. The target 13.1 deals with strengthening resilience and adaptive capacity to climate related hazards and natural disasters. This target emphasizes building systems to withstand climate related disasters like flood,

drought, cyclones and heat waves. So, this involves strengthening early warning systems, disaster risk reduction strategies and climate adaptive infrastructure.

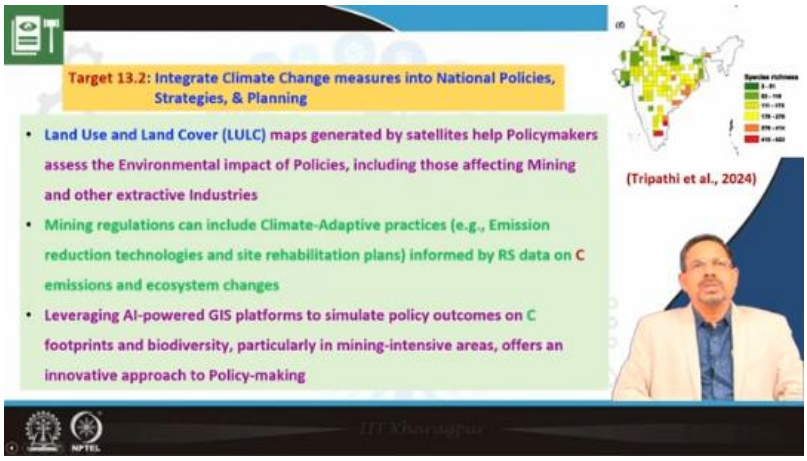



On the upper right hand side, you can see an image of the globe that is dealing with annual average probability of global heat wave occurrence during 2011 to 2020. And the scale bar is shown there the orange and the dark red talks about higher in terms of the probability. And as we can see most of the areas over the earth's terrestrial land surface is showing higher probability in order of means annual average global heat wave occurrence. So, satellites like MODIS and Sentinel-1 provide real time monitoring of natural hazards. These systems including the MODIS, the Sentinel over India we have the Indian remote sensing system IRS.

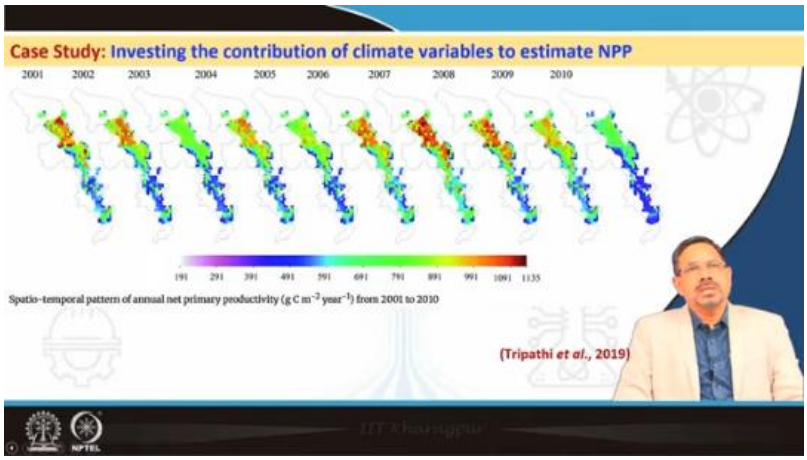
So, all the systems they provide lot of real time data for monitoring this natural hazards which are mostly induced from the extreme weather events. So, these systems can track the systems which can be generated using geoinformation technologies can be useful in terms of tracking the weather patterns, monitoring deforestation and detecting changes in terms of the land use that increase the disaster risk. The mining regions often have altered landscapes that are prone to disasters such as flooding and landslides. Geoinformation can map hazard prone mining zones and assess their resilience to extreme events. So, geoinformation has a really really important role to play as far as strengthening resilience and adaptive capacity to climate related hazards and natural disasters.

And remote sensing by virtue of providing data over inaccessible and over larger areas play a very very important role in order to address the adaptive capacity to climate related hazards and the natural disasters. Now let us move on to target 13.2 that deals with integrating climate change measures into national policies strategies and planning. So, land use land cover maps the maps generated using the satellite data can help the policy

makers to assess the environmental impact of policies including those affecting mining and other extractive industries. On the right hand side, we can see that such a map in terms of the species richness are useful in terms of bring or giving the giving inputs as far as national policy and planning is concerned.




Mining regulations can include climate adaptive practices such as emission reduction technology and site rehabilitation plans that may inform or that could inform using the remote sensing data on the carbon emission and ecosystem changes. So, we can use such mining regulations as far as the climate adaptive practices as concern that will inform the remote sensing data as far as the carbon emission and any changes over the mining region or per say any kind of ecosystems. So, in this in this in today's day we can use the AI or artificial intelligence powered GIS platforms under the broad umbrella of geo information to simulate policy outcomes on carbon footprints and biodiversity. Particularly in mining intensive areas that could offer an innovative approach to policy making. As far as the next one is concerned is a case study that deals with investing the or investigating the contribution of climate variables to estimate the net primary productivity.

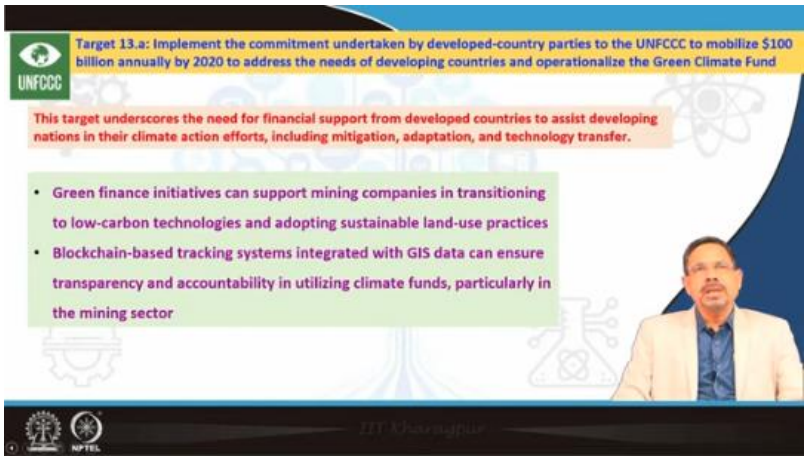



These kind of studies in terms of are are benefited from geospatial technology, where we do lot of observations, satellite based observation and modeling and the integration of ground based inputs. So, that we can come out with spatio temporal pattern as far as the annual net primary productivity is concerned. So, this deals with in terms of the carbon which is fixed or withdrawn by the process of photosynthesis by plants from the atmospheres or you say from the ambient atmosphere. So, this kind of regular maps also talks about different pattern and spatially also it quantifies how much where in terms of the annual net primary productivity in annual scale. So, these when we corroborate the net primary productivity with other climate variables such as temperature, precipitation, moisture availability all these which controls the plant photosynthesis gives us a very comprehensive idea and understanding as far as the climate variability in order to withdraw the atmospheric CO2 or carbon by the plants.

So, these studies are very helpful and useful in terms of understanding the potential of the plant or the ecosystems or the plant system of present over any ecosystem such as mining area in order to understand their carbon dioxide or carbon withdrawal potential. Now, the target 13.3 that deals with improving education, awareness raising and human and institutional capacity on climate change, mitigation, adaptation, impact reduction and early warning. So, this target highlights the importance of educating individuals, institutions and communities on climate action and equipping them with the skills and tools that are necessary for effective climate response. So, in order to achieve this, the geoinformation technology helps in terms of providing open access to satellite data. We have various data portals.


We have as far as the Indian remote sensing series of data is concerned, we have Bhuvan. Sentinel data, we have the Copernicus and so on. So, these actually help the local bodies, local communities, the mining authorities, researchers to monitor and understand the trend as far as the climate is concerned. And coming to the virtual reality VR, simulations using the GIS based 3D models over the mining areas can enhance community education about the impact of mining on climate change and the disaster risk. So, educating the people or the stakeholders those stay around or within the mining industry or mining areas is very, very important and that can well be achieved using the geo information set of tools.

Moving next target 13.a deals with implementing the commitment that are undertaken by the developed countries or parties to the UNFCCC to mobilize 100 billion dollars annually by 2020 to address the needs of developing countries and operationalize the green climate fund. So, this 13.a talks about the green finance and green finance targeting. Now, let us move on to a technique that is used in the mining industry called the green mining technology. So, this technology promises a lot of things as far as the future of the green mining is concerned that deals with advancement in terms of AI driven analytics, advanced sensors and automation they are transforming the mining operations. Technological innovations, AI applications enable predictive maintenance process, process optimization and informed decision making.

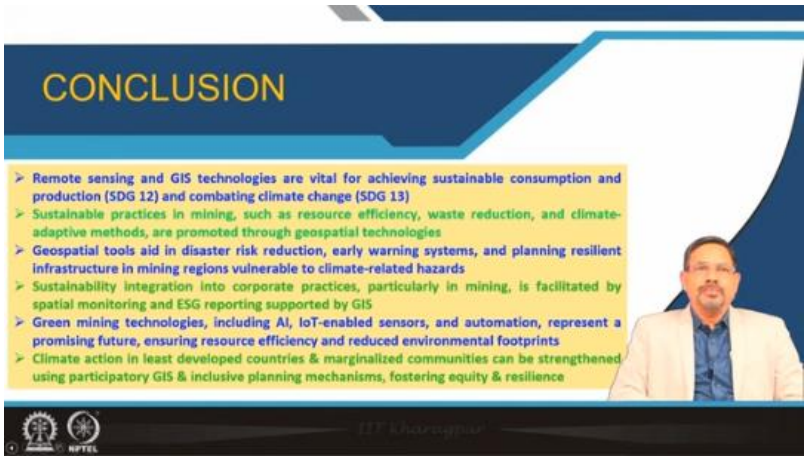




We also have sensor technology advances. We also have lot of benefits as far as automation goes. So autonomous vehicles, robotic systems enhance the safety by reducing human exposure to hazardous environment. So integration of renewable energy future mining operations will increasingly rely on the reliable energy resources. So all this together is included under the green mining technology and also there by benefit in order to achieve sustainable mining.

Target 13.b emphasizes inclusivity in climate action, thereby ensuring that vulnerable and marginalized groups actively participate in climate planning and decision-making processes. So, in this case, satellite imagery helps to identify climate-vulnerable regions. The mining operations in these kinds of least-developed countries are areas where development is lacking. It helps in integrating gender-sensitive and community-focused initiatives. The other one involves participatory GIS platforms, which help in engaging both genders—women and youth—in mapping climate-vulnerable communities.


All these references I have used for framing this particular lecture, number 37. So, we need to conclude that we have understood that geoinformation technologies are vital for achieving sustainable consumption and production (SDG 12) and also for achieving climate action or combating climate change (Sustainable Development Goal 13). Green mining technologies, including AI, IoT-enabled sensors, and automation, represent a promising future, ensuring resource efficiency and reduced environmental footprints. Climate action in least-developed countries and marginalized communities can be strengthened using participatory GIS and inclusive planning mechanisms, thereby fostering resilience and equality. So, in totality, we have understood that geoinformation technology is extremely useful in achieving or realizing Sustainable Development Goals 12 and 13, which deal with participatory resources and climate action in the mining industry.




Thank you very much.