SUSTAINABLE MINING AND GEOINFORMATION

Prof. Mukunda Dev Behera

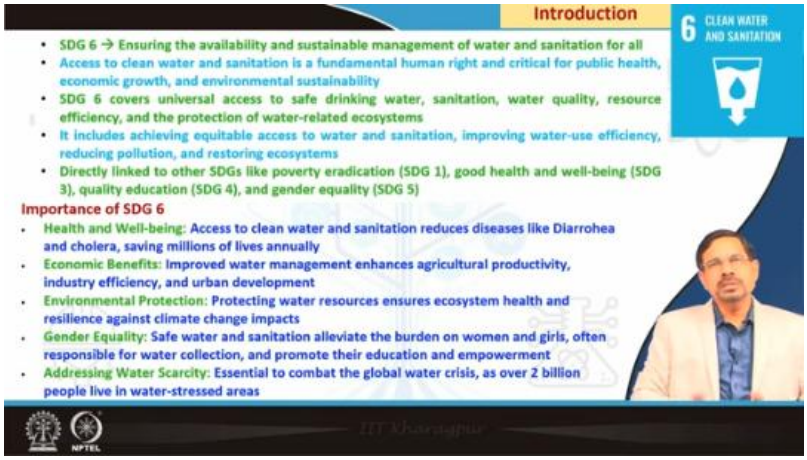
Centre for Ocean, River, Atmosphere and Land Sciences (CORAL)

Indian Institute of Technology Kharagpur

Week – 07

Lecture 34: SDG 6 [Clean Water and Sanitation]

Welcome, let us discuss sustainable development goal number 6, which deals with clean water and sanitation. So, through this, we will cover the concepts, particularly water resource management in mining areas, in terms of monitoring contamination and optimal water usage. Then, we will see how geoinformation can benefit in terms of detecting water scarcity and implementing sanitation programs. Also, we will take on a case study that deals with groundwater potential zones as far as sustainable development is concerned. So, what is SDG goal number 6, which deals with clean water and sanitation?



As far as SDG 6, sustainable development goal number 6, is concerned, it ensures the availability and sustainable management of water and sanitation for all. It is extremely important that water sustainability should be managed. And sanitation should be good; sanitation should be ensured and available to all of us. So, to achieve this, what are the things? First, access to clean water and sanitation is a fundamental human right and critical for public health, economic growth, and environmental sustainability.

It is the importance of availability or accessing clean water and sanitation. It is a really fundamental human right. So, SDG 6 covers universal access to safe drinking water, sanitation, water quality, resource efficiency, and the protection of water-related ecosystems. It includes achieving equitable access to water and sanitation, improving water use efficiency, reducing pollution, and restoring ecosystems. It is also the sustainable development goal number 6, which deals with clean water and sanitation, and is directly linked to other sustainable development goals like poverty eradication, that is SDG number 1.

Good health and well being that is SDG number 3, quality education that is SDG number 4 and the gender equality that is SDG number 5. So, this is directly linked to SDG 1, 3, 4 and 5. So, let us see the importance of SDG 6 it talks about health and well-being that means access to clean water and sanitation reduces diseases such as diarrhea cholera thereby saving millions and millions of lives in an annual time scale the economic benefit. So, economic benefit could be improvement in terms of could be improved as far as the water management enhances the agriculture productivity industry efficiency and urban development. If it can be properly managed if clean water and sanitation then it the through water management this can the agriculture productivity can be enhanced the

industry industrial efficiency can be enhanced the urban development also can be properly managed.

So, these are all very linked economic benefits. Third as far as the environmental protection is concerned protecting the water resources ensures ecosystem health and resilience against climate change impacts. So, if we protect the water system and the resources particularly the ecosystem that holds the water resources. And this this through this climate change impacts also can be addressed or we can also have a resiliency measure as far as the water resources is concerned. Then the gender equality safe water and sanitation will alleviate the burden on women and girls often responsible for water collection and promote their education and empowerment.

So, it will have a double benefit. So, if we ensure safe water and sanitation on one hand it will reduce the burden which already is there on our children particularly girl children and the women in a household. So, if we can do that then the same human resources such as women and girls they can be responsible for more important activities such as they can be empowered for many other activities they can also get better education or devote more time towards quality education. So, it will so, SDG 6 helps in that way in terms of promoting the gender equality and empowerment. Addressing water scarcity is essential to combat the global water crisis as over 2 billion people live in water stressed area.

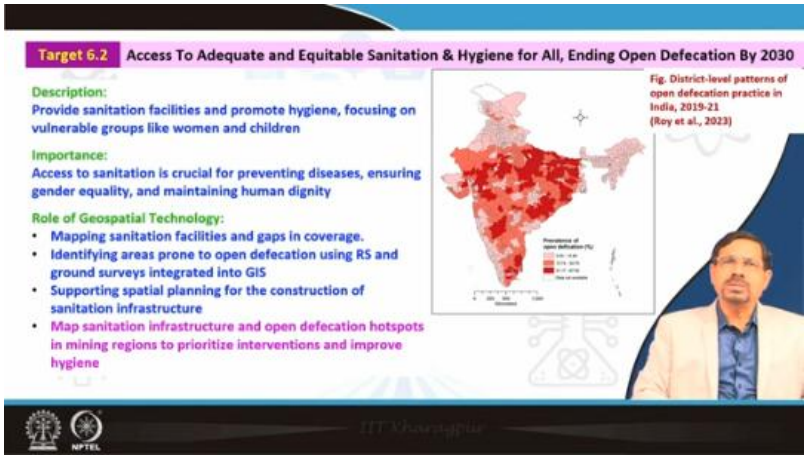
So, look at this—over 2 billion people live in water-stressed areas. So, if you can address the water scarcity, then it will help in combating the global water crisis. As far as the mining industry sector is concerned, SDGs 1, 3, 4, and 5 all have affiliations and are directly or indirectly linked to SDG 6. So, if we ensure clean water and sanitation within the mining industry areas or their surrounding areas, then we can really contribute to achieving SDG goal number 6. Let us see each subsection of target 6.1 as far as SDG goal number 6 is concerned.

Target 6.1 deals with universal and equitable access to safe and affordable drinking water for all by the end of this decade. So, on the right-hand side, we can see a map with representations in different colors showing the proportion of the population using basic drinking water, and over some parts of the African subcontinent, we can see many places where it is less than 50 percent. So, there we have challenges; there we have things to do. So, as far as target 6.1 is concerned, ensuring everyone has access to clean and affordable water reduces health risks and improves quality of life—this is very important and valid for the mining industry sector. The importance of target 6.1 is to ensure access to clean drinking water, which is essential for public health and human dignity.

So, how can geoinformation as a technique or tool play a very important role? The role it can play is mapping water resources and their accessibility in the mining region and the surrounding regions. Identifying underserved and vulnerable communities that inhabit the mining industries or their surroundings using geoinformation tools. Then, this technique can be useful for monitoring water quality parameters. Here, satellite remote sensing also helps in assessing turbidity, contamination, and pollution.

A lot of data is also collected, generated, and computed using remote sensing and satellite sources. This in totality is useful in terms of identifying and monitoring safe water sources available near mining areas, thereby ensuring that they remain uncontaminated and accessible to nearby communities. So, in general, as far as target 6.1 is concerned, a lot of data and information can be generated, collected, and computed using certain data, which can again be attributed or linked to the different sources of water availability. And thereby, it can also be linked to the community—how much is the population, how much is the demand in different sectors—and that is how we can calculate equitable access to safe and affordable drinking water in mining areas. Target 6.2 deals with access to

adequate and equitable sanitation and hygiene for all, thereby ending open defecation by 2030.

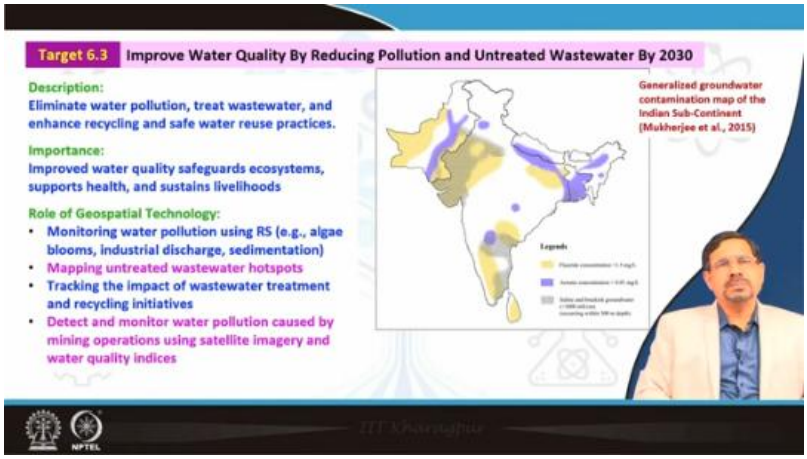


So, what is on the right-hand side? If you see a map over India, it shows district-level patterns of open defecation practices in India. Using the database from 2019 to 2021, we have the scale around it—the red one indicates a higher prevalence of open defecation, going up to 67.83 percent. So, in other areas, it is less. So, what does it mean? If you see, more of these areas are on the southern side, and the northern tip has very few, as do the northeastern states. So, that means we need to work on this, and many of these areas also fall under mining areas or mining industry zones.

So, as far as the description is concerned, providing sanitation facilities and promoting hygiene, focusing on vulnerable groups like women and children—those are the most vulnerable groups—will help in their empowerment. Access to sanitation is crucial for preventing diseases, thereby ensuring gender equality and maintaining human dignity. So, as far as the role of geoinformation is concerned, it is useful in mapping sanitation facilities, and thereby, the gap areas can be analyzed. Identifying areas prone to open defecation can be done using remote sensing and ground surveys, which can be well-integrated using the GIS approach. So, thereby, geoinformation technology is useful in supporting spatial planning for the construction of sanitation infrastructure.

So, once the database is there, once the analysis is done, then it can be very well formulated that where you need the construction of the sanitation infrastructure. So, that way it helps in planning and particularly infrastructure planning. And the geoinformation also maps the sanitation infrastructure and open defecation hotspots in mining regions to prioritize the intervention and improve the hygiene. So, as far as the improvement of hygiene is concerned over the mining areas the defection hotspots can be identified

mapped and prioritized for infrastructure or sanitation infrastructure construction. Now as far as target 6.3 is concerned that deals with improvement of water quality by reducing pollution and untreated wastewater by 2030.



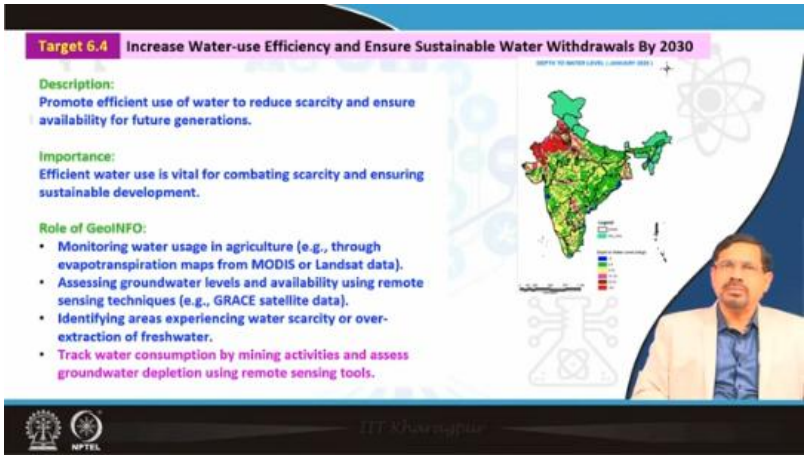
So, the description could be elimination or the to eliminate the water pollution treat wastewater and enhance recycling and safe water reuse practices. So, four things first is eliminate the water pollution. So, we can say zero pollution as far as the as far as the river and other channels are concerned. Second, treat the wastewater at the point sources wherever it is generated. Third, enhance the recycling and reuse potential as far as the safe water use is concerned.

So, safe water reuse should be practiced also. On the right-hand side, we can see a generalized groundwater contamination map of Indian subcontinent Where the fluoride concentration, arsenic concentration and saline and brackish groundwater concentration are also shown in different color as far as yellow, violet and grey sets is concerned over India and its subcontinent. So, what role the geoinformation plays in this? It helps in monitoring the water pollution using various remote sensing data sources.

For example, the algae bloom identification and its distribution mapping can be done very well using the optical data. The industrial discharge can be traced, mapped, and quantified to a certain extent using the satellite data. The sedimentation load of the water bodies can also be calculated, linked, and computed using the satellite data. So, this is where geospatial or geoinformation technology helps in terms of providing and generating the information. Then, mapping the untreated wastewater hotspots helps once this information is available, and the untreated wastewater hotspots can be mapped.

So, we can know where the treated water or wastewater is, and where the untreated wastewater is. So, that can be very well discriminated in the form of maps. Then, tracking the impact of wastewater treatment and recycling initiatives. So, once this is done, the impact of the wastewater treatment and recycling initiatives can be assessed, and thereby the geo-information technique helps in detecting and monitoring the water pollution caused by various mining operations using our satellite-based images and water quality indices. Once we know where our various mining industries are located and which water bodies are linked, surrounding, or within the mining areas, then that can be mapped and linked with respect to the wastewater, treated water, distilled water, or the various types of pollution load.

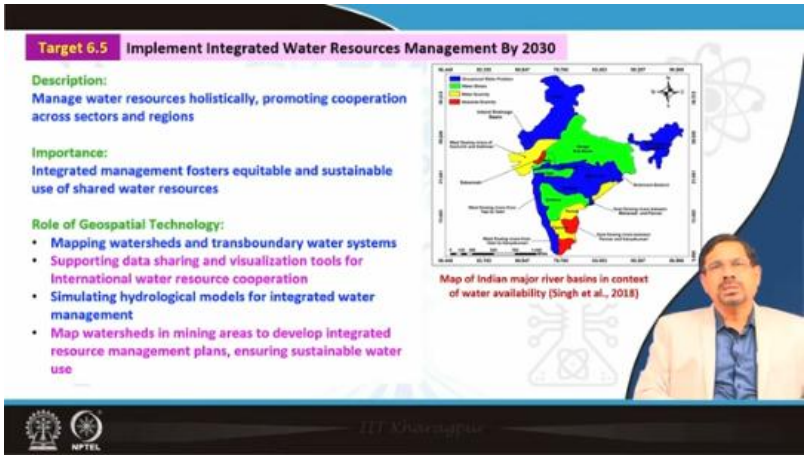
Once this is done, this can be monitored. Once this is detected and mapped, it can be monitored regularly, and thereby we can also develop and use various water quality parameters in terms of water quality indices that are useful for regular or periodic monitoring. So, Target 6.4 deals with increasing water use efficiency and ensuring sustainable water withdrawal by 2030. So, the description could be to promote efficient water use to reduce scarcity and thereby ensure availability for future generations. Efficient water use is vital for combating scarcity and ensuring sustainable development. On the right-hand side, we have a figure that talks about the depth of the water level as of January 2020.



So, how does the geo-information technique help? Geo-information technique helps particularly in target 6.4 subsection by monitoring water usage in agriculture. For example, Landsat data and MODIS data provide ET or evapotranspiration maps. This helps or gives an indication of water usage monitoring in agriculture. Assessing groundwater levels and availability using various remote sensing techniques such as

GRACE. The data from the GRACE satellite helps or provides groundwater level and availability information.

Geoinformation also helps in identifying areas experiencing water scarcity or over-extraction of freshwater. Thus, it helps track water consumption by mining industries and assess groundwater depletion using geoinformation. Let us look at target 6.5. On the right-hand side, we have a map over Indian territory. The major river basins, in terms of water availability, have been mapped across various river basins. Target 6.5 discusses implementing integrated water resources management by the 2030s.

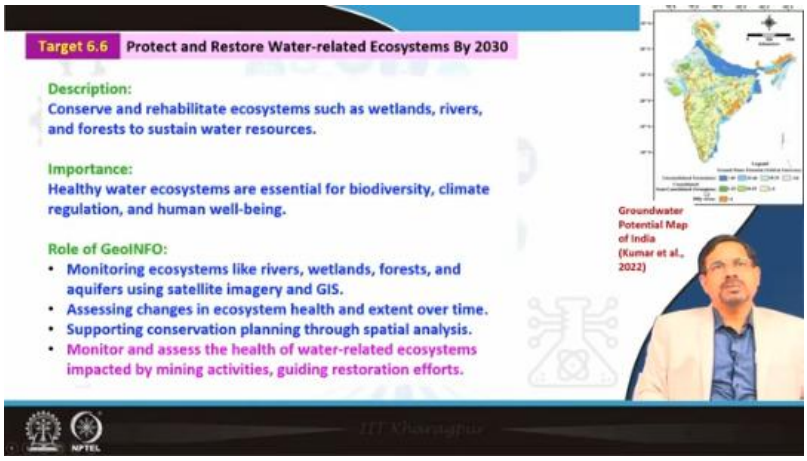


This is very important for the implementation of integrated water resources management. It helps manage water resources holistically by promoting cooperation across sectors and regions. The importance of this integration is that it fosters equitable and sustainable use of shared water resources. Whatever water resources are available, it helps ensure equitable and sustainable use, which is extremely important for optimizing water resources management. Here, geoinformation plays a role. It helps map watersheds—river basins being larger watersheds—and transboundary water regimes.

So, as far as the industry or mining sector is concerned, we can use geoinformation to map the various watersheds falling within and surrounding the mining industries, as well as the areas on the boundary or periphery. So, thereby, it supports data sharing and visualization tools for various water resources management cooperation and activities. Simulate hydrological models for integrated water management. Yes, the moment we get the data about the locations, availability, quantity, quality, and all this, we can run many hydrological models over the industry or mining areas situated in one or more watersheds. So, using hydrological models, we can simulate the conditions as far as integrated water resources management is concerned. So, geoinformation also helps in

mapping watersheds in mining areas to develop integrated resource management, thereby ensuring sustainable water usage.

As far as Target 6.6 is concerned, it aims at protecting and restoring water-related ecosystems by the end of this decade, that is, 2030. In the upper right corner, we have a map showing the groundwater potential as far as the Indian territory is concerned. So, this kind of Target 6.6 aims at conserving and rehabilitating ecosystems such as wetlands, rivers, and forests to sustain water resources. It is extremely important that we conserve and rehabilitate ecosystems; only then can water resources be ensured, equitably and properly managed, or optimally managed. Healthy water ecosystems are essential for biodiversity, climate regulation, and human well-being.



The role of geoinformation in terms of monitoring ecosystems—where and how much in terms of river extent, water availability, and the spread of water areas. Wetlands, forests, and aquifers—all these can be analyzed using satellite data and geoinformation tools. Geoinformation also helps in assessing changes in ecosystem health and extent over time, so periodic changes can be well analyzed or assessed using geoinformation in terms of change detection. And geoinformation also helps in supporting conservation planning through spatial analysis. So, in totality, geoinformation helps in monitoring and assessing the health of water-related ecosystems impacted by mining activities or involved in various activities as far as the mining industry sector is concerned. So, thereby, it also helps in guiding restoration efforts.

Target 6.a or 6a aims to expand international cooperation and capacity building in water and sanitation by 2030. So, this is one of the subsections that deals with strengthening support for water-related technology infrastructure and management in various developing countries. The importance is collaboration and knowledge sharing. So, here

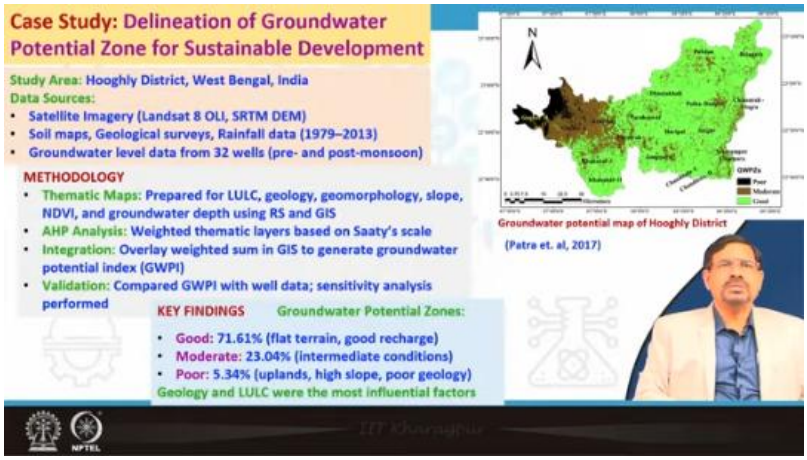
the role of geoinformation technology is very vital in terms of facilitating technology transfer for water management, such as GIS and remote sensing tools for different developing countries. So, as far as the mining industry is concerned, if we also develop, practice, and experience such water management activities over mining areas, this can serve as an example to be shared with other developing countries as a technology transfer measure.

So, share geospatial data and tools for better water management practices in mining areas globally, enabling technology transfer. So, the mining areas, which may sit over one or more watersheds, can also serve as an example in terms of developing technology for water resources management, and that can be shared with others in terms of technology transfer. So, another point, as far as target 6b is concerned, is that supporting local community participation is extremely important because we need to support local community participation. So, in terms of water and sanitation management, unless the local community participates, because it is for them, it has to be by them. So, we have developed, or there are concepts in terms of Participatory GIS or PGIS, which is an approach that integrates spatial planning with participatory methods for managing and communicating GIS or geographic information.

So, as far as the description goes, it helps in empowering communities to contribute to and benefit from water and sanitation initiatives. So, if the contribution has to come from the communities, and they are the ones who are the beneficiaries. So, it demands participation or involvement. In terms of importance, community involvement ensures sustainable, inclusive, and context-specific solutions to water and sanitation challenges. The role of geoinformation is engaging communities through Participatory GIS or PGIS to map and manage water and sanitation, empowering local decision-making by providing accessible geospatial data and tools.

Use participatory GIS to involve local communities in mapping water resources and sanitation issues in mining regions. So, as far as PGIS or participatory GIS is concerned, it merges participatory learning and action. So, we say PLA participatory learning and action technique with that of GIS. So, that is the main thing about PGIS or participatory GIS. It is a wedding or merging between PLA participatory learning action and GIS.

So, this PGIS utilizes diverse geospatial tools, including sketch maps, participatory 3D modeling (sometimes abbreviated as P3DM), aerial photography, satellite imagery, and GNSS. PGIS also helps in representing community spatial knowledge through two-dimensional or three-dimensional maps, such as physical and virtual. Thereby, PGIS aims to make geographic technologies accessible to marginalized groups within mining areas or the mining industry sector. Let us take the case study that deals with delineation of groundwater potential zones for sustainable development. This is a case study, and as far as the map is concerned, on the right-hand side, it has been put for the Hooghly district, one of the districts in West Bengal state, depicting groundwater potential.



Different data was used: satellite-derived data, Landsat 8 OLI, SRTM DEM (which deals with topography). The soil map, geological survey, rainfall data, and groundwater level data from 32 wells were also utilized. All these datasets—satellite, soil map, geological survey, rainfall data, and groundwater level data from the survey—were combined to produce a potential groundwater map for the Hooghly area. The same approach, as far as geoinformation is concerned, can be utilized for any mining industry areas to delineate groundwater potential, which is helpful for sustainable development. The methodology here mostly involves an AHP (analytical hierarchical process)-based analysis that deals with weighted thematic layers based on Saaty's scale.

So, it is a weightage we give between 1 to 10 in terms of a 1 to 10 point scale or 0.1 to 1, which is a 0 to 1 scale. So, as far as Saaty's scale is concerned. So, finally, integration overlay weighted sum in GIS to generate groundwater potential index (GWPI), validation compared GWPI with well data, sensitivity analysis, and performance. So, importantly, it deals with the preparation of thematic maps, deriving the weightage based on Saaty's scale to come out with the potential mapping activities, and by integrating them, and then a kind of validation with a comparison as far as the ground-based or groundwater level data that has come from the survey. So, the key findings come out with a groundwater potential zone and say that this is good, moderate, or poor based on the percentage in terms of flat terrain, good recharge, intermediate conditions, or upland high slope, poor geology.

So, geology and land use land cover are the most influential factors as far as this groundwater potential delineation is concerned. These kinds of studies are very well benefited from geoinformation technologies, and here a case study has been presented by Patra et al., published in 2017, and the same approach can be used over any mining

industry areas. Next, are the various Government of India schemes that are aligned to Sustainable Development Goal number 6. We have, in terms of water management and supply, Har Ghar Jal. So, under the Jal Jeevan Mission, a scheme initiated Har Ghar Jal that is also attributed or can be practiced over a mining industry sector because as a

unit, Atal Bhujal Yojana, and the National Water Mission in terms of the Ministry of Jal Shakti, we have the National Water Mission and sanitation and hygiene, Swachh Bharat Ek Kadam Swachh Ke Or, and the Nirmal Bharat. So, these are all various Government of India initiatives or schemes that are aligned to Sustainable Development Goal number 6 and can be very well managed, studied, or understood using or can be benefited using geoinformation-based technology. And all these are applicable to mining industry sectors which have an area spread over a certain region or the mining region. These are the references that have been used. So, to conclude, SDG 6 is essential for achieving equitable and sustainable water and sanitation access, significantly impacting health, gender equality, and economic development. And geoinformation technology plays a transformative role in water quality monitoring, resource management, and addressing gaps in terms of access and sanitation.

So, addressing SDG 6 targets such as all these—in terms of pollution reduction, efficiency improvement, and ecosystem restoration—benefits other SDGs that are linked to SDG goal numbers 1, 3, and 5, like poverty eradication, education, and climate resilience. It helps in terms of engaging communities via participatory GIS. So, addressing water scarcity and contamination, particularly in vulnerable and marginalized areas—which is more linked or more probable in the mining industry sector—is vital for achieving sustainable development goals by 2030. Thank you very much.