MINERAL ECONOMICS AND BUSINESS

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Week 1

Lecture 02 : Mining Enterprises

Hello, once again I welcome you to this course on Mineral Economics and Business. Today, we will be discussing mining enterprises, their specific structures, uniqueness, and how special they are as enterprises. If you look at other organizations, other business organizations, the difference is that we have specific functions. First, we will go into the details of the uniqueness of this. We are organized and have specific responsibilities and targets: exploring minerals, extracting them, processing, and selling the minerals and metals in the market.

We operate in diverse geological regions and contribute significantly to the economic development of any country. The importance of mining organizations is that they ensure efficient resource utilization. That means sustainable and responsible exploitation and utilization of minerals for development purposes. They help in managing large-scale

operations involving workforce, technology, and environmental impact. Many safety-related aspects are also involved.

They align operations with legal and sustainability requirements, meaning conservation and development at regional, national, or international levels. How historically we developed as enterprises. In the early stages, as you might have heard or read, mining used to be small-scale artisanal operations because of the primary concern I am talking about: safety. If that is going below ground, you cannot approach when you don't have the technology, so it used to be mostly confined to surface operations, artisanal operations during ancient civilizations like the Mesopotamian, Chinese dynasties, or Roman empires.

In our case also you will see that even in ah in cushion ah periods also you will see lot ah the the evidences of mining are there. So, the moment people started ah thinking of their development of the society, the metal ah and other things came into play and of course, we needed more energy ah sources from the natural resources. Minerals such as gold, silver, iron or copper they were crucial to the economy of the Indian kingdoms in ancient times. So, these resources were used for coinage, making coin, currency, weapons, jewellery and the temple construction also.

Precious gems as you know that like diamonds were extracted from mines particularly in regions like Golconda, the modern day ah Telangana. Later on, many rulers exercised control over the natural resources to have control over the property rather. Treating mines as the state property and revenue from mining activities was a significant part of the income of the state. Kautilya's Arthashastra and the 3rd century BC but influential into the medieval period also that provided detailed guidance on mining and metallurgy indicating the strategic importance of the minerals. That means how important they were for the rulers, for the state, for the people.

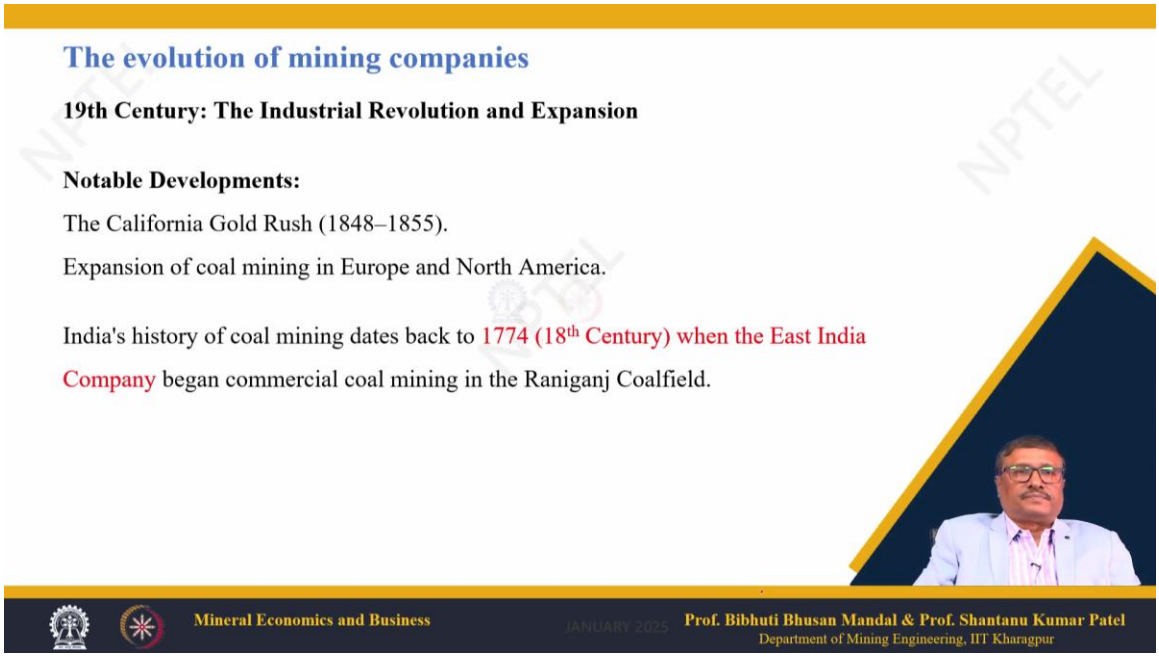
So, it mentions officers like Suvarnakara means goldsmith and then we also we call them Suvarnakara nowadays. Then your Lohadaksha that is the people who are superintendents supervising the extraction and use of metals. Showing that mining activities were regulated by the state. Now the evolution of mining companies much later on if we now come towards 18th, 19th or say 20th or 21st century nowadays then what we can see that in 19th century during the industrial revolution and the expansion of activity there is rise of heavy industry because of the technical upgradation of the things that is we came into we reached that stage where we have machines that can handle huge work that was previously being done by human beings.

So, and then that also increased demand for coal, iron, and other metals in turn, and then what happened was the modern mining companies started being formed. So, they transitioned, they transformed themselves from small-scale operations to structured companies. Like, even in 1873, the famous Rio Tinto started operations. Colonial exploitation. The European powers mostly exploited the mineral resources in their colonies, like our East India Company in India.

They established mining operations in various parts of Africa, South America, and Asia. And this was mostly driven by technological advancements, as I was telling you, the steam-powered machines and railroads. So, the steam-powered machines helped in operating the mines, and railroads helped in the transportation of minerals and coal from one place to another. Now, the workforce challenges were labor-intensive operations that relied heavily on manual labor still because mechanization had just started. And this workforce had to work under harsh and very unsafe conditions.

Further, the notable developments were, say, the California Gold Rush from 1848 to 1855. The expansion of coal mining in Europe and North America. In our case, we will just take an example. Our history of coal mining dates back to about 1774. This is organized mining in the 18th century when the East India Company began commercial operations in coal mining in the Raniganj field, which is nowadays in West Bengal.

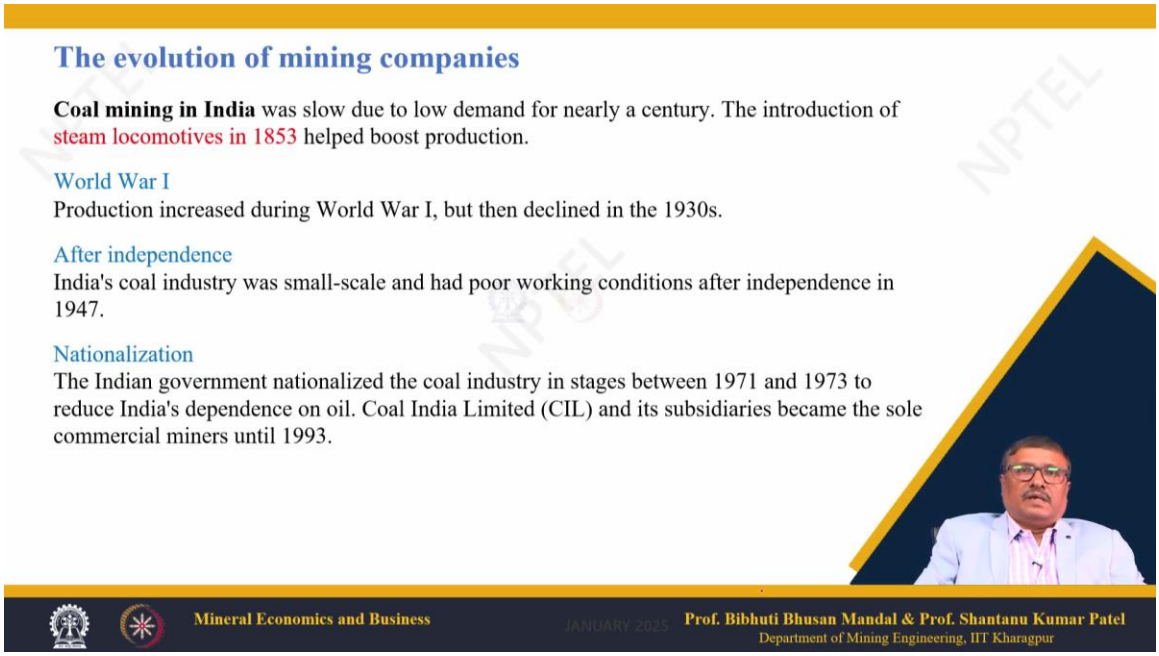
Now this coal mining in India was slow because of the low demand in the beginning for about a century. The introduction of steam locomotives in 1853 that helped boost production. In World War I, during the World War, production increased because the huge demand. Then declined in say in 30s onwards. After independence, it was still small scale and not a very big organizations.



It still had poor working conditions and lot of accidents were there. So, the government of India nationalized the coal industry in various stages during 1971, 1973 to reduce India's dependence on oil. So, we we started becoming in the owner of the ah thing ah coal natural resources in a more organized way. to mobilize the industry, develop the industry in such a way that we generate more, we can produce more coal.

And Coal India Limited and its subsidiaries became the sole commercial miners until 1993. Now, coal mining in India that also transformed after nationalization also. In 1993, the Nationalization Act was amended. So, that we allow the private companies to playing to mine coal for their own use like the steel power or cements industries. So, you can have your captive mines to suffice the requirement for this for supplying energy for supplying coal to those and production of steel power and cement.

Currently, we are the world's second-largest producer and consumer of coal, but the coal sector has a lot of challenges that we will also discuss at the end of this class. Now, in the 20th century, you see for others the tech—what is different from the previous one and from the 19th century to the 20th century, which we have just discussed. In the 20th century, there was huge technological innovation. During World War I and II, mechanized mining equipment, as a benefit from technological innovation, started like the excavators and drills, which increased productivity. The introduction of processing technology, like flotation and leaching, started coming, and then there was a shift to global corporations.



So, the companies from one country became multinational, with participation from different countries. Operations spanned multiple continents, like Anglo-American in 1917 or Wales. Environmental awareness was again becoming a concern because, when we started growing in the beginning, we neglected its severe impact on the environment. When it became aware, we saw a growing consciousness about mining's environmental impact, leading to more stringent regulatory frameworks thereafter. Also, we saw that economic and political factors, like post-World War II reconstruction, increased demand for minerals.

The nationalization of mines in some countries, like Chile and Zambia, reshaped the global landscape of mining operations. Workers and trade unions became more organized. They emerged and advocated for safer mining conditions, better wages, and better occupational health for mining people. Also, there was an interesting thing like

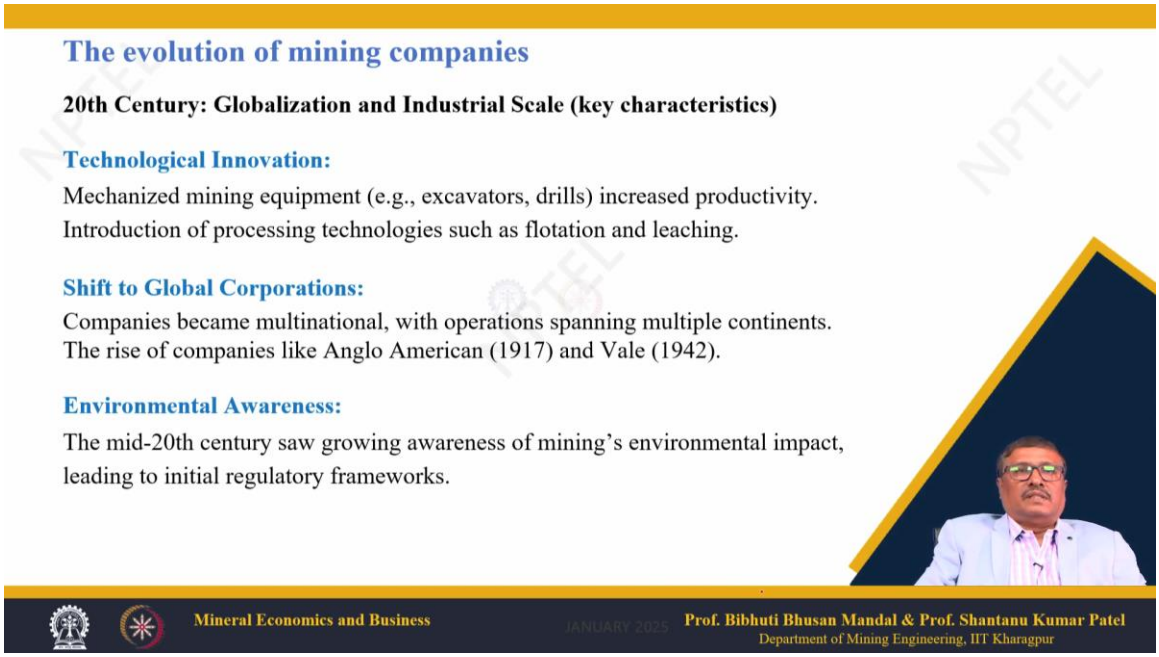
resource diversification. So, beyond metals, companies also, as part of their business and to sustain it, ventured into materials like oil, natural gas, and rare earth elements.

Still they were still somewhat connected with the natural resources, mines and metals, but they diversified. So, that if one sector does not work much better, then they can depend on the on the output of the other sectors. That continued like then we came to the 21st century where now the sustainability of the business and innovation, these are the key words or key characteristics of this particular era. What are these things? The sustainability and environmental and social governance, these mining companies are now heavily scrutinized for their environmental and social impacts.

much heavily compared to the 20th century. So, the companies are investing in green technologies and rehabilitation of the mining sites where people are displaced, societies are disturbed, the ecological things are imbalanced. And of course, a much faster and a sophisticated technology that is coming. It is not just by mechanization, but the effect of automation in mining, the artificial intelligence applications, data analytics to optimize the operations and the safety of people that is coming in very very fast. Remote control and automation, the autonomous machinery, they reduce the need for on-site personnel.

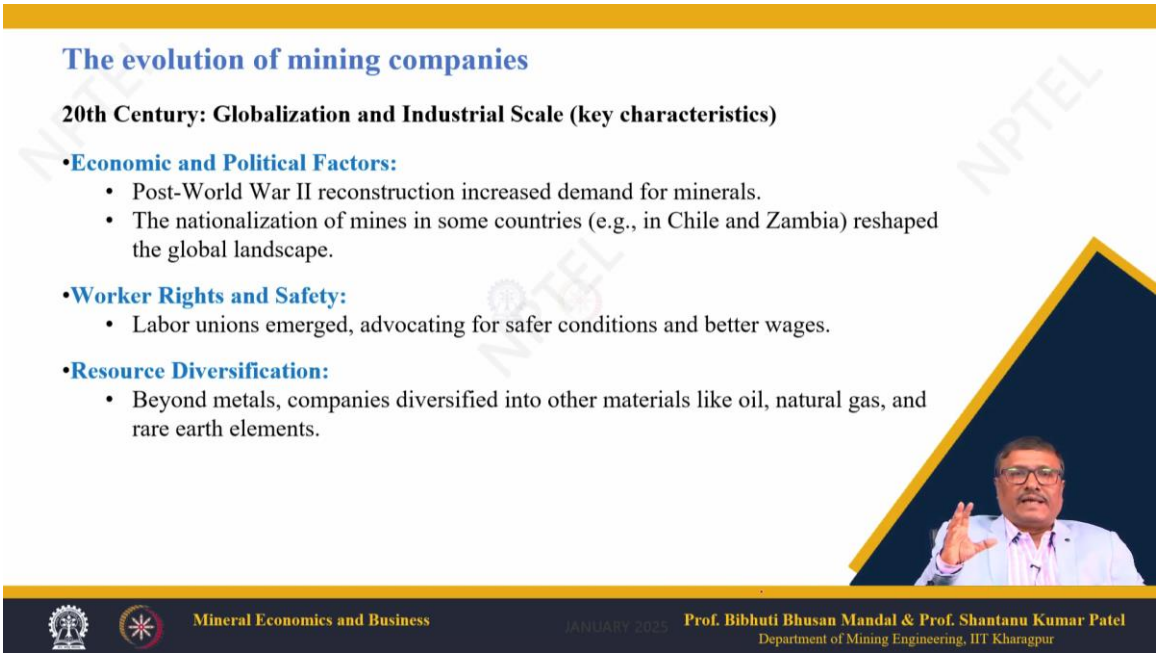
So, you can operate many machines nowadays, from hundreds of kilometres away. So, where the environment is say in minus 40 degree or so or it is not easily approachable, where people have extreme difficulty in operating the mines, then you can switch over to

the remote control. That is coming very fast and many countries have already started doing that. Resource transition, the typical traditional coal and metals. Now we are switching over to many critical minerals.



Those things were critical for the development and the sustainability of the civilization or the country. Like the lithium, cobalt, nickel for renewable energy and technology industries. We are also becoming more ah active in recycling of metals that means, which which we first we previously considered as waste. Now, we are considering that the resources a secondary resource that is recycling back to again primary use. So, we call it the cyclic ah mining recycling of metals.

Also, there is more awareness about the environmental and safety matters. So, there are more stringent global and local regulations. So, that will limit the pollution and preserve our ecosystems. And in global ah challenges, the ah the interesting thing is that there are lot of volatility in commodity prices that you cannot expect a steady growth or even a long term growth and fall. but it can change anytime because of there are lot of geopolitical tensions like the war that we say we suddenly saw between the Russia and Ukraine only like this thing they have serious implication on the on the business and also mining is equally affected.



This supply chain disruptions like absolutely un-warranted like COVID-19. In COVID-19 everything was absolutely disturbed. The business many business came to a halt including mining. It was heavily affected.

Notable trends, like, say, the good thing is that we are moving toward carbon neutrality. That means we will minimize or neutralize this thing—carbon footprint, net-zero emissions. And where we also started in the 20th century, like deep-sea mining, we are expanding into that, like the Arctic or deep-sea mining operations. We can summarize these things by looking at the changes that are happening in different aspects like scale,

technology, focus, society, environment, and how it is shifting. So, I have given this table; you can study these things, and you will see that.

How it has changed from the earlier days—we have just projected here only 300 years—and how it is now: high technology, artificial intelligence, more consciousness about sustainability, environmental regulations, and carbon neutrality now. We will see the mining enterprises as of today—what are the different types of enterprises that we have. We have public sector enterprises, very well known; they are owned and operated by the government to manage resources that are naturally important, nationally important. For example, Coal India Limited focuses on coal extraction and supply, which is also a very important company for economic development, employment generation, and resource security—it is under our government's control. We also have a second type: private sector enterprises, owned by private entities or shareholders.

We have encouraged them, and now there are big players like Vedanta, Adani, and the Jindal Group. So, they are very much into the mining business, and today, very big projects are being taken up by these mining enterprises, mining companies. Their focus is definitely profitability, innovative technologies brought from everywhere, wherever available, and making the market more competitive. So, people have to work to stay in

the business now. You don't have the security or a secured position of being in the government.

And so much there has been deregulation in the government sector also that you are directly competing with the private sector in many, many cases. There are also joint ventures like the public and private enterprises. So, when these investments started, then we first saw these things can happen like we have the public sector enterprises and say we divested these invested 26 percent or 25 percent. So, what we have done now is there is a private partnership, private and public partnership. So, that has got a lot of interesting things like the technology transfer and that is infusion rather from outside to inside.

We have also risk sharing between the partners and also we increase the operational efficiency because now the private sector has interest in the operation of the mining business. Now, how the structures can be defined like functional structures where we have an exploration department, geology department, we have survey especially, then we have maintenance. The mechanical, electrical, the production section which are mostly engaged into the production of the mine, production of the minerals, then we have the commercial part, the processing part, and then we have the commercial, the sales and marketing divisions. So, we organize these things into modular form integrated with each

other, interacting with each other, and we increase the efficiency and expertise in operations. These are very common functional structures.

There are, of course, divisional structures like when we have a very big company, then we can decentralize the power and then give power to the division. Each division is more or less given the financial authorities also. Their region or region-specific or product type also we look after the coal business of a company, we look after the gold business of the company. That also is possible. So, the major change is that the decision-making is decentralized and there is flexibility even though it is under the same umbrella of the deep organization.

We also can have a matrix structure where it looks like each units are like cells in a big matrix and they have typical powers they can look after their own part very clearly and and their responsibilities and rights are very well defined. But after all and overall they will report to ah same ah the head of the entire organization, but will have much more power and ah and authority and responsibility compared to the typical divisional structures or functional structures. In hybrid structures also we have combined elements to utilize. So, that customizes for in a specific enterprise goals and global operations like that can be customized. So, there can be a hybrid structure combining the benefits of the structures that we have discussed before.

Broadly, two things come out from our previous discussion. First thing is centralized model. That means decisions are taken by the top management and corporate headquarters and that percolates down. But in decentralized models, decision makings are also delegated to the regional and site specific managers. that gives more ah authority and of course, satisfaction to the management team also that they have also the power to take decisions like.

So, that is the decentralized model even though it is organized to work under ah big umbrella big company, but their authority and responsibilities are well different ah well well defined a different from each other. As we can see from whatever we have discussed that now the role of technology in mine organization especially the automation in mining operation like the say driverless truck, robotic drills that improves the productivity and that is reducing operational risk also because of this kind of mechanization. And when you look at nowadays educational courses or technical in educational courses in universities, you will see lot of importance is being given on the artificial intelligence, machine learning and there are lot of application of the IoT, sensor based technology. And you can see everything also on the screen from control loop what is happening in your mind. There are lot of sensors placed wherever you are violating safety norms you get automatic warning much before anything happens.

Role of technology in mining organization

1. Automation in mining operations:

- Integration of automated machinery like driverless trucks and robotic drills improves productivity and reduces operational risks.

2. Real-time data monitoring:

- Adoption of IoT sensors to track equipment performance and environmental factors, enabling predictive maintenance.
- Enhances decision-making through data analytics.

3. Use of artificial intelligence:

- AI optimizes exploration activities by analyzing geological data for resource estimation.
- reduces costs by identifying high-yield areas for mining.

4. Environmental compliance technology:

- Digital tools to monitor emissions, manage waste, and ensure adherence to sustainability standards.
- examples: Carbon capture solutions and reclamation technologies.

So, using the very powerful data analytics we are enhancing our decision making process when so many parameters are involved in any business. So now the computational power and real time data monitoring is helping us to take decisions using this facility. We are using artificial intelligence much more than ever before even though it started in 20th century the best utilization is now. We are having environmental compliance ah technology like digital tools to monitor emissions whatever is and the manage waste that we are also ensuring adherence to sustainability goals and standards.

Labor and Workforce Management in Mining Enterprises

Composition of Workforce:

- Mining companies typically employ a mix of skilled, semi-skilled, and unskilled workers. With increasing automation, the demand for manual labor is decreasing, and the need for technical skills is on the rise.
- Workers are employed in practically operations such as extraction, processing, machinery maintenance, and environmental monitoring.

Training and Skill Development:

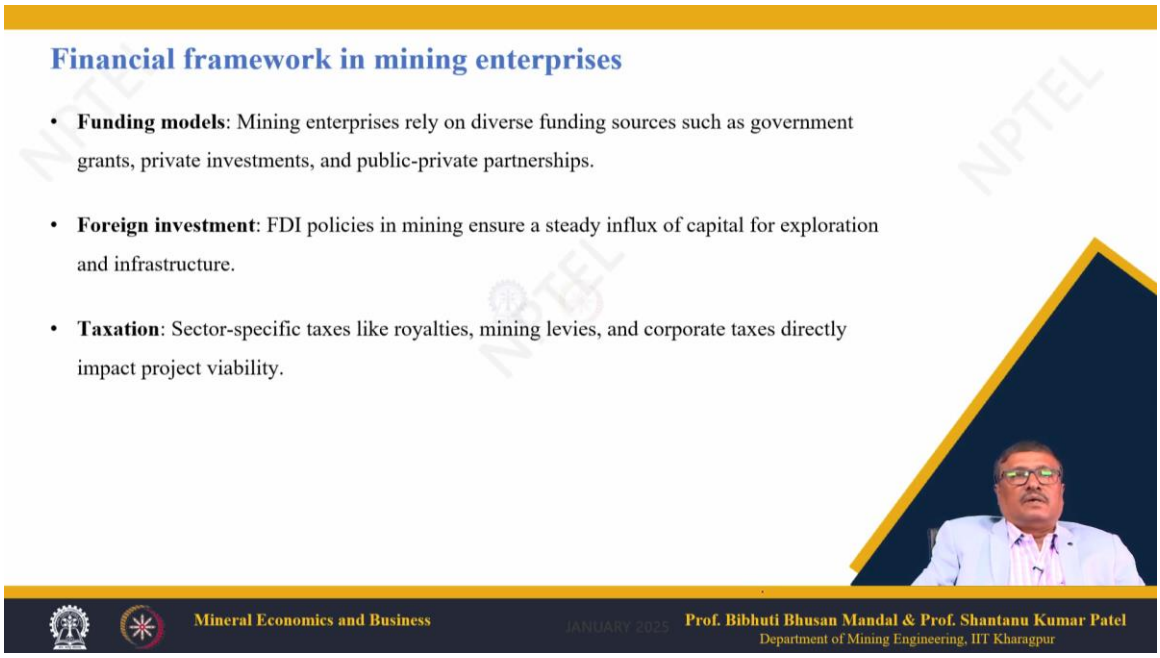
- Mining organizations invest in training programs to enhance the skills of their workforce, particularly in technical operations and safety management.
- Example: Coal India Limited has several training centers to upskill workers in mining technologies, safety protocols, and environmental management.

So, you can capture the different ah ah data through different sensors and then give a feedback to the management. So, that easily you can take decisions based on the information that you are getting. Now in mining enterprises what kind of labour and workforce like as you understand that typically we employ a mix of skilled, semi skilled and unskilled workers and with increasing automation the demand for manual labour is decreasing fine, but at the same time you need technically skilled people, well educated also, well trained and not only that to run the business smoothly we need many people who are multi skilled. The people who have several skills and that will help from easily deploying people from one type of work to another.

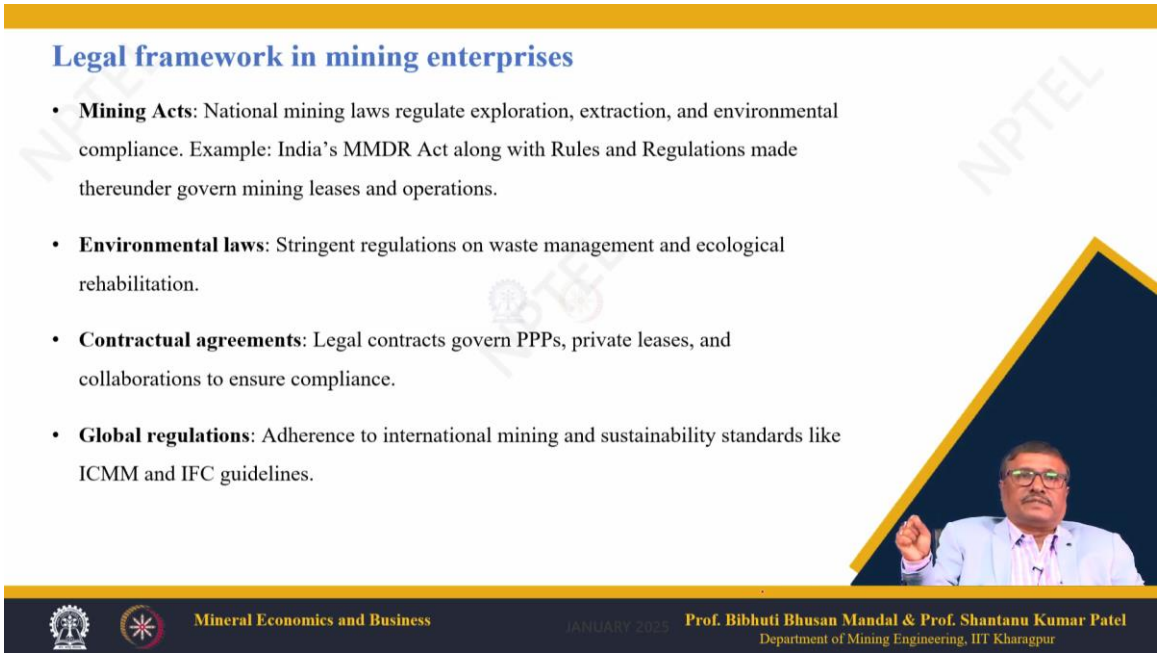
That is also a typical of the composition of the workforce in mining that is very much required. Now the mining organizations also they are investing in training programs to enhance the skill of their workers. You will see that many companies are having much longer training in their day to day operations as well as the increasing the safety awareness. Lot of investment are there in safety management plan, how they are implementing the, , safety management plan in their minds. Lot of investment, lot of training in that, lot of skill development of how to manage their own business in terms of safety and environment other than, the typical traditional functional things.

Now, this multi-skilled workers and up-skilled workers, that help in managing today's business and of course, the addition of the artificial intelligence, machine learning and data analytics. The public-private partnership is enhancing the execution of large-scale mining projects by pooling resources, knowledge and expertise from all possible corners. We are also having technology sharing, risk and resource sharing as I have said earlier. We are generating huge employment by expanding the business. So, we are giving training to the local people, the skill is enhancing and they are integrated into the business.

So, they are becoming a part of the development of the society. Now, this is boosting the local and national economies through royalty payments, export and lot of tax revenues that we are getting also we are spending lot of money in corporate social responsibility for the development of the local society where the mining enterprise or organization is working. So, we are more focusing into the environmental aspects like land reclamation, waste reduction, community engagement as I said CSR activities like education, healthcare, livelihood programs that is affecting the communities that that also we will discuss in national mineral policy most ah specifically. We are trying to align with the global standards not that we will follow only Indian standards to stay in the business and also to increase or enhance our image in the global business. We also follow the ah environmental social governance of the ah international standards



We have different funding models like the typical government grants, private investments, also public private partnership. We are inviting foreign investment direct investment like the FDI. We have a we have a special session on FDI also and global mining enterprises. The mining enterprises also having a separate taxation system like the royalties, the mining levies, different rents, different corporate taxes that is typical to the taxation of the mining business. Now, in the investment part also we will learn this in separate class, how we are into the business using equity, debt or all kind of different kind of financing the business.



In the legal framework aspect of the mining business, we have national mining laws that regulate the exploration and extraction. You must have heard about the Mines and Minerals Development and Regulation Act. There are other rules and regulations made under the principle act that govern the mining needs and different aspects of the mining operations. We have stringent and detailed regulations nowadays. It takes time to comply with them, but they are very detailed and strict in waste management and ecological rehabilitation. Now, legal contracts govern public-private partnerships or when we are contracting out many of the operations. We have contractual agreements that are typical in mining enterprises, which we will discuss separately.

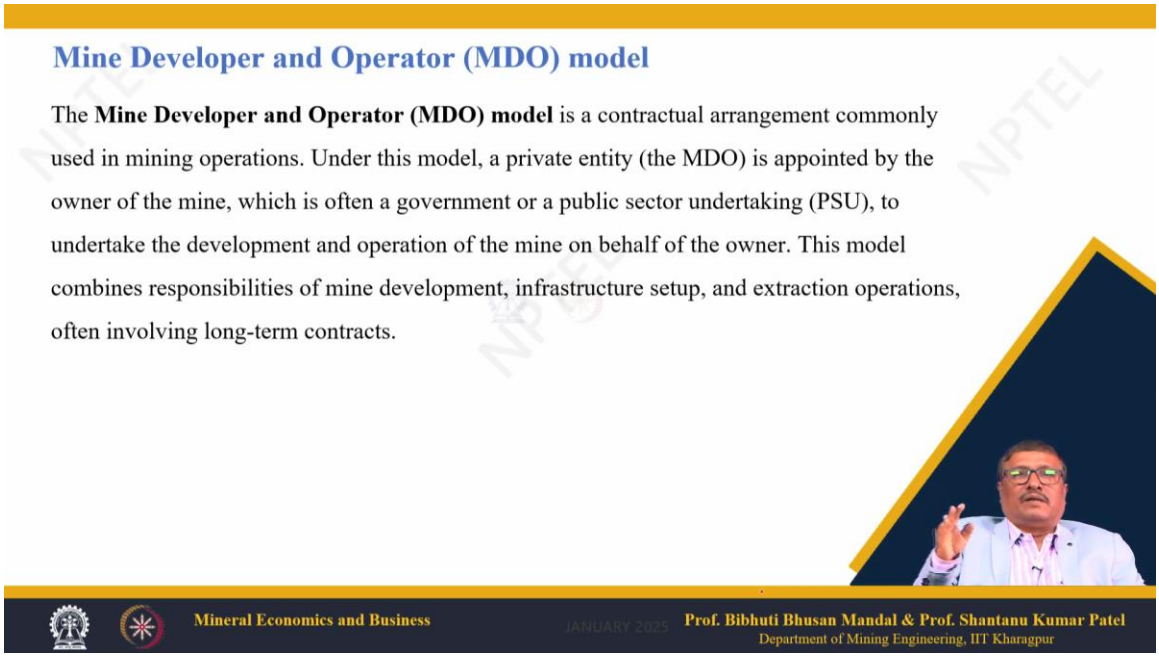
And as I mentioned, global regulations include adherence to international mining and sustainability standards like the ICMM or the IFC guidelines. In mining, we have a large number of people on record—around 2.9 million. However, many in the small mining sector might not report to government authorities. A huge number of people are engaged in mining, from very big to very small operations. Public sector entities like Coal India or the National Mineral Development Corporation dominate key mineral extraction and provide employment to the majority of the workforce. Private players like Vedanta Limited or Adani Enterprises are now major players in mining. They are driving modernization, higher productivity, and greater economic contributions, while also offering more employment opportunities.

If you look at the regional employment distribution of mining in India, you will find more people working in Jharkhand, Odisha, Chhattisgarh, and Rajasthan. Gujarat also has significant mining activity. But you will see many in Jharkhand, Odisha, and Chhattisgarh due to the mineral wealth and properties they handle. A key trend now coming into play is the outsourcing model. This means we are hiring and contracting out most of the work to external contractors. The traditional ownership of all aspects of the mining business is no longer prevalent.

You will see that many government organizations are simply hiring external contractors to carry out the mining operations, and they are having the management, safety, and environmental aspects under their control. So, these are third-party companies to carry out specific operational tasks. So, that will, of course, include everything from the exploration, extraction, and then equipment maintenance—all aspects. So, this is expanding in the Indian mining industry, and it is witnessing steady growth because of the outsourcing model.

So, the risk and cost management is definitely better. You can study this, and the policy support, efficiency, and government reforms are towards private and public sector participation under the MMDR Act, which is driving the outsourcing trend, streamlining all the processes involved, and improving the productivity and efficiency of the mining operations. The Mine Developer and Operator—a very well-known and famous term, a

very well-known keyword—is the MDO model, the Mine Developer and Operator model. So, this is a contractual arrangement commonly used in mining operations. So, here, a private entity—the MDO, by definition—is appointed by the owner of the mine, which is often a government or a public sector undertaking, to undertake the development and operation of the mine on behalf of the owner.



That means, right from the beginning, they will do all these things—operations on behalf of the owner—that is, they are basically a big contractor. They develop and then operate on behalf of the owner of the mine. This model combines the responsibilities of development, infrastructure development, extraction, operation—all aspects—often involving long-term contracts to continue in the business. What are the challenges that our mining enterprises are easily facing?

The main difference is occupational safety and health. If you look at the last century, the 20th century especially, there has been huge research and development in safety and occupational health, particularly in mining, especially underground mining, which distinguishes mining enterprises from all others. All companies also have vocational training, and rescue personnel are very specifically trained for mining operations. But

overall, I must say that the safety and occupational health aspect clearly distinguishes mining companies from other companies. Regulatory complexities are there, along with strict policies, because this industry mostly has an image of unsafe operations, and many health issues are present.

So, naturally, the policies will be strict, and there should not be any unnecessary wastage. So, the conservation of minerals is also very important, which is why the policies may seem strict, but they are absolutely rational and logical. We need, in the upcoming trend, skilled people to work with companies that are using robotics, automation, AI, and ML. So now, in our organization and in Indian companies, we also need people who are skilled in all these fields. This is capital-intensive because, in the beginning, we need a lot of money and do not get immediate returns.

So, capital-intensive it was, it is, and it will remain like that in the beginning, right from the start, especially in underground mines, where you do not get a return and have to wait. So, you need to have big players in the market who must invest money initially to get returns in the future. There is a lot of market volatility, as I discussed, with many fluctuations in commodity prices that impact profitability and planning. And you cannot just switch off your mining operations if there is a huge fall in market prices. When you discontinue mining operations, you must continue certain things to keep the mine alive so that you can reopen it later. You do not have to spend crores and crores of money to restart the mining.

That strategy is a new challenge for the mining industry because the market is volatile. So, we have to cope with it and develop certain techniques by which we can close or suspend operations temporarily and then return to business without much investment or hassle. In future trends, we have technology adoptions, as I said—AI, robotics—all these things we have to bring in. We must focus on renewable energy, and global partnerships are increasing. Because of FDI, as I said, recycling mining waste must continue so that we reduce consumption of primary resources.

We must learn and include data analytics in the process, which provides the facility for data-driven decision-making and predictive maintenance. We must decentralize operations to give more power to satellite offices. Remote monitoring systems are needed, and there has to be a proactive approach instead of just reacting to regulations. So, I have to comply. Now, many companies are switching to a proactive approach. That means learning how to maintain or cope with the regulatory regime proactively, because it helps the business.

Not that an inspector will come, point out issues, and then we act. No. We are proactive. We are no longer reactive. This new approach, this new philosophy, will definitely help.

And of course, it will include all the challenges that I have listed here. If you effectively think about this, then you can definitely contribute to the growth of the industry. These are the references that I have included, but not only these things—you can also study from different resources available on the internet. Thank you very much.