MINERAL ECONOMICS AND BUSINESS

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Week 10

Lecture 50 : Management and Quantification of mining investment risk

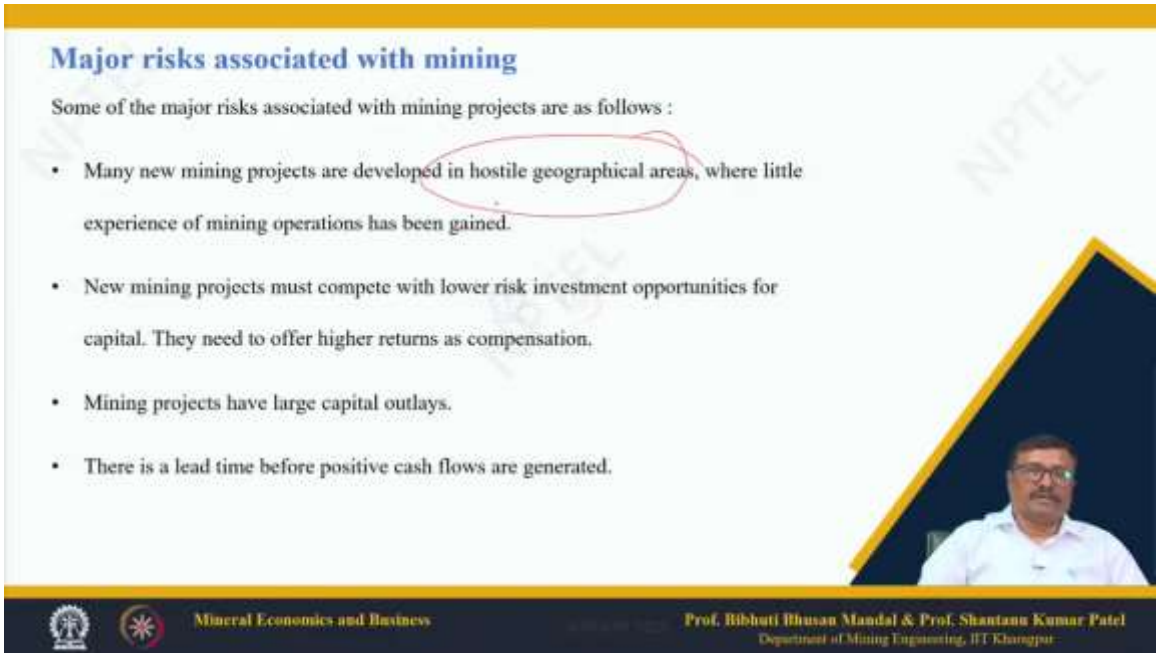
Hello welcome everybody. Today we will be discussing about the mining risk that means the risk in mining investment, its quantification and mitigation management. So this part will be discussed mostly conceptual but very important in managing or conceptualizing the management of investment risk. So, we will try to first list the concepts that we covered basically we will cover the risk in mining project the concept what are the risk try to list them out how to quantify them can we quantify the risk. Then how to manage the risk and how this responsibility is shared for management of investment risk and the management risk in mining operations.

Ah the the ah lecture materials is not necessarily in this order, but we will be switching between these basic concepts throughout the ah today's discussion. To start with ah I must say that the risk management in general not only for mining in general involves

identification assessment and mitigation of the uncertainties in any investments for mining operation also it applies. This ensures that a sustainable and efficient execution of mining project can be planned And if we know that means if we can identify, assess and develop a mitigation program and we can successfully implement them.

What are the risk type of risk that are involved? It can be technical, it can be financial, it can be regulatory, it can be environmental So, if you are if you are managing the risk effectively, this will help prevent delays that means, there will be not delay that means, you first identify and you do not know a certain risk and it has come. So, now, I I develop mitigation procedure implement. So, that will cause lot of delays.

That will involve cost overruns because if you are not properly prepared, then you will incur additional costs which you could have avoided if you had known the actual risk beforehand. Operational failures are very common if you do not know the risks involved and suddenly encounter them, and the operation stops, and the production also stops. The management of risk in mining will balance the economic goals—that means our targets—with our environmental and social responsibilities effectively. What are the major risks associated? Many new mining projects are developed in hostile geographic areas, where the geographical conditions are not very favorable, and little experience of mining operations has been gained in those areas.

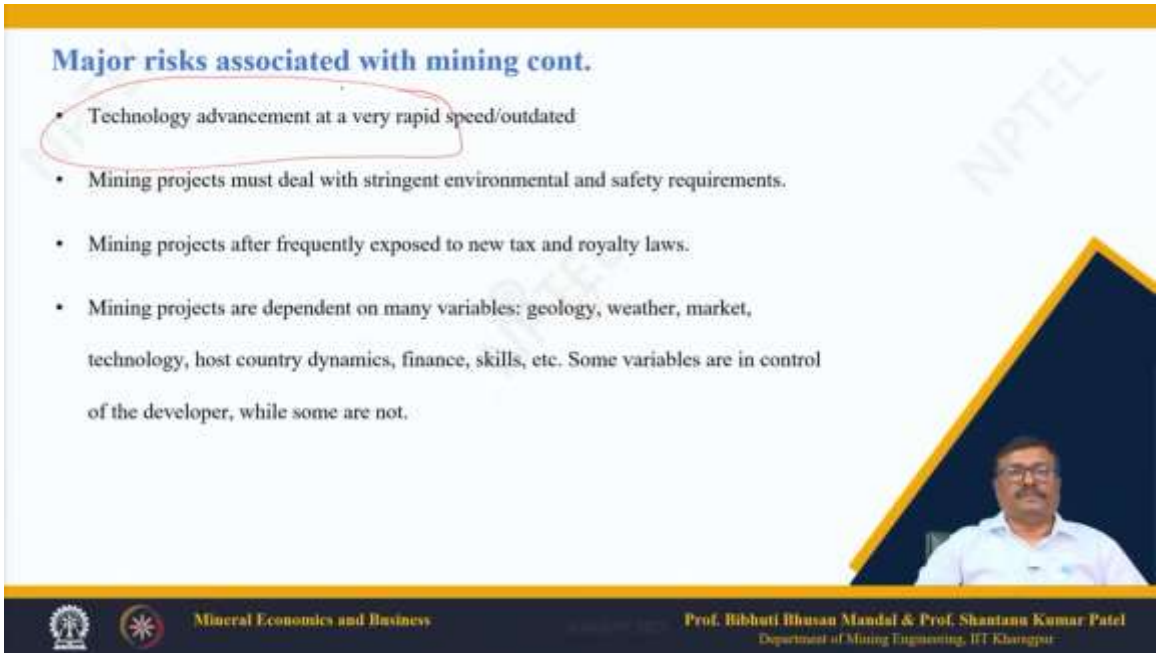


So, it is an unknown area—absolutely unknown—where there may have been no previous mining operations. This can happen very, very commonly. Now, new mining projects must compete with lower-risk investment opportunities for capital; they need to offer higher returns as compensation. That means when you are considering investing in mining, it will demand a lot of funds—a lot of financing—instead of investing elsewhere. Instead of investing in mining, you could have invested somewhere else. So, the struggle is with the opportunities of investing the same money elsewhere.

So, you need to justify that. Usually, mining projects have large capital outlays. So, it cannot be a small business. For example, big open-cast mines or big underground mines require huge capital investments initially, and more importantly, there is a considerable lead time before positive cash flows are generated to compensate for the investment and you start getting positive returns. There is a considerable lead time before the positive cash flows are generated to compensate for the investment, and you start getting positive returns. Technology and advancements in mining at the moment are progressing very rapidly.

So, you may easily get outdated and may have to replace the machines due to technology. So, you may need intermediate financing, which is not always easy for you. Now, the mining project must also deal with stringent environmental and safety requirements. For

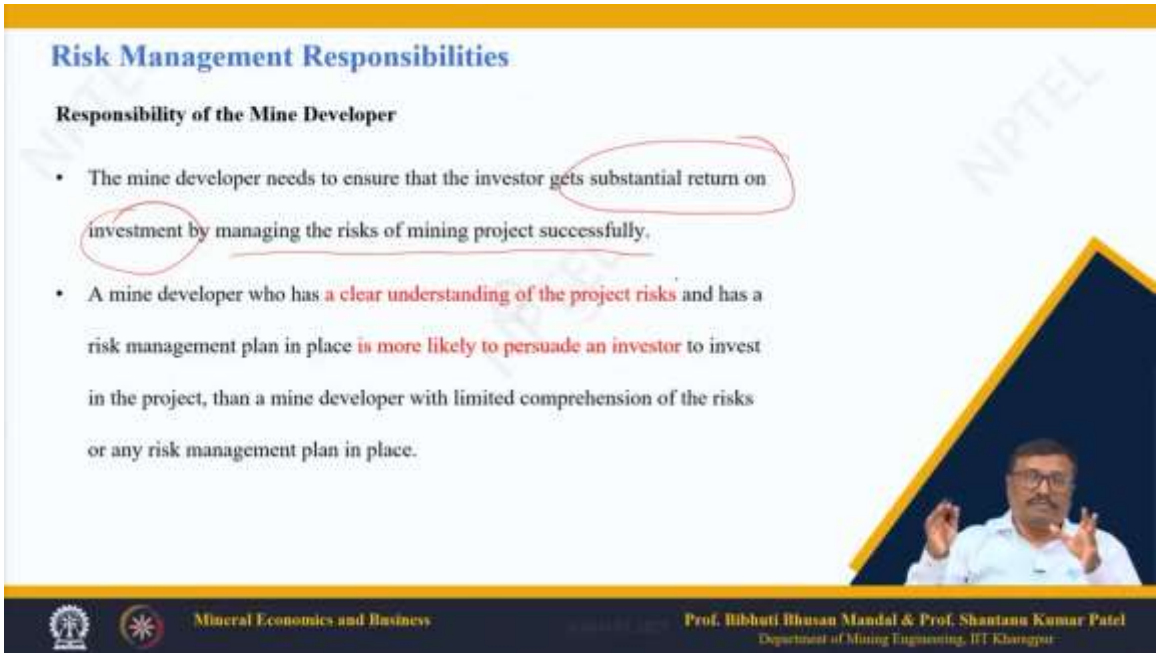
example, the safety requirements for mining operations are very stringent and extensive because mining is considered a hazardous occupation. So, the safety requirements related to mining are expensive.



At the same time, you must have detailed knowledge and trained manpower to look after the safety of mining operations. Similarly, how to mitigate environmental degradation and the regulatory laws, especially since they are very stringent about environmental degradation—how to mitigate that. So, mining projects are frequently exposed to new tax and royalty laws. This may not be regular, but it can happen. So, you may face new taxes or new royalty rates, which may substantially change your positive cash flows.

Now, mining projects also depend on various variables like geology, weather, market, technology, host country dynamics, finance, skills, and so many things. Some variables can be controlled within the developer's scope, while others are not at all under the developer's control. So, what are the responsibilities of the mine developer? Let us list them out. The mine developer needs to ensure that the investor gets a substantial return on investment by successfully managing the risks of the mining project—substantial return.

It is risky, it is capital intensive. So the mine developer has to ensure in such a way that this money that we are investing should give you substantial return. So, you need to not only plan it, but also visualize beforehand what are the risk in future that this mining project can encounter accordingly you have to develop the mitigation strategies. So, any mine developer who has a clear understanding of the project risk will definitely more likely to persuade any prospective investor to invest in the project. compared to any other developer who has limited comprehension of the risk and or any risk management plan in place.



So, if you are trying to convince some investors, you must have a thorough knowledge of mining operations, the risk involved and how this risk will be managed. Otherwise, the investor will never be impressed. The mining investor also needs to be fully aware of the risk profile of the investment because the mine developer has identified and quantified the risk. And the risk management is in place, this has to be projected to the mining investor very clearly convincingly that this are the risk associated as I have been telling before and this can happen and if this happens what I am going to do to counteract or rather the mitigate these things and there will be practically no loss and there will be no practical production loss also in between.

Most mining investors are also aware that the investment in mining project is high risk undertaking. So, the people who are in business they have idea nowadays people have

information more information than ever before. So, naturally ah they will ask for a higher return on investment. higher return on investment like compared to others because there is more risk if the investors are taking more risk they will definitely require more returns they will ask for more returns on the investment and as soon as possible the money should be recovered the capital invested in the beginning should be recovered. So, what we can say that the mining investor

will prefer to have a calculated risk. If someone is investing in mining project, he would prefer to have a calculated risk that I have risk, but I know this much is the risk and how to mitigate and what are the following consequences that can follow and how we can manage that risk. Now we can make a table and then show at what stage what kind of risk assessment is associated. At the feasibility stage itself, we need to identify all technical economic and human risk and identify the solutions related to this technical economic and human risk because when we conduct a feasibility study then we have to attempt this technical thing economic and human risk all. because this is a feasibility study.

So, there we can identify the risk associated with this and develop identify solutions also. In mine development stage when we have got the investor we have started developing the mine. So, the risk assessment appropriate to the source of funding identify solutions also.

And during the operations monitoring of the risk because when already the mine is developed now we are running it.

So, now we have to monitor the risk and if something happens then immediately we should implement solution and in most of the cases preventive measurements should be presented preventive measure should be taken. So, that the risk does not confront you do not confront the risk that you have apprehended that is even better solution in mining operations. Now, we are coming to the end of the project stage mine closure. The last phase of the project different project

So, you have to determine the magnitude of risk that a mining company should deal when the project is closed. There will be environmental problem, there will be rehabilitation problem, there will be socio-cultural issues because you thousands of people or hundreds of people may lose jobs all these things and you whether you have taken all the closer actions or not, whether you have restored deforestation or not. Otherwise, there will be different governmental, statutory, social, , outrage against the mining company. So, we need to be fully aware of all these things. And being a responsible miner, we need to develop all these mitigation strategies and implement everything that is related to the mine closure plan.

Now let us categorize operational risk and what are the risk that is associated with the details of this thing. Risk category operational is geology or exploration, mining risk

when you are excavating and bringing it, processing when you are processing it that you are not getting the right grade why it is happening. Infrastructure risk not fully supported in that case what additional measures are required to provide full infrastructure. Environmental risk I have told earlier also. Now weather force measure you do not know that something has happened tsunami or flood or anything, but remember that this can happen.

So, we must not say that this will never happen to you and you just be careless about this thing not at all. This can happen to anybody and everybody. So, if this happens what is the mitigation measures, how to minimize the loss related to these hues weather related mishaps. So, in that case what actions we are taking to see that this can never create havoc in the mining settlements, residential area or the or the operation of the mine itself.

Now, there are poor machine availabilities, which can severely hamper the production, directly hamper the production. How do you manage that? If health and safety of the employees are compromised. So, the workforce again you have to take industrial actions. contractor non-performance.

So, if the contractors that you have given certain job, certain duty, certain agreements and they are not performing to our expectation, these are you are identifying the risk involved. completion risk, we have a plan to complete a particular work or task or job within a say 6 months or 1 year, you have to installation of an additional facility in a

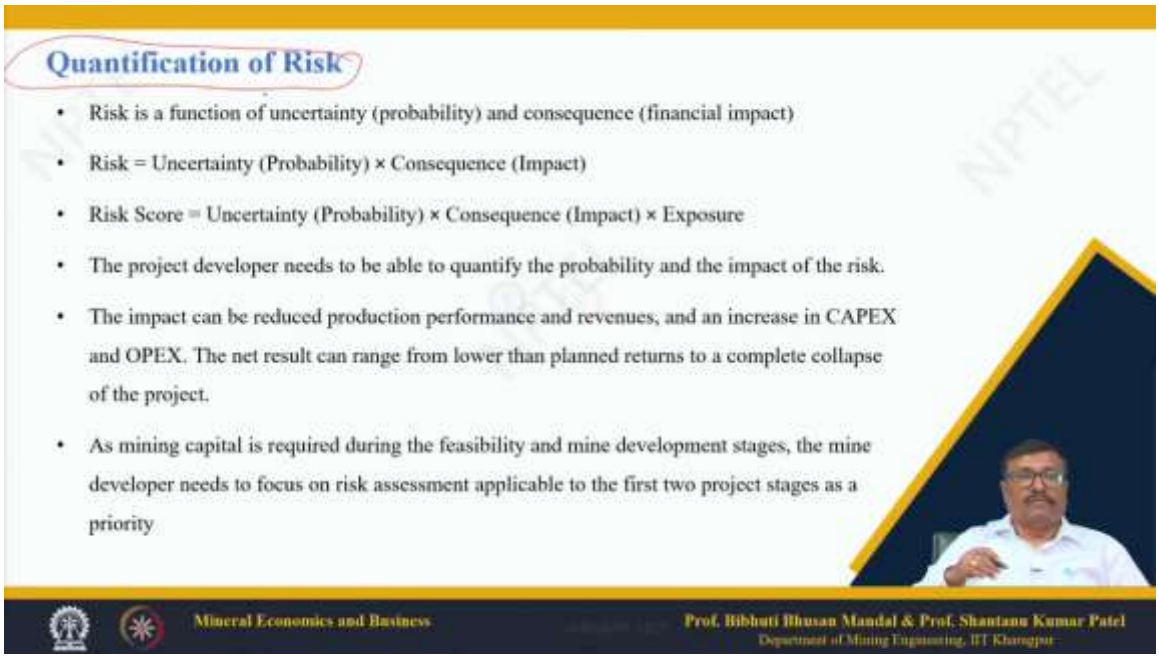
plant, can you do it in that period or if you are, if you cannot complete this then what will happen that you have projected that the production will be or the processing, beneficiation will be, the capacity will be enhanced but if you cannot do it then what happens, it will it will hamper the smooth flow of operation and it will stop mining operations or rather what you thought that it is going to help you in business grow then that you will never achieve. If your project assumptions in the feasibility stage is incorrect and you see now that the parameters that you took for assessment of the viability or feasibility of the project are in that case how do manage that because it is if it is completely out of proportion then then then it is very difficult very difficult to manage but if it is deviating then how we can manage these things so this can be a risk involved in mining operations.

And last but not the least the operating cost if they are escalating whether it is a variable cost, overhead cost, labour all these things. So, operating cost can increase if the diesel, petrol or anything all these things spares it can increase. So, how to manage all these things up to what extent it is manageable by you. So, identification of the risk is very important. you are operating a mine with a team definitely.

So, what are the risk associated with the team or team members that the team members some of them do not have the required skills. They lack in team cohesion, there is no

bondage between the team members. They truly do not act as a team and there is a lack of communication between themselves. They do not communicate with each other effectively. So, the performance of the team is greatly hampered.

Let us talk about the market risk. Simple thing falling commodity price is definitely we identify as a risk. So our revenue will be dropping down. Legal risk mining regulatory framework is inconsistent for some reason. which we thought in the beginning which may be inconsistent with the although the present regulatory framework may not be perfectly consistent with what we are doing.



Then contractual risk mean the legal terms between the contractor and the mine operators are different or if that drastically change then we will have a risk in operating or successfully operating the mine. The country politics will greatly influence the operation of the mining or any business. We need to be prepared for that. Now about the financial risk part. So, in in financing the funding terms or say lack of lack of finance.

So, in the beginning we have, but when you are operating the mines, then what is happening in between? You want additional short-term funds also. You need, so you need to be very careful that if this situation arises, will you have your financial support and where will you get it from? Now, say the currency movements, ah, equally, and then the project is not insured correctly. As we have studied in the insurance chapter also, that proper insurance is not, ah, provided for the machines, large equipment. Even, ah, there

are insurance related to, ah, the manpower also. So, we do not—our project is not properly insured. So, in case we have some kind of loss of life and property, then we do not get the insurance benefits.

We need to be sure that we have properly insured, but, but naturally, we will have to pay a lot of premiums to fully get insured. Now, the credit risk. Credit risk, so as I said, this is also a part of the finance. So, your credit rating also needs to be good so that you can get easy loans from the market. Now, the corporate risk: wrong strategic direction. The corporate is not behaving in the line that we thought in the beginning. And acquisitions, for example, we are trying to do the acquisition of other companies.

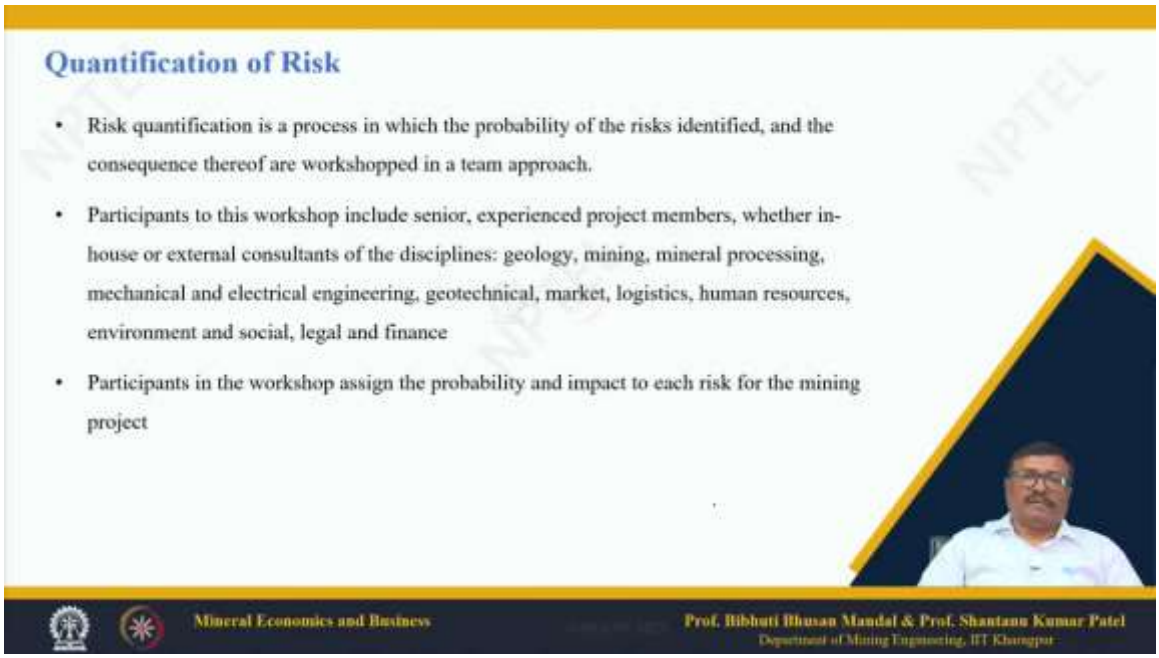
We are diversifying our business. We are doing mining; maybe we are investing somewhere else where we are going for an acquisition. So, we need to be careful because this is going to be— going to influence or affect the overall performance of the, ah, of the company. So, the wrong investment decision in the name of, ah, diversification or to support the—

The argument that if the core mining business somehow suffers drastically then our expansion schemes will give us a support in future that needs to be very carefully examined. Otherwise what is happening both the things may suffer. I mean if the mining is not suffering even then a wrong investment decision will lead us to a situation where the expansion schemes will suffer more than our core mining operations. Now, the joint vendor venture partners or shareholders or the shareholders are not aligned. This can happen ah ah then the taking decisions as to what dividend you are ah going to declare or the partners they are not in good terms.

So, how do manage? This is a corporate risk. very critical but still you need to be aware and the corporate governance overall who that is a typical management problem unless they have they behave like a team they have a common interest of the benefit of the company Then we cannot grow I mean if I look after my own personal benefits and also the 2, 3 other people who are running the who are at the helm of affairs they have their absolutely selfish and personal motos and motives in that case you cannot grow. So, the corporate governance is basically a very important team work with leaders they will lead the the company towards higher and higher goals.

Now, let us quantify the risk. let us try to now we have talked about we have we have talked so much about the risk what kind of risk and what risk is associated with what kind of operation. But here we are just trying to quantify this is it possible to quantify this the

answer is yes to some extent definitely. The risk is basically a function of uncertainty or in mathematical probability and the consequence that can be termed as a financial impact that can be converted as a financial impact that can be transformed or expressed in terms of money also to some extent not fully. So we can write this as a formula or equation you can say that: Risk = Uncertainty (Probability) x Consequence (Impact)



If you multiply this, then we get a risk. Why are you multiplying? Because the thing is that the uncertainty remains the same. If the consequence changes, then the whole thing will also change. And they are, these two are very critical. I mean the probability of something happening and its related consequence.

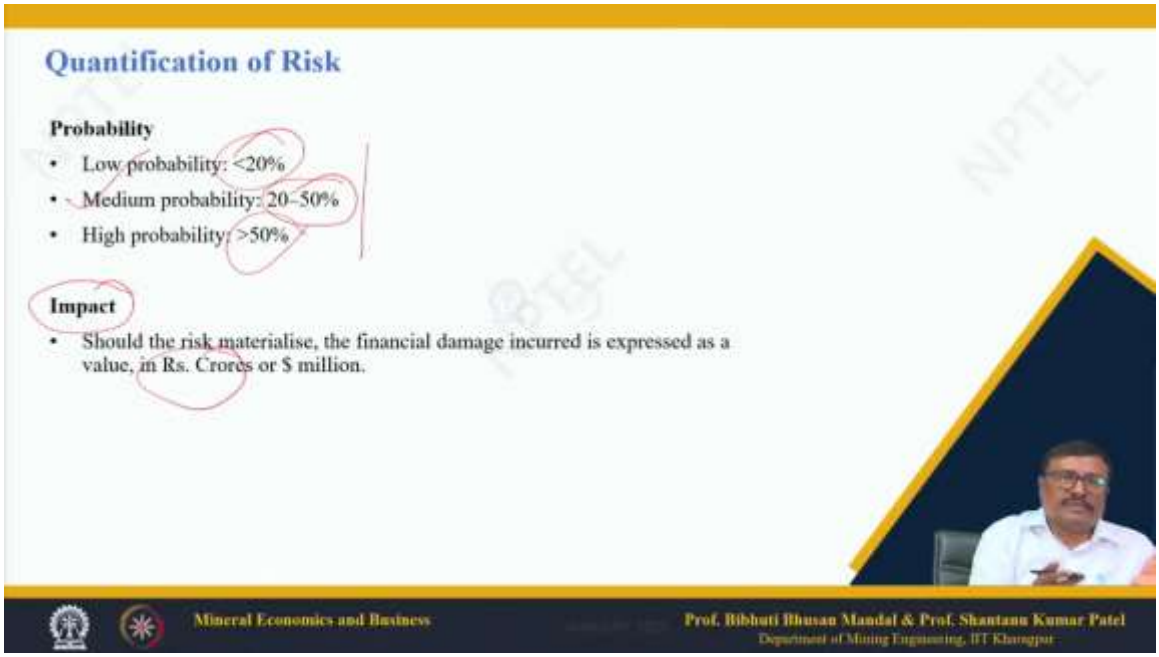
So, when we multiply both, we are getting the risk, trying to quantify the risk. So, what is the risk score? It is:

Risk Score = Uncertainty (Probability) x Consequence (Impact) x Exposure

Now, the project developer needs to be able to quantify the probability and the impact of the risk. See, in the beginning, the people who are experts in doing this kind of analysis will definitely be able to quantify the probability and the impact of the risk.

Quantifying the probability means determining the chance that this will happen. Now, if this happens, then what will be the risk, the financial impact? How many people will be exposed? What sections, what divisions of the operations will be exposed? How many people will be impacted? So, the impact can be reduced. It can reduce production performance and revenue, and it can increase capital expenditure and operational expenditure, both.

And the net result can range from the lower than planned returns that means, we have a planned return and the return will be less than the planned return. and it can if it is if the risk is too big and the consequence and impact is even more severe then you can think of a complete collapse of the business. So as mining capital is required during the feasibility and mine development stages, the mine developer needs to focus on risk assessment applicable to the first two project stages as on the priority in the beginning itself, in the beginning itself. So, now the process can be now ah expressed or or we can tell that this is the the it is a process in which we ah identify the probability of the risk and the consequence there are and so we can find out the risk associated and we can try to find out the mitigation approaches. we can give a priority also if we can find out the risk score then we can give a priority 1, 2, 3 the highest risk score gets the top priority that also we can do in the quantification.



So, participants ah we need lot of participant brainstorming session. So, in that workshop kind of thing we include senior experienced mining project members whether in house or you can invite external consultants who are less biased from all geology mining and mineral processing sectors mechanical electrical engineering geotechnical market specialist, the logistics suppliers, the human resources, environmentalist, social and legal and finance experts also to work together, go for brainstorming, find out the probability of something occurring and the risk associated with it, the impact associated with it. So, probability and the consequence can be easily found out by discussing with each other. arguing with each other counter argument are very much required to arrive at a definite quantification.

So, this workshop will ultimately assign the values to the probability and also the likely impact of each risk associated with that occurrence of that risk. So, the probability ah we we consider low probability is less than 20 percent, 20 to 50 percent is a medium probability and greater than 50 percent we consider as high probability. And in in in case of the in in in in terms of a rather impact. So, if the risk really materialize then the financial damage associated should be expressed as much as possible in rupees crores or rupees lakhs whatever it is or say in million dollars.

So, probability and the impact if both the things we can try to your say something you can say that the failure of a dump will it happen? chances. So, we can have a data I mean from the past that we had we have examined 1000 dumps how many dumps have failed instead of maintaining them at least one of them or three of them has failed or 10 of them has failed. From there at least we can have the idea of what is the probability of the failure of the dump even though we are maintaining certain So, that could be due to bad weather or certain unforeseen things.

There is a probability of dump failure even if you are trying to maintain something. So, from there we can find out the what is the chances of the of the probability of occurrence of dump failure. If that dump failure what financial damage it can incur can we express in terms of money is it possible if that is so then the basic things are done the probability is known and at the same time the monetary loss related to is this is also known. So, now we can use this for the purpose of calculation of the risk and risk score.

Usually the low medium low ah naturally if you have if you have given ranking of the risk then naturally people will go for the high and medium risk for developing the mitigation ah ah strategies compared to the the the ah risk of low probability which

which is very very less likely that it can happen. So as I said earlier that the management is nothing but this systematic process of identification then analyzing, evaluating that means we are assigning the values and then finding out the risk. So from there we can find out a positive effective mitigation strategy. so that otherwise there is a chance that it would negatively impact the organisation's operations, assets and objectives. So mitigate that we have to identify beforehand, analyse them, evaluate them and then calculate the risk and risk scores.

In mining, there are a lot of uncertainties, like geological variations, as we have said earlier. Market fluctuations of the commodities and environmental concerns are inherent to mining operations. So, risk management—effective risk management—plays a great role in the mining business. Now, if you consider all these things, you can make informed decisions—we can say informed decisions. We prove resilience—that means our capacity to fight against the odds and maintain stakeholder confidence.

And we foster long-term success in a competitive and unpredictable environment. This is how—I mean, we can say that being informed— and being able to identify risks, analyze, evaluate, and develop mitigation procedures beforehand is very, very helpful. So that, if it happens at all, we can have counteractive measures that will not hamper the smooth flow

of mining operations. Now, I will quickly go through this list of risk management initiatives—just for your reference—like, say, for geological and exploration risks.

So, the control is risk management through evaluation of geological information—correct evaluation from proper mineral resource information is very important. So, internationally acceptable resource evaluations like UNFC or JORC, as I have said in the beginning of a few lectures, and, of course, you use third-party independent evaluators for the resources. You must appoint reputable mining consultants to provide monthly mine planning input; mine contractors should be well-established, reputable people. And for any variable, you must use experienced mine planners. If you do the planning properly with good, experienced mine planners, half the job is done.

In processing technology, for example, you can use proven technology with less risk, which is already being practiced by many companies. You will have less risk. Input and guarantees from the suppliers: what are the raw materials that you require? And of course, there should be a provision that in the future, if I want to modify, then how do I modify? The provision should be there. And at every stage, an independent expert will give you unbiased views in most cases, which will help you in growth. And now, in say weather cases, for mature cases, we said that we have no control.

But the question is, due to the nature of SARS-CoV-2, can you imagine whether there is a huge landslide in the area? Is there any possibility? Can there be a huge flood? Or what is

the chance that we will have a devastating cyclone in that area? So, if that happens, yes, okay, we have no control over this, I understand that. But you must have insurance, enough insurance to counteract this, so we get compensation for that from the insurance.

And you can recover from the diversity of the situation to restore normalcy and bring the whole project back to life. How quickly with that? You must keep these things in mind that this can happen. As I said, if it happens, then what can happen? How can you take the counteraction or say you can restore normalcy as quickly as possible and provide due compensation to the people who are affected. Environmental risk: we have control definitely. We must implement the environmental management report and then we always take independent opinions on how to do these things, and we can continuously monitor the environment. So that we can implement the environmental management plan and reduce your environmental impact assessment. In production, if poor machine availability is there, we can control it. We can focus on preventive maintenance and we should not wait for breakdown maintenance.

We should provide regular preventive maintenance. So, we must have a proactive maintenance management system so that we are least affected by breakdown. So, we must go for mechanical skilled people, we must do incentive that if you can maintain the machine and operate smoothly you will get more incentives. So, we should focus more on the operators discipline and that training. So, that they do not you abuse the machines

misuse the machines and so that we get more life and more effective service life from the machines.

We must maintain the whole load properly and engage the original equipment manufacturers and suppliers to look after and to participate effectively to see that our machines give the maximum productivity. Make mine regulatory we have also no control, but we can go on consulting with the local department. We can review the assumptions by independent technical and financial advisor, how this can be managed, ok. You keep a provision of 10 percent contingency that if something happens we will manage from this fund. And as I said repeatedly, a scenario planning, that means to visualize, okay, this can happen and we have the contingency.

So, if this happens, this is how we will be managing these things. This can be controlled, provided you have a contingency you manage for that. Now, if there are lack of skills for example, we have steel control. So, you can identify it also provide training and you can promote talent in house as far as practically possible. And then we can collaborate with other institutions to secure talent, bring talent so that your management of the business is much more efficient.

Similarly, we have the the market forecast, if you can use the independent market study and the price hedging arrangements which we have discussed earlier also. The financing part, so whether we have fixed interest debts or bond like this. Now, insurance also we

have we need to have diligent operational management. and the ensure must ensure equipment breakdown period. So, all these things are very much required for effective risk management, some of them are under our control, some of them are not under our control.

But the the risk categorization is very much department that identification of risk I will come back to what I told in the beginning that identification, evaluation and development of the mitigation is most important right from the beginning and throughout the operations and also during the closure of mining operations. We have taken lot of materials in this particular lecture from Michael S, famous book Mining Capital. You can download this book which is freely available in from the net internet and you can of course, definitely you can read our many other resource materials. So, today we discussed about the risk associated with the mining operations, how to quantify

can we quantify ah what what extent to what extent we we we quantify the mining risk and can we develop an effective mitigation strategy. So, that we can run the mining business without in between hampering the operations or stopping the operations. Thank you very much.