

Namaste! We carry forward our discussion on Case Studies and in today's lecture we will have a look at the Economics of Environmental Disasters. What is a disaster? A disaster means a catastrophe, a mishap, calamity or a grave occurrence in any area, arising from natural or man made causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property and or damage to, or destruction of environment. And is of such nature and magnitude has to be beyond the coping capacity of the community of the affected area. So, what it means is that a disaster is something that is a grave occurrence in any area and it may occur because of natural causes or manmade causes.

So, we can have natural disasters or we can have manmade disasters. Good examples of natural disasters are things like floods or hurricanes or volcanic eruptions. Good examples of manmade disasters are industrial disasters. So, you can have natural disasters or man made disasters and disasters may also be caused by accident or negligence.

Now, a common property of these disasters is a substantial loss of life or human suffering or damage to and destruction of property or damage to or destruction of the environment; that is a common feature is that either human lives get lost or there is human suffering. In certain cases people might get sick; people might get injured. Even though they are not dead because of a disaster, it leads to a very huge amount of human suffering because of a disease or because of, say, an injury.

Or in certain cases, there might be a destruction of property or a destruction of the environment. And these are of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area; that is it overwhelms the resources and the coping capacity of the local community and in that case we will call it a disaster.

Now, disasters can be natural disasters such as earthquakes, landslides, tsunami, flood and so on or we can have human made disasters such as industrial accidents, oil spills, war, terrorist attacks and so on. So, there are all these different kinds of disasters. Now, in the case of the management of disasters; we have certain definitions.

The first is risk; risk is the effect of uncertainty on the objectives or a combination of the probability of an event and its consequence. So, risk is a combination of probability of an event and its consequence. Which results in an impact on this uncertainty on the objective of normal management.

When we talk about risk; we talk about what is the probability of such a disaster happening, what is the probability of a flood in your area, what is the probability of having a tsunami in your area and should there be a flood; what would be its consequence? Now, consequence would depend on whether your area is, say, up lying or low lying, how much is the given density in that area, how much are the infrastructure levels in that area, and what is the quality of infrastructure.

So, there are a lot many things that are involved. This is a combination of the probability of an event such as the probability of a flood and the consequence of that event; that is to say the consequence of a flood in your area. Risk perception is the way in which a stakeholder views the risk, based on the set of values or concerns.

So, it depends on the stakeholders needs, issues and knowledge. It is the way in which a stakeholder views a risk, based on a set of values or concerns. Now, for a single risk; the level of perception might be different in different stakeholders. Because there are people who might not perceive the risk at all because there could be people who just do not think that there could ever be a flood in their area. There are a number of people who say that there is absolutely nothing like climate change that is happening.

These people are completely oblivious to the occurrence of the risk. On the other hand, if somebody is more knowledgeable; then they would have a very different perception of risk; they would not think that this risk of a flood coming to the area is because of a previous karma.

But they would think that this is because of, say bad management of the water resources in the area. So, the perception of risk varies with different stakeholders and it is the view or the way in which the stakeholder perceives the risk, based on a set of values or concerns. A person who has a lot to lose in a disaster would have a very different concern from say a bystander. So, a person who is living in India will probably have a very different view of say drought in Australia than an Australian; who is living in Australia.

Which is why the perception of risk varies between different stakeholders. Then, we have risk management; so if there is risk; it has to be managed. Risk management is the coordinated activities to direct and control an organization with regard to risk. So, it is a set of coordinated activities; so it is not a one of solution it is a set of coordinated activities that all aim to direct and control an organization with regard to the risk. So, in the case of risk management; we will talk about how we quantify the risk.

And what are the kinds of steps we should be taking to minimize the risk and should the disaster occur, what are the kinds of preparedness that we would make so that the amount of risk is minimized. Next we have the risk management system which is the set of elements of an organization's management system that is concerned with managing the risk. So, for instance if there is a disaster or there is a probability of a disaster; who is going to respond? Do we have a set of people who are trained in this response?

This is known as the risk management system; the set of elements of an organization's management system that are concerned with managing the risk. Then, we have risk source: the element which alone or in combination has the potential to give rise to others; an element which alone or in combination has the potential to give rise; to a risk. For instance, if there is a dam; that is made in an area that has been suffering from earthquakes.

So, this dam is now a source of risk because the dam would hold a very great volume of water which will have a very large amount of mass. Now this amount of mass will exert a downward force on the tectonic plates that are there in that area. Now, because of that the earthquake probability might go up or suppose an earthquake occurs.

And if the dam fails, in that case a huge area will get inundated; it will be flooded. So, this dam is now a source of risk in that area both because it can increase the occurrence of earthquakes and also because should an earthquake occur; it would lead to very great amounts of damage. This is a risk source, an element which alone or in combination has the potential to give rise to a risk. An event is defined as the occurrence or change of a particular set of circumstances, even if

the occurrence of a circumstance or changes in a particular set of circumstances and consequence is the outcome of an event that affects the objectives. So, you can have an event of flood in which case there is a flood and the consequence could be things like loss of life or damage to property or damage to the agriculture of the area. So, it is impacting the normal management which is why it becomes a consequence; it is the outcome of the flood, so it is the outcome of an event.

Then, we have likelihood; likelihood is the chance of something happening. If you live in an area where you have a river, then there is a likelihood that there could be a flood. If you live in an area that is very dry and perhaps it rains say just a few millimeters in a year, then probably the likelihood of having a flood is much less.

So, likelihood is the chance or the probability of something happening; control is a measure that maintains or modifies the risk. When we have a risk and we try to control the risk, it is a measure that maintains or modifies the risk and in a number of cases it tries to reduce the risk.

A stakeholder is a person or organization that can affect, be affected by or perceive themselves to be affected by a decision or an activity. Stakeholder is a person or an organization; so you can have a person or you can have an organization and their role is; they can affect a decision.

They can be affected by a decision or they perceive themselves to be affected by a decision or by an activity. If the government is deciding to build a dam in your area; then the government is one of the stakeholders because they are doing something. If you live in that area and you can get affected by this dam; then you are also a stakeholder.

And if there is say an organization that caters to the well being of wild animals in your area; so and they think that because of this dam the wild animals will have a negative consequence, they will suffer a negative consequence and they perceive that they, that their activities will also get affected because of the construction of this dam, then all of these are stakeholders. If there are people who can tell the government that this should be the height of the dam or this should be the structure of the dam.

Then they are also the stakeholders. The experts are also the stakeholders, the media is a stakeholder. So, stakeholder is all those persons or organizations that can affect a decision or activity, that can be affected by a decision or activity or who perceive themselves to be affected by a decision or activity; they are all the stakeholders.

How do we manage risk? What are the principles of risk management? Well, the first principle is that risk management is integrated; it is an integral part of all organizational activities. It is not a one of solution, it has to be there whenever you are doing any activity in your organization. So, whenever we are building a dam; we have to think about the kinds of risks that it might pose and we have to incorporate all these risks and the management of those risks in the construction of the dam.

Risk management always has to be integrated; it has to be structured and comprehensive. A structured and comprehensive approach to risk management contributes to consistent and comparable results. It is not that when you make one dam, you will have a different set of results; when you make another dam, you will have a very different approach to making this dam. It has to be structured; it has to be comprehensive so that it can be applied to different circumstances.

But at the same time you also need certain customized solutions. The risk management framework and process are customized and proportionate to the organization's external and internal context related to its objectives. So, risk management also has to be customized, it has to be inclusive, appropriate and timely involvement of stakeholders enables their knowledge, views and perceptions to be considered. This results in an improved awareness and informed risk management.

Whenever we are taking a decision; it is always prudent to include all the stakeholders. Whenever the government gives permission for a dam to be made, then before the construction ever begins; people have to go out and talk to all the different stakeholders that are there.

What are their perceptions, what are their fears and all those perceptions and fears, views; they have to be incorporated in the project document. So, risk management has to be inclusive; you cannot take decisions on behalf of others, you have to include them whenever you are making a decision.

Risk management is dynamic because the risk can emerge, change or disappear as an organization's external and internal context changes. So, risk management anticipates, detects, acknowledges and responds to those changes and events in an appropriate and timely manner.

What we are saying here is that the risks may change with time. When for instance, you set up an industry and the whole of its surroundings is a barren land; then the sort of risk is very different than at a later point of time, when suppose the town has extended itself, the town has expanded and it is now right on your doorstep.

Because in the earlier situation, when it was a barren land and people were not living there; in those circumstances, there was hardly any risk of loss of life or property should any industrial accident occur. But when the town has expanded and has come to you; then the risk would be very different because if any industrial accident occurs.

Then there will be a huge loss of life and property. Now, in this case the organization that is the industry is not doing anything to change the risk, but the external conditions have changed to such a level that the risk has changed. In certain other conditions, it may be a result of the organization's internal dynamics that the risk changes.

For instance, if there is an industry and currently it has all new equipment; everything is computerized, everything is working properly, but then because of bad management over time; it is possible that the equipment now does not work in that way. Now, in such a scenario; you even though the outside environment remains the same, because the equipment is now failing; so that would increase the amount of risk that an accident could happen because of which the risk management needs to be dynamic.

So, it has to change; if the equipment becomes old, you will have to make changes to your risk management strategy. If the town expands and comes to your backdoor, you will have to make changes to the risk management strategy. Then risk management should always incorporate the best available information.

The inputs to risk management are based on historical and current information, as well as on future expectations. When you are setting up the industry; you should know if any similar industry elsewhere in the world has resulted in any industrial accidents. If so, what kinds of

accidents, how many people were involved, what was the response of management and was the disaster contained in a set period of time or not? So, you have to look at the historical context.

You have to look at the present quantities which is the best available way of mitigating the risk that the industry can propose to the surroundings. We also have to incorporate the information about the future set of events. How fast is the town expanding, how soon will people be able to reach into this area, is there any other industrial facility that is supposed to be set up nearby? Because they will all change the total amount of risk that the industrial setup is posing to the surroundings.

It has to be based on the best available information. Risk management explicitly takes into account any limitations and uncertainties associated with such information and expectations. Information should be timely, clear and available to relevant stakeholders. So, when we say that it explicitly takes into account any limitations and uncertainties associated with such information; what are we saying? Is that if you do not know how fast the town is going to expand.

Or how soon are people going to come near your industry? Then, you have to acknowledge this risk and work on a precautionary principle approach which means that if there is say a 10 percent probability; that people would have reached to your industry, then the precautionary approach would say that let us assume that this 10 percentage or probabilities going to happen and let us make all the arrangements. So, if there is a limitation or uncertainty that is associated with this information.

Because risk management is based on the best available information; you have to incorporate any limitations that you are facing. Risk management is based on human and cultural factors. Human behaviour and culture significantly influence all aspects of risk management at each level and stage which means that in certain societies.

There people might be more risk averse, in certain societies people may be less risk averse. Now, whenever you are making any decision; you have to incorporate what is the level of risk aversion of the surroundings, of the people in the surroundings, what are the other risks that these people are already facing, and what are the cultural aspects?

All of these have also to be incorporated into risk management. And risk management is based on continual improvement through learning and experience which means that if there is say a new study about how a risk should be managed and if it is applicable; then probably it should be implemented in the current scenario.

So, it has to be continuously improved; it is not that once you have made a risk management document and once you have implemented it, then there are going to be no further changes; there has to be a continuous process of improvement in the risk management strategies in any organization.

The process of risk management comprises communication and consultation, monitoring and review and establishing the context, risk assessment and risk treatment. What happens in the case of a good risk management strategy is that we begin by things such as communication with the stakeholders, consultation with the stakeholders and getting to know everything that can be known about this particular risk. Then, we establish the context.

What is the site of the place where the industry is going to be set up, what is the setting of this area? In this context, what is the assessment of the risk, what is the possibility that things may go wrong and what is the possibility that we will have certain consequences because of something going wrong; so that is risk assessment.

It includes identification of the risk, analysis of the risk and evaluation of the risk. And then we make a strategy for risk treatment; how are we going to reduce this risk? And in all these processes; there is a continuous communication and consultation with the stakeholders.

Because remember we cannot take decisions on behalf of others, we have to incorporate every stakeholder in all the steps of risk assessment and risk management. There is a continuous process of communication and consultation and in all these processes; there is also a continuous monitoring and review.

When we talked about risk identification; did the person who was doing the risk identification; did he or she include all different kinds of risks that he or she should have looked at or perhaps they missed out on certain risks. Now, who is going to tell this; if there was no monitoring and review mechanism.

A monitoring and review mechanism is there during the risk; identification stage, it is there during the risk assessment stage because it is possible that the person who is doing the risk assessment probably comes up with a very low assessment. It has to be there when the risk management strategy is being implemented.

Because they could be lacunas in the implementation of the risk management strategy. In all these steps; there is a continuous monitoring and review. Now, this is a theoretical framework on which risk management works and this is how it should be managed, but then this is not always how things are managed in practice.

Now let us have a look at what happens if the risk is not properly managed. What are the kinds of reasons because of which a risk is not managed properly and what are the consequences?

We will have a look at certain case studies; the first one is the Minamata disease. Now, the Minamata disease originates from a village that is known as Minamata in Japan and this village was traditionally a fishing village. It was full of fishermen whose main source of livelihood was fishing in the nearby sea.

In 1932, a local industry by the name of Chisso factory; it begins the production of acetaldehyde and it uses a compound of mercury as a catalyst for the reaction. Now, once the reaction is done; what happens to the spent mercury, the spent catalyst; it is now of no use to the industry. Now, the industry could have done 2 things; one process this catalyst because whenever you are throwing something out as a waste, it might have a negative consequence on the environment.

The industry could for instance have spent money on the processing of this spent catalyst that was having mercury inside it. But it did not do that; what it did was it just dumped the spent catalyst into the sea. Now, here again it is important to note the importance of externalities.

If the industry had spent resources on the processing of the spent catalyst; then it would have reduced the contamination of the surroundings, but it would have cost the industry; whereas, if the industry just threw it out into the environment, then the industry could increase its profits.

It is in the short run when it does not have to pay for damages and the damage is felt by the

people who are there in the surroundings. It is not experienced by people in the Chisso factory, but by people in the surroundings in whose area they are throwing this waste. So, the spent mercury catalyst is dumped into the sea.

Now, by 1950; so it is now 20 years or roughly 20 years to the time when they start dumping off the catalyst; the spent mercury catalyst. Now, by the 1950s it is known that in a number of locations, fish are found floating in the water. So, these triangles; these white colored triangles are all those locations in the surrounding where fish are dead and they start to come to the surface, they start to float on the surface. Now, this is a disease that nobody had seen before; another thing that happens is that the cats in the area.

So, this is the water body and all over the water bodies; we are finding that the fish are dying. Inland, what we are finding is that at all these locations we are finding strange symptoms in the cats. Symptoms such as this; by 1952, people are starting to report that the cats are committing suicide.

The cats have a large number of neurological deficiencies; a large number of neurological diseases. So, they go on repeating an activity again and again and again and these cats are so highly depressed and they are so diseased because of these neurological symptoms that at times they jump from a cliff or they die off.

So, there are a number of instances of cats committing suicide in this area. So, this is when people actually started to look at this particular phenomenon. What is so special about Minamata is that the cats have started to commit suicides. What is suspicious is that the fish are dying and floating on top of the water.

Then in a short time, we start observing symptoms in the human sense value. So, the humans also start to show very similar symptoms. So, their hands, their body parts are now showing symptoms such that their joints are getting affected; they are showing repeated movements and the number of the human victims is increasing.

And by the year 1959, the scientists and the doctors have discovered that mercury is one of the reasons. What are the kinds of symptoms that we observe in humans? Disturbance of sensation, superficial sensation and deep sensation; the people are not able to sense properly, showing that there is damage to the nerves.

There is a constriction of the visual field in 100 percent of the people that is they are not able to see properly. There is dysarthria; arthrosis joint, dysarthria is a deformation in the joints such as what we have seen here. So, there is this dysarthria in a large number of patients; there are disturbances of coordination; people are not able to walk properly, people are not able to do any activity properly. We have things like impairment of hearing, tremors, changes in salivation, mental disturbances.

These different kinds of symptoms are noted; it is observed that a number of these symptoms arise because of neurological problems and it is known now that mercury is one of the reasons or the primary reasons. We will start observing damages in the brain. If there is a postmortem, people would find that the brains are having holes and importantly cat number 400 dies; what is cat number 400? One of the scientists; what he did was he took cats and he started feeding them with the residue that was being thrown by the company into the sea water.

Once he started feeding the cat; he was able to develop all these symptoms very quickly in the cat and so it was proven that it is because of this waste material that is being dumped that we are seeing all these different kinds of neurological symptoms. And in 1959, this cat died because of all these neurological symptoms.

Then in 1959, demonstrations began against the company and what the company does now is that they install equipment that supposedly treats the waste. But, here again what the company did was that they did not actually install a machine that could process the waste efficiently.

It was more of an eye wash because there were demonstrations; so, the company said ok we have to do something. So, they did something, but that was the; that was not the most efficient thing. So, the company still carried on dumping the waste into the sea even after knowing from one of its scientists that this waste was causing the neurological symptoms in the animals, in the fishes, and in the humans in this area. And because the company did hardly anything to stop these wastes; ultimately in 1975.

This whole area had to be dredged which means that all the sediments in the sea had to be excavated, processed and thrown to some other location so that the level of contamination goes down. Now, just think of the amount of money that a company would have to spend to process its waste.

Well, when the company is throwing the waste; the waste is in a very concentrated form and it is easy to treat. Once we have dumped the waste into the sea; it has spread to such a large extent over such a large area that now you have to dredge the whole of the sea in that; in the surrounding areas; so the cost goes up like anything.

Then, if you look at the environmental damage that the company did; a payment of 12.63 billion yen per year; now billions of yen per year are projected for health damage compensation, sludge treatment and damages to the fishery. And if we look at the human cost.

By the year 2005, total number of officially certified patients around 3000, recipients of the medical task of the comprehensive measure of Minamata disease; since 1992, around 13000, patients manifesting health effects of methyl mercury that were recognized by the ruling of the supreme court in 2004; 58 and applicants for certification before the judgment greater than 3300. So, what we are observing here is a huge cost. In terms of human health, human life, animal health and environmental damage.

And all of these walls were preventable had the company just treated the waste before throwing it out into the sea. So, this is what happens, when risks are not properly managed. The kinds of tragedies that we can observe, when people just contaminate the environment because it is just an externality, just a cost cutting measure.

Another example is the Aral sea. Now, this is an image from 1974; that is telling us how big this Aral sea was. It was formerly the fourth largest lake in the world with an area of 68000 square kilometers. In the 1960s, the Soviet government decided to divert waters of Syr Darya and Amu Darya, these are 2 rivers that were providing water to the Aral sea. And the soviet government decided that the water of these rivers can better be used for agriculture.

In the 1960s; the Soviet government decided to divert the waters of Syr Darya and Amu Darya into the desert to enable cotton production. So, the water that is getting into the lakes is now

diverted. A large system of canals was created; due to lack of water flowing into the Aral Sea, it started to shrink.

The lake earlier was in a dynamic equilibrium; the amount of water that it was losing out because of evaporation was roughly equal to the amount of water that was flowing inside. So, it was losing out as much water because of evaporation say because of some amount of seepage into the soil and so on.

But the amount was largely balanced by the amount of water that the rivers were bringing in. Now, if you stop the flow of these rivers and if you divert the water; then the input to the lake stops, but the output because of evaporation or because of seepage continues as it has. So, now, you are not letting water enter into the lake and so the size of the lake starts to shrink and the salinity increases from around 10 grams per liter to above 300 grams per litre; killing off most of the fish.

Now, we have observed in one of the earlier lectures that every organism has a range of tolerance for different components of its environment. Now, fishes also have a range of tolerance for salinity. When it becomes too saline the fishes are going to die off because it is now no longer fresh water, it has now become very salty water.

The salinity increased from 10 grams per liter to above 300 grams per liter killing most fish. Pesticides and fertilizers from the cotton fields reached the Aral Sea; increasing pollution and killing off most of its natural life. Not only was the salinity increasing, but at the same time; the pesticides and the fertilizers were also reaching into the sea and that was also causing a lot of contamination to the sea. Then cancer rates, infant mortality and diseases in humans have gone up.

Now, because the humans that are living in the surrounding of the Aral sea; now remember that the Aral sea was one of the largest lakes and it was a very beautiful tourist location. There were a number of resorts, there were a number of people who were fishing in the Aral sea. Now, when the Aral sea starts to shrink and when it becomes more and more contaminated; then the surrounding water, the fresh water that people are using also starts to get more and more contaminated.

Because all those pesticides and fertilizers that are getting drained into the sea; they will also be into the groundwater level and so we start to observe that the humans in the surrounding that were a very substantial population; we start observing a number of health problems in those women as well. The rates of abortions go up, diseases go up, cancer rates go up, infant mortality goes up. All these different kinds of diseases and symptoms are now increasing in this area.

Dust storms and salt deposition impacts the local communities who have already lost employment. Now, when the sea starts to shrink; then more and more land becomes exposed and whenever there is any storm; then all of this all the dust of this land would get airborne and it would spread.

Similarly, this lake has now become very saline and so the shores where the salt is getting deposited; that salt will also become airborne whenever there is a storm and it will get into the houses, it will get into the equipment of the people who are living in the locality.

On the one hand the tourism industry is gone because it no longer is a pristine water area, the

fishery industry is gone because all the fishes have died, the level of diseases have gone up because the water is contaminated. Then, we start observing environmental damages because of this contaminated water and highly saline water and exposure of the soil through the winds. So, we start observing dust storms in the area and we also start to observe climatic changes.

Since the moderating effect of the water body has been lost. So, near any water body; we have moderate temperatures, it does not become very hot in the summers; it does not become very cold in the winters because of the moderating impact of the water body now that the water body is gone.

We also start to observe a much changed climate with more and more extremes. So, if you look at the hydrology of this area; the annual water balance changes like this. 1911 to 1960 that is before the expansion of agriculture and before the diversion, the blue is showing us the river inflow, the yellow is showing us the net evaporation. So, roughly the river inflow is equal to the net evaporation. The area is also getting certain water from ground and there is a small surplus that we observe.

The surplus is very close to 0; so roughly the Aral sea is being maintained in the same size, but now after 1961, the inflow has gone down. So, the inflow from here becomes this, but the level of evaporation; it roughly remains the same. Why? Because of dimming of the river you are reducing the inflow, but because the lake is still of roughly the same size; so the evaporation is roughly the same. But then from this point onwards, we start to observe a change in the net evaporation as well.

What we are observing here is that over the years from the 1970s to 2005. What we are observing is that the level of evaporation is also going down which is telling us that the size of the lake is also going down and at the same time; the river inflow has also reduced substantially. And so, earlier while we were having a net surplus through a small surplus, but a net surplus of water that was entering into the lake. Now we are starting to observe a huge deficit. So, in the 1980s and 90s, there was a deficit as large as 30 cubic kilometers per year which means that in 1 year. The amount of water that is being lost from the sea is 30 kilometers multiplied by 1 kilometer in height and 1 kilometer in width. So, that is the amount of water that the Aral sea is using every year and what does that loss look like?

This is the image that we saw in 1974; by the 1980s; so this is the image from 1984 and we can observe that, this was 74, this is 84; it has already shrunk by a large amount. But then, over the years; it goes on shrinking even further, this is the year 2000, this is 2008. So, all these areas that were earlier the Aral sea are now gone; this is 2016.

Something that was as big as this in 1974 is now as small as this. So, when people were beginning to divert the waters of the Syr Darya and the Amu Darya river for agriculture, especially cotton cultivation; they did not foresee the kinds of impacts it would have on the nearby Aral sea.

Because had they known that it is going to cause this greater damage to the Aral sea probably they would not have done this. Even though the cotton cultivation went up; for it for the time being, after a while it again went down and in that time period the tourism industry was gone, the fishing industry was gone.

The local people, quite a lot of them have migrated out. The people who remain are diseased and they are suffering from the vagaries of nature because of extreme climatic events and also because of a huge amount of salt and dust that is getting into their houses and into their equipment. This is what happens when risks are not managed properly and this all happened because people were looking at the short term benefits and not the long term environmental damages.

The third case study we will look at is the Bhopal gas tragedy in our country. So, the Bhopal gas tragedy begins with the plant of Union Carbide; so Union Carbide; an American corporation, had an Indian subsidiary and they set up a pesticide plant in the city of Bhopal.

And it was hailed as one of the shining examples of the new India because in the; in the newer India, in the modern India more and more amounts of pesticides would be used in the case of agriculture so that we have bumper harvest. Now, the area that was chosen for this company; it was very close to the city limits and in a very short period of time, the population had or the city had grown to such an extent that people were living right next door to an industry.

This is an industry that is dealing with toxic materials because it is making pesticides. Now, what happens if these toxic materials ever get out? It will observe a large size mortality. So, this is a risk that should have been perceived at that point of time, but sadly it was not. So, it began with this shining example of new India; so this is the Union Carbide factory. And these are the kinds of advertisements that the Union Carbide was putting in.

If we have a look at the location of the factory. So, this is the upper lake of Bhopal and this is the location of the Union Carbide plant. As you can observe, all this area is the area where people live; here you have small bits of forest and agricultural lands, but this is where people live.

It is said that when the plant was set up; the human population nearby was not at large, but then when the plant was set up it provided employment opportunities; so a number of slums were set up near the plant. As we saw, risk management changes with time.

And on the night of December 2 and 3, 1984; the methyl isocyanate gas was released from this plant, it led to a large number of deaths and blinding of people. It was heavily documented because it was the worst industrial disaster in the history of humankind; 2500 people would die, it would injure thousands.

And we find documentation in all major media. So, this is the BBC, this is The Hindustan Times; on that particular day, the death toll was 1200 and it was rising; this is The Indian Express. So, this is something that has been very well documented and very well studied and the impacts of the release of methyl isocyanate on that night, they still continued. People are still disabled, people are still sick; now the basic question is, why did we have such a tragedy?

The Union Carbide happened to be a very established name, a very respected name. So, how was it possible that we just could not foresee the risk and we could not manage the risk, how was that possible even? So, after this documentation; there were a number of studies. What went wrong?

And we are interested in knowing what went wrong economically; well the insecticide named Sevin that they were manufacturing was not selling as expected. Only around 20 percent of the plant capacity was being used. So, everything begins from an economic point of view; the cause of this disaster was that the insecticide was not being sold at that large a quantity at that larger

volume that the industry was expecting. So, only 20 percent of the plant's resources were being utilized.

When that happens; the cost that the company had put up in setting up of the plant that was not getting recuperated fast enough. Well it was still showing a profit mind you, but it was not showing profit to that large in extent or that fast that the company had expected to see.

Now, when only 20 percent of the plant capacity is being used; the plant was shut down for maintenance. And because it was only 20 percent of the plant capacity being used, they also did a large number of cost cuttings to maintain the profit of the company; cost cutting such as the excess methyl isocyanate gas.

Now, methyl isocyanate was the gas that got released on that particular day. Now, this is such a toxic gas that it is never stored in the company. Generally, the standard procedure is that when you make the methyl isocyanate gas; you make it in very small quantities and then you use that quantity so that you do not have to store it in any large quantity.

But because the company was going through a cost cutting measure, what they did was that methyl isocyanate was made in larger batches and it was stored because they wanted to increase the profits, they wanted to reduce the cost; so what was done was that the MIC was manufactured in larger quantities and it was stored. So, why run the equipment again and again? Then, not only was it stored in the tanks; it was stored above the requisite capacity.

So, the tank from which the gas was leaked, it was 75 percent full when safety procedures required that half of it should be kept empty to serve as buffer for heat; that is when the when this gas has been stored in a tank, then it is being stored above the capacity because again why run the equipment again and again to manufacture the gas.

They were trying to maximize the storage of the tank of the gas, but when it was being stored; the refrigeration unit was also shut down which raised the temperature. Now, MIC had to be stored below 0 degrees Celsius and the; what we are observing here is that the refrigeration unit was shut down. Why was it shut down? Well, why waste electricity? It is all profits. So, to maximize profit, the refrigeration unit was also shut down.

Then, impurities were getting in because of lack of maintenance and leaky walls. So, if there was a leaky wall; then the company officials did not bother to get it changed. Why? Again, cost cutting; maximization of profit, if there is something that is not working; why spend money on fixing it?

So, impurities including water were known to cause runaway exothermic reactions and this is actually what had happened on that day. Sensors were either not installed or did not work; why? Cost cutting. There was a lack of computerization; why? Because if there is a plant that is only working at 20 percent of its capacity; why spend money to modernize the plant; so, no computerization here.

The gas scrubber that used caustic soda was shut down. Now, why do we need a gas scrubber? Because if there is any gas that gets leaked from the industry, then it should be neutralized; so there are different ways of neutralizing a gas. One is that you treat it with certain chemicals such as caustic soda, second is that you can burn the gas, third is that you can make it pass through certain other chemicals that will absorb the gas but in this case, the gas scrubber or shut down;

why?

Well again to maximize profits, to bring the cost down. The decontamination towers and the flares were shut down. Now, these flares are something where there is a big tower on top of which a flame is always burning so that if any amount of gas gets leaked, then that gas will get burnt in that flame. But, then these flare towers were also down; why? Because, why waste money in lighting up a flare tower? Water spray to reduce the temperature and neutralize the gas did not reach far enough of the stack.

So, we are observing a large number of deficiencies; then we talked about keeping the stakeholders in the loop. Now, in this case there was a lack of emergency plans and training, the locals were not apprised and drilled about safety procedures when sirens sounded and the locals just thought; it was a shift change.

Now, when you are manufacturing something that is as toxic as MIC, the locals or the stakeholders; they should have been kept in the loop. And a good way of keeping these people in the loop is through regular communication. Now, if you will remember when we talked about risk management; we were talking about communication at all different points of time. So, in this case what we can observe is that there was hardly any communication with the locals.

There were hardly any drills on what to do if this gas gets leaked? What are the kinds of emergency precautions that we should be taking? There was no such training, there was no such planning and there were. So, many accidents occur regularly in the plant due to the faulty maintenance that sirens were sounded regularly reducing their impact.

So, what was happening was that because of these leaky walls because of equipment that was not being maintained properly; there were so many accidents regularly that now people had gotten accustomed to the siren blaring. So, they just thought that ok it is a routine affair, there is nothing to be worried about. Safety equipment such as gas masks, oxygen cylinders etcetera were lacking; again why waste money in buying these safety equipment in a plant that is not running to the full capacity.

Technical workers were laid off; again this is a cost cutting measure, why use technical workers whom you have to pay more when you are not earning that much amount of profit. So, the technical workers were laid off and in their place; non technical staff was handling the equipment. Now, these non technical staff would hardly know what to do in such a dire situation. And no citizen watch group was groomed and none existed; again when we talk about stakeholders, this was the level of stakeholder participation. So, when there was the release of this gas - now, this release happened because in one of the tanks water got in because one of the walls was leaky and when the water gets in; there is an exothermic reaction. The tank is already above the stipulated level of capacity and it is kept much warmer than is desired.

It had to be kept refrigerated at 0 degrees so that if even water entered into it; then the whole reaction would be cooled down, which is why you need to always keep the refrigerator on in this case, but the refrigerator was off; so there was no cooling that was happening.

So, there was an exothermic reaction; the pressures increased, and the tank failed. So, when the tank fails; the gas gets out, when it gets out; it could have been neutralized by the chemical scrubbers or it could have been neutralized by the flares in the flare tower; they were not

working.

The sirens were not working, there were no sensors. So, people did not know about such a mishap that was happening. If the sensors were installed, especially things like temperature sensors, then we would have known much before that there was some exothermic reaction happening, but then there were no sensors.

There was no computerization and this gas when it was getting released out, then we did not have the equipment to even pour water then bring its temperature down or at least dissolve some of the gas before it gets away from leaking out. And when it gets out into the surroundings; the locals just do not know about it because the sirens are blaring every day because of the regular accidents and so everybody thinks that it is a normal affair.

And then when they are actually exposed to the gas; they do not know what to do. Now a very simple way to have to prevent the deaths would have been just to take a piece of cloth and dip it in water and place it on top of your mouth so that the amount of gas that you are getting exposed to it; gets diluted it, gets dissolved in the water and so you are exposed to less of the gas, but the locals did not even know that. So, what happened was when they got exposed to the gas.

There was such a huge choking sensation there was so much burning of the eyes that people actually tried to run away from the location. And when you try to run away; what happens is, you get outside of your home and you get exposed to even greater concentration of the gas.

Because it is not that you are getting gas inside your house, your house is much safer; outside the concentrations are much harder and all of these things can be linked down to bad management, bad planning and bad economics. So, around 500000 people; that is 500000 of people; they got exposed to the MIC class.

And we can end with this quote; the morality that pollution is criminal only after legal conviction is the morality that causes pollution. It means that the morality that pollution or spreading pollution itself is not wrong, you are only wrong when the court punishes you; that is the morality that permits the society to tolerate pollution.

To tolerate damage to the environment, to tolerate not taking proper risk management procedures and we as a society will have to suffer the consequences, if we let this morality prevail. If we do not teach ourselves and our children and our grandchildren that pollution is wrong in any way. If you do not do that only we have to suffer the consequences.

That is all for today. Thank you for your attention. Jai Hind!