Natural Resources Management (NRM)
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Week - 10
Lecture - 58
Climate Change; Vulnerability; Adaptation - Part 01

Participants, today we will be discussing a very pertinent topic within this MOOC courses on Natural Resources Management and that is on the issue of Climate Change, Vulnerability and Adaptation in the field of Natural Resource Management. I am sure that most of you heard about climate change a lot, vulnerability and adoption also probably some of you have already heard.

So, in this lecture, actually, I will divide this lecture again in part 1, part 2, part 3 like that. What we are going to do is that we will start with the few basic concept of climate change, vulnerability, adaptation and then we will look at that how climate change actually interact with the natural resource management and how actually it could affect the overall well-being and especially within that natural resources management paradigm.

So, this particular topic is very pertinent at the present context, very contemporary topic and I hope that together we will have a good discussions. And also in one of the upcoming live sessions, I would go into further detail depending upon your queries or doubts.

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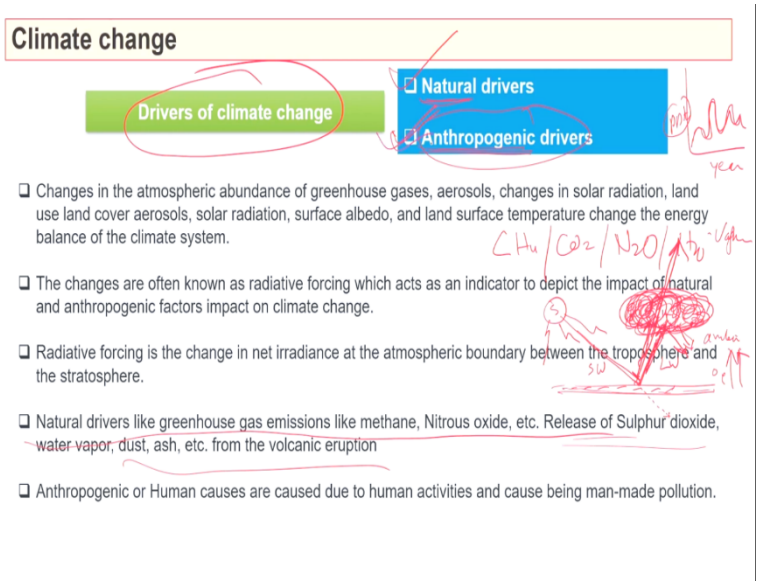

Let us start today with the few basic ideas and concept of climate change vulnerability adaptation. When you talk about climate change, basically, we talk about the statistical average of weather events over a period of 50 to 100 years. Remember, there is a significant difference between weather and climate. Many a times what happen is that we often mistake considering weather event or change in weather event as change in climate.

So, at the very beginning I would like to clear that confusion. Weather is instantaneous today what you have, if you have a rain that is weather but that rain event of today if this day over a period of say 30, 40, 50 years or this September month, if you suppose capture it over a period of 20, 30, 40, 50, 100 years and then you take the average, statistical average of that particular event of rainfall and if then you see certain change in the precipitation or rainfall with year then we can say that yes, there is a change in the one of the climatic parameter that is precipitation or rainfall.

But only 1 or 2 years of changes in an event like this would actually call change in weather not in climate. Now, there are 2 major drivers associated with climate change. 2 drivers which actually trigger the change in climate and these 2 drivers are natural drivers and anthropogenic drivers.

That means that there will be some natural phenomena which will actually trigger climate change and there will be some phenomenon which are purely man-made that could also trigger climate change. We will discuss all those things with example in due course of time. Now, changes in the atmospheric abundance of greenhouse gases, methane, carbon dioxide, nitrous oxide, even water vapor and many other things which you all of you know.

So, what happen is that, that the incoming solar radiations, suppose, you have sun and the radiation comes in and then here is your earth surface, soil surface, it heats, some of them is return backs. Here you have a kind of a blanket in the atmosphere which is actually made of greenhouse gases, a thick blanket.

Now, some of this radiation actually absorbed by the earth surface, some actually gets reflected. This reflected rays are short wave while coming from the sun after striking the ground, it becomes long wave. So, short wave can penetrate much faster, long wave is little less in energy, so they go back. What happen is that these gases, the blanket will absorb part of this return radiation.

And that is how, what happens, this blanket will absorb and then re-radiate some of the heat in ambient environment and thus our ambient temperature will increase. But this total phenomenon is purely natural and it is important and I could say that it is beneficial also because this is what allows the life to get form in this universe.

Because this phenomena of greenhouse gases allows your ambient temperature to be around 15 degree Centigrade which is conducive for different various life form to come into this universe. Now, if you start thickening this greenhouse gas blanket with pumping in several types of greenhouse gases other than natural resources; from anthropogenic sources like industry, air condition system, various kind of emissions from various kind of industry, what happen is that these blanket become much more thicker.

So, what happen is that, the returned radiation which some of them gets absorbed some actually pass through and goes back to the galaxy where from it has come. But if it becomes thickened then what happened that these rays long wave return rays cannot pass through, they will also get captured here and then re-radiate into the ambient air.

So, that means more gases will be there more energy, more radiation will be trapped, so re-radiation will be higher and ambient air temperature will be much higher. This is what is actually in brief you can say, simplest way one can explain the global warming phenomena due to climate change. So, now these are actually few trigger, already drivers that I have mentioned.

So, changes are often known as radiative forcing changes which act as indicator to depict the impact of natural and anthropogenic factor which actually impact our climate change. So, different natural drivers like greenhouse gases emissions like nitrous oxide, methane, these are all coming in and getting packed here and the layer becomes thicker and thicker. So, anthropogenic or human causes are one of the major drivers for this kind of changes.

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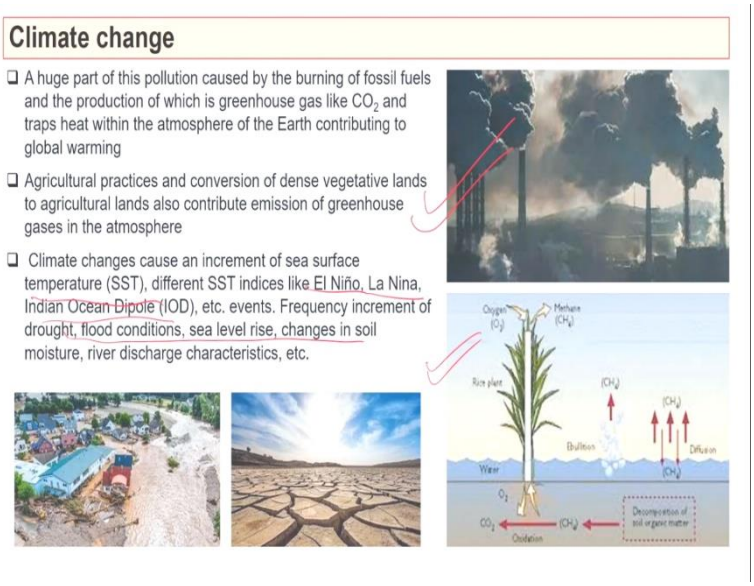

Now, there are various sources of these gases that we just discussed in the previous slide. It could be industry; it could be even agriculture, very very small amount, and various other sources. Now, climate changes cause and increment in the sea surface temperature also. And different sea surface temperature indices like El Nino, La Nina, IOD, Indian Ocean Dipole, these all things you might have heard. These are all different even due to climate change is taking place.

And the frequencies of increment of drought, flood, sea level rise, this has become very frequent these days and that is the OD and that some expert, scientists are attributing to the climate change. So, that is the overall concern that the global community has on climate change. Now, if you look at, I just now mentioned that greenhouse gases phenomenon in brief, how actually the global warming take place.

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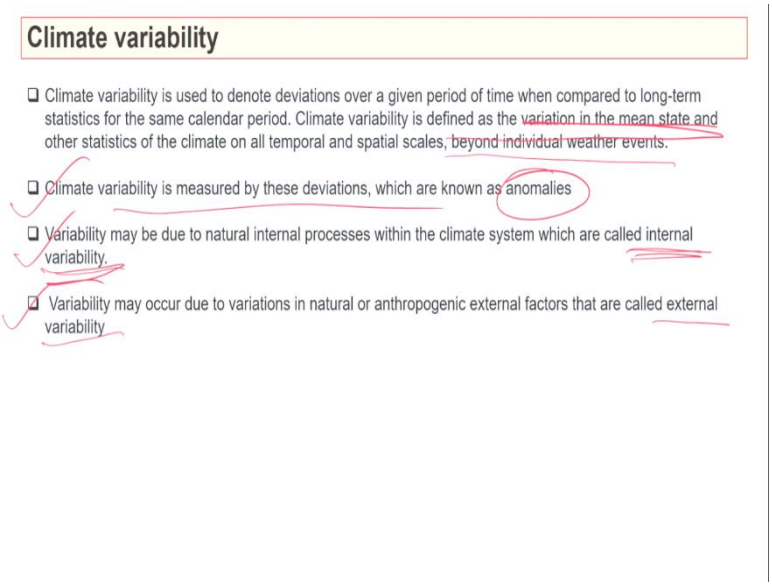

Now, there are few parameters involved in climate change business. And because of any change in these parameters, climate variability takes place. Now, what is climate variability? Climate variability actually denotes the deviation over a given period of time, from this business as usual, when compared to a long term statistics, as I said, for the same calendar period.

As I said the example of rain in September this year next year 20, 30, 40 past year's data if you carry out statistical analysis. That statistical average you plot and then if you find there is a change in the rain you say that there is a change in the climatic parameter which is rainfall.

Now, climate variability is defined as the variation in the mean state and other statistics of the climate on all temporal and spatial scales. Remember, this is beyond individual weather event. Today, there is heavy rainfall, it is a weather event. We should not say climate is changing just because of 1 day, 2 days, 3 days a year of heavy rainfall or less rainfall. Climate variability is measured by this kind of deviations which we call as anomalies.

Now, variability may be due to natural various internal processes within the climate system because you have atmospheres, earth surface, then albedo phenomenon, then greenhouse gas blanket then aerosol, presence of moisture and many things. It is happening within the internal system of climate.

So, any change due to a natural internal process within that climatic system is actually known as internal variability. So, internal variability of climate is when it takes place within the

climate system, not impacted by any external factor. And this internal variability is almost beyond our control. So, we do not have much role to regulate that directly.

Now, variability can also occur due to variation in natural and anthropogenic various external factors like I said our lifestyle, industry, even say agriculture practices, some of the agriculture practices. So these all are actually external factor and these are anthropogenic mainly. So, we have control on that. The entire game of climate change management lays here, on the external variable, external variability. So, that is where we have actually control or regulation.

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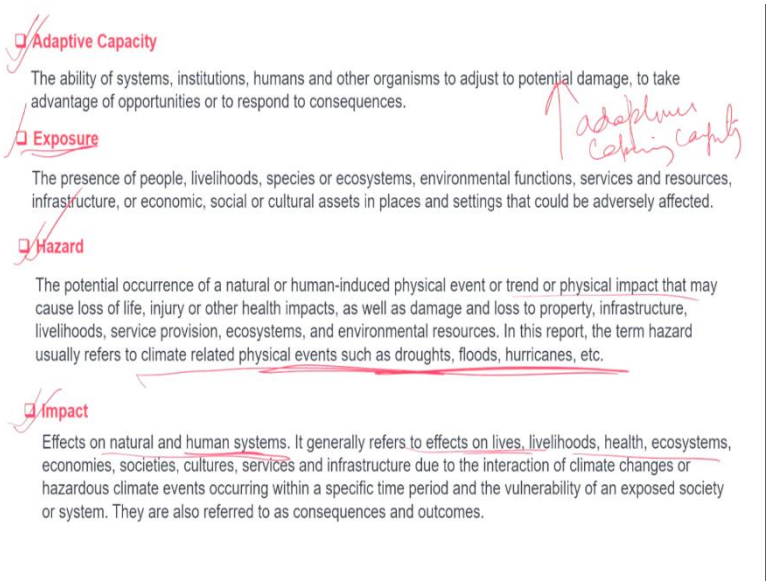

Having said that, if we consider that okay, we do not have much role or regulating power with the internal variability of the climate system but we have some amount of control on the external variability which actually happens because of us, our activity. Now, if we are the cause of the problem then certainly the solution lies within us.

And then when we come, the human factor comes into picture, then comes various other concept, one of them is adaptive capacity. Adaptive capacity or adaptation capacity of individual. Now, I am here, sitting in a room, giving a lecture to all of you. Now, with this lecture, suppose it is very comfortable, suppose air condition is running and I am comfortable. But another person after me comes for another lecture in the same place and he request the people here that please increase little bit the temperature, I am feeling very cold.

Now, you see to individual to individual adapting with some environmental factors or any change per se is very different. Now, same temperature where I was feeling comfortable and giving lecture to you with lot of energy and happiness, other professor comes in and he requests to increase the temperature and he told that he is feeling very cold and that is his adaptive capacity.

Now, the other person probably is feeling uncomfortable. Now, he has the control to change it. So, he requested to increase the temperature. But if that particular air condition system cannot be regulated to increase or decrease, suppose for some malfunctionality it is fixed at 25 degree Centigrade or 22 degree centigrade then what to do?

Then the other professor has to look for jacket. So, that he can increase his adaptive capacity. Now, he can get the jacket only then when he has money, resources to buy that jacket. So, if he has money then he can buy the jacket and that is how he can increase his adaptive capacity, sometime people say coping capacity.

So, the coping capacity or adaptive capacity can be increased if you have money in pocket and that is where is another aspect comes in. If some person does not have money, he has to suffer the change, the change in the climate or change in the system. You see in this example I have mentioned many things.

One is the individual differences towards a change where I feel comfortable another person may not feel uncomfortable. Second, I say that if the change in the system can be adjusted then you adjust it but if it cannot be adjusted then you have to enhance your adaptive capacity to adjust.

And to enhance that adaptive capacity to adjust, you need to buy a sweater or a jacket or suppose in some places is very rainy, rain has increased umbrella, water coat. So, if you have money you can also enhance your adaptation. So, the finance part also I have given an example within this single example.

So, I think that you have understood. Exactly this is the basic contention of climate change. And that was the difference between rich and poor. So, climate change that is why hurts the poor much because they do not have the capacity to buy and enhance, buy something which they require and enhance their adaptive capacity, adjust with the changes.

So, that is why impact of climate change you can see could be severe for people with fewer resources than people with large amount of resources. So, from this argument the thing comes that resource poor people, resource poor countries should be helped more for adjusting this change in the climate.

So, you see that now, next fundamental concept come is exposure. Again, the same example that I have given on classroom and 2 teachers. Exposure is the presence of the people, a livelihoods, species or ecosystems, environment functions, services, resources, infrastructure, fine and social and cultural assets in places or settings where those could be adversely affected. So, that is your exposure like the exposure for me and my teacher here in this same room could be exposure to the chillness because of the air condition.

Hazard, the potential appearance of a natural or human induced physical event or a trend or a physical impact which may cause loss of life, injury or any other health impact as well as damage and loss to property, infrastructure, livelihood, service provision, ecosystem, environmental resources, etc. So, hazard usually refers to climate related physical events such as drought, flood, hurricane, etc.

Impact, already you might have understood effects on nature or human system because of any changes in the climatic system. So, when our people lives, livelihood, health, ecosystem, availability of natural resources or any other resources becomes at stake or in danger due to some changes in the climatic condition then it is already impacted, the impact of climate change is visible.

So, just a quick recall of this particular aspect that we discussed. So, I gave an example to make you understand that what is adaptation, what is adaptive capacity, what is exposure, how adaptive capacity can be changed through the power, financial power, resources, poor who do not have money can get more affected. So, various issues have come from one single example. We will move to the next other concepts which are involved with the climate change.

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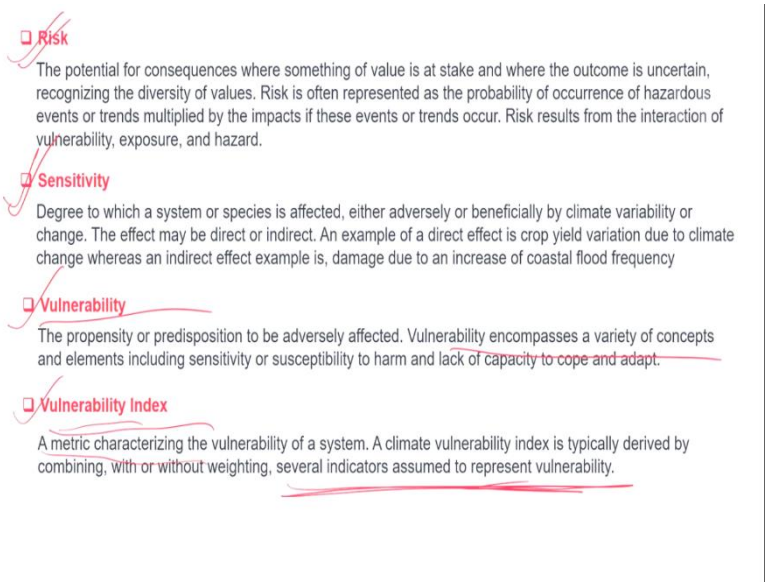

Risk. Risk already we have different kind of risk, right, in this ecosystem in our life. Climate change is aggravating that situation. So, what happen is that suppose say case flood. Flood was there, hundred, thousands year back and now also. What is the new thing that climate change has brought? It has aggravated, increased the frequency and so the risk associated with flood or associated with drought has increased. This is what actually the link between risk and climate change.

Sensitivity, we discussed, remember in modeling classes. So, it is the degree to which a system or a species get affected because of any change in the environment or in the ecosystem.

But remember, they might get affected positively or also negatively. Because if climate change takes place in some cases it might enhance rainfall, temperature, humidity. So, some crops or some animal who like this kind of environment they will enjoy and they will flourish but in the same location if there used to be a dry, cold weather, so, the animals, plants, all were accordingly were available there.

Now, suddenly if that area becomes warm, rainy, humid, what will happen? The existing system flora, fauna, plants, animals, they will face stress and over a period of time you would see that there might be a change in the flora and fauna. Because any life from naturally start adjusting with the change in its environment.

Next is vulnerability. Vulnerability is the propensity or predisposition to get adversely affected. Now, you tell me the example that I have given in this room. Me and my colleague, another professor coming in feeling 2 different kind of thing. I am comfortable but he is feeling very cold and uneasy. So, that means the other person is vulnerable to cold temperature, means if temperature goes down he feels uncomfortable. So, he is vulnerable.

Vulnerability also accomplices a variety of concepts and elements including your sensitivity or susceptibility to any kind of harm, lack of capacity to cope and adapt. So, one person, if I say that highly vulnerable to cold temperature means he is susceptible. Little bit of drop in temperature he or she will feel uneasy. This vulnerability of individual can be evaluated through vulnerability index. Because we need to know that if I say that he is vulnerable, how much vulnerable? If there are 2 individual both are vulnerable, we need to then compare, no? He is more vulnerable than he is or she is more vulnerable than her, we have to then do some kind of analysis.

Vulnerability index is a matrix actually characterizing the vulnerability of a system. Climate vulnerability index is typically derived by combining with or without weightage. Several indicators actually assume to represent vulnerability in the field of climate change.

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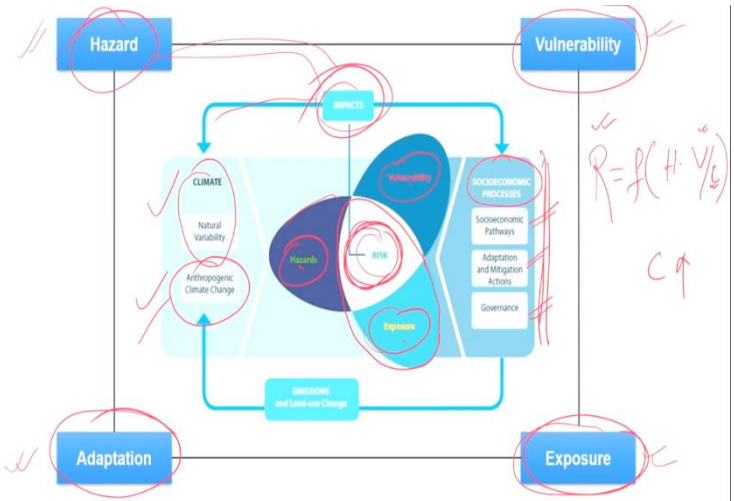

Figure: The risk management and assessment framework. Risk arises from the interaction of vulnerability, exposure and hazard (IPCC 2014)

Now, let us see the risk that I mentioned here. How to manage? The risk management and assessment framework. If we find that there is a risk, how actually we can manage that? Now, this is a framework given by IPCC in its 2014 report. And what do you see in this figure? You see a hazard; you see vulnerability, exposure, adaptation.

Now, suppose you have one hazard, if in your area flood is issue you imagine flood. If in your area drought is issue imagine drought. Now, if you are exposed to that particular hazard and if you are vulnerable then there is a high chance that you are going to be impacted by that particular hazard.

Because there will be an impact of this hazard. This impact on your socio-economic processes, socio-economic pathways, adaptation mitigation action, governance, these impacts can also change the climatic system itself through natural variability or anthropogenic climate change. These 2 things 2 driver that I mentioned. So, these are 2 driver and these are the aspects which can get affected.

Now, you see that vulnerability hazards and exposures; these 3 are actually interacting and in the center you get risk. So, risk is very much a component of these 3 together vulnerability, hazard and exposure. You find that this risk is somehow related to all these 3 driver vulnerability, hazards and exposure. So, you need to have if you want to reduce your risk, you need to work on this aspect. How do you do that? One way of addressing this is adaptation and the other one is, of course, mitigation.

Now, adaptation I said already in a previous example that you can enhance your adaptive capacity through accessing resources, more and more resources. You can also reduce your risk by enhancing your capacity, building your knowledge, training to know how to handle in this kind of situation, so your impact or your risk will get reduced. Remember that risk is a function of hazard into vulnerability by capacity.

R is equal to function of H, V by C

So, if you enhance your capacity this component then definitely your vulnerability will get reduced. So, then your risk will get reduced. That is a very basic concept.

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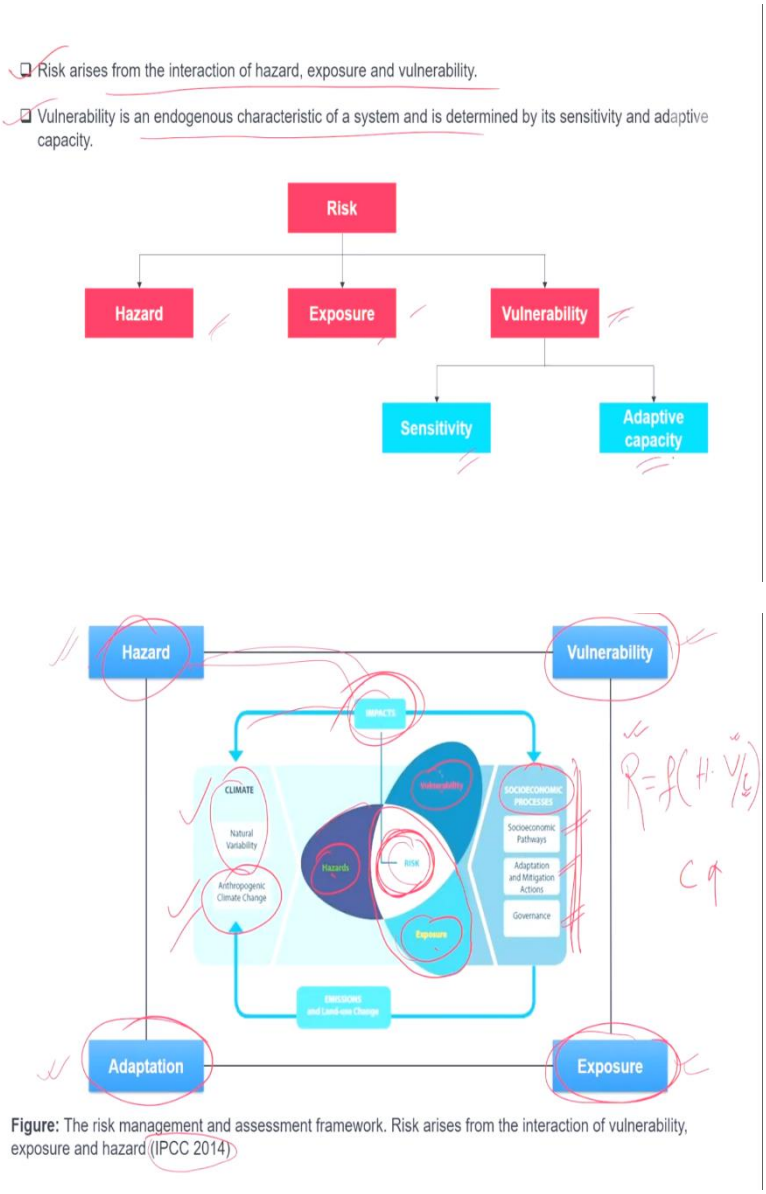

Figure: The risk management and assessment framework. Risk arises from the interaction of vulnerability, exposure and hazard (IPCC 2014)

Now, risk we know that it arises from these 3 component you saw here vulnerability, hazard and exposure. Now, vulnerability is an endogenous characteristic of a system which is largely determined by its sensitivity and adaptive capacity. Now, risk, these 3 hazard, exposure, vulnerability are involved. Now, vulnerability you can analyze through sensitivity, and adaptive capacity.

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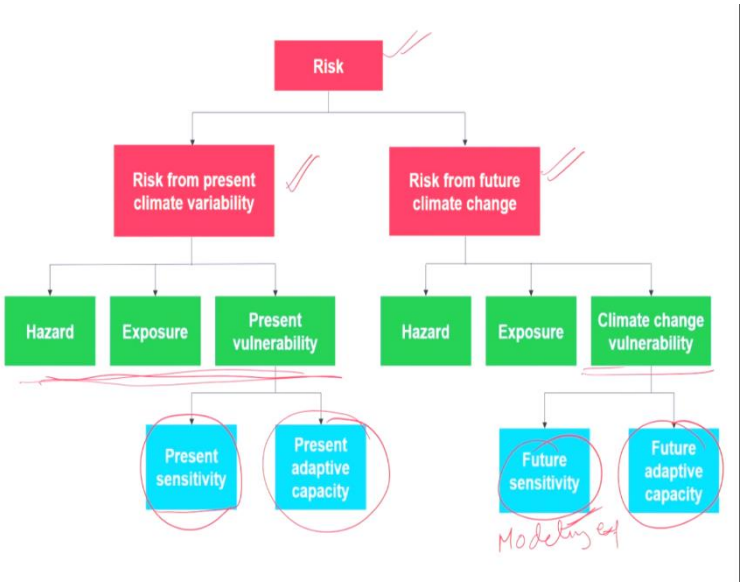

Now, risk can happen from present climate variability what is right now. And risk also from future climate change, what you have not seen. Now, 2 scenarios; present and future. Now, how to handle that kind of situation? So, risk from present variability, climate variability, of course, again three this parameter that you have to work with.

Here you have to work mainly on present sensitivity and present adaptive capacity. What is happening you address that right now; forget about future past. But in case of future risk from climate change, your future sensitivity and future adaptive capacity need to be looked at and this requires some kind of modeling exercises that we have discussed earlier.

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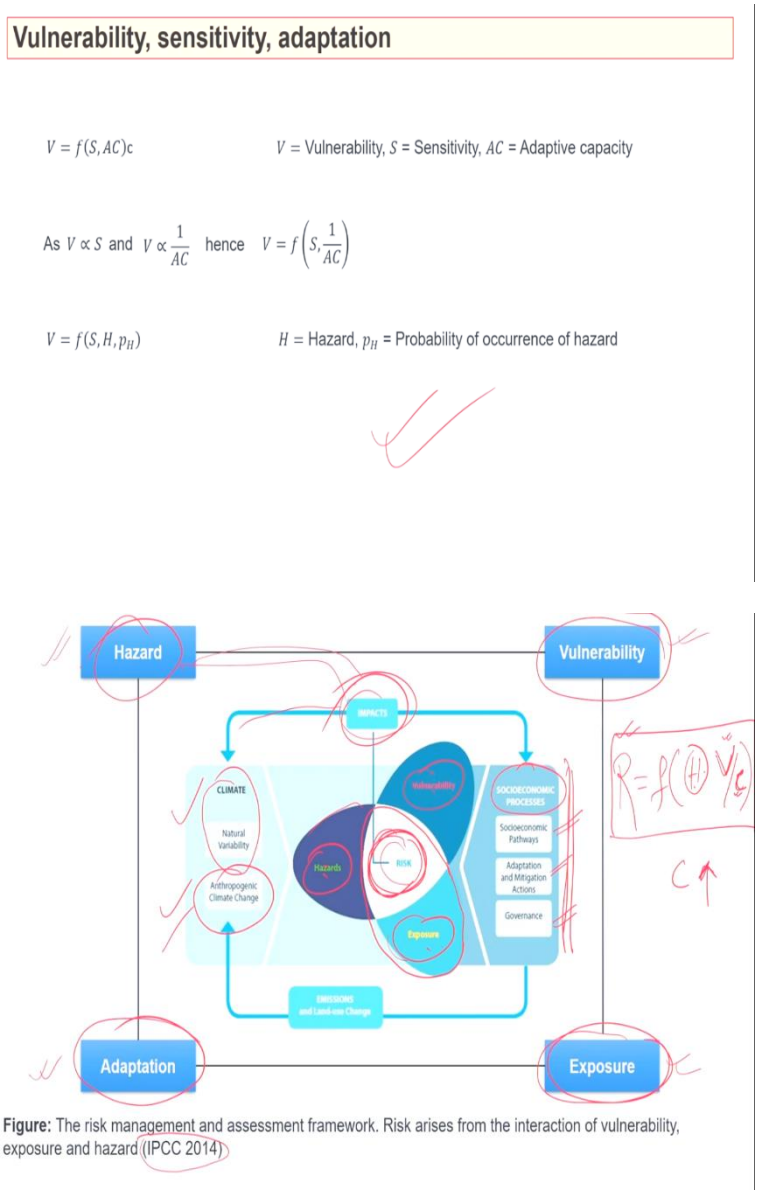

Figure: The risk management and assessment framework. Risk arises from the interaction of vulnerability, exposure and hazard (IPCC 2014)

Now, vulnerability, sensitivity, adaptation, these you can analyze in different way. I just now discussed about this risk function that risk is a function of hazard, vulnerability, and capacity. This is the simplest form. Here you can actually, you cannot play with hazard but you can always reduce your vulnerability by enhancing your capacity. So, the capacity part is something which is in our hand. So, we can enhance capacity through training, through different manner, we can reduce our risk. This is what actually this particular question also tries to explain.

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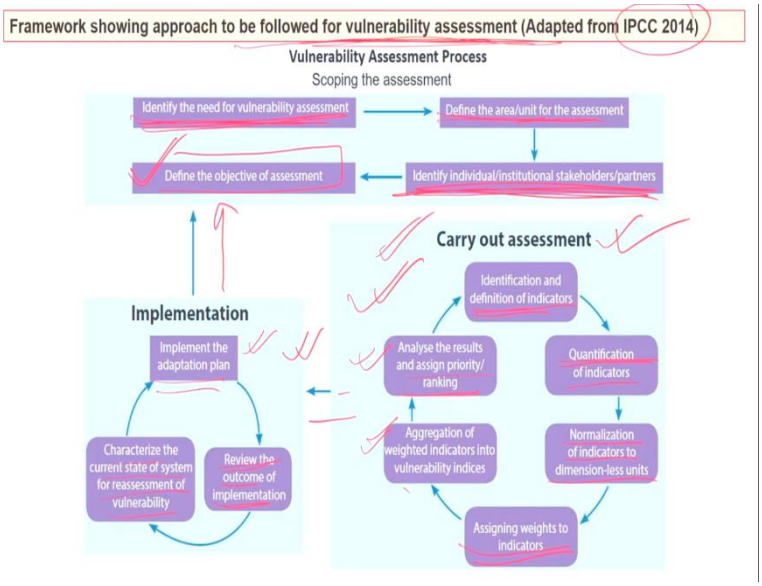

Now, look at the framework which shows the different approaches that one can follow for vulnerability assessment. Because assessing the vulnerability of a particular system individual, society, community, area is very very important. Because on the basis of this assessment of vulnerability, only your future strategy can be built upon. So, how you actually can assess the vulnerability?

There is already a standard procedure which IPCC also has given very clearly. Most of us actually follow that framework for assessing vulnerability. Now, what you do is that suppose, we identify that there is a need for vulnerability assessment. What should we do? We first define the area or unit for the assessment. Means what particular place or particular community need to be looked at?

Then we identify the individual, institutional, stakeholder and partners who are going to be impacted or potentially vulnerable. Then we define the objective assessment. Once our objective is clear, what we are going to assess. Then we carry out the assessment. Identification of definition and indicators, various indicators that we need to find out because for different, for drought we will have a set of indicator, for earthquake, for flood, for different different event we will have different type of indicators.

Then we quantify them. After quantification, normalization of indicators is done, then we assign weightage to those indicators. Then we go for aggregation of weighted indicators into various vulnerability indices. Once that is done then we analyze the results and then we rank them on the basis of priority.

Then the implementation will carry out. So, from here then let us come toimplementation part. Once your assessment is carried out then you move here. So, how? So, implementation of the adaptation plans. You have to review the outcome of the implementation that you implement on the basis of your assessment.

Once you review the outcome of implementation then you characterize the current state of system for reassessment of vulnerability. Means after your implementation whether vulnerability has gone down or gone up, that you have to identify. And once that is done on the basis of that again, probably, if you see vulnerability has gone up instead of going down then again you go for another assessment. And this is the way the process of vulnerability assessment continues.

Remember, a good vulnerability assessment decides the fate of an implementation plan whether that will be successful or not. So, that is why your vulnerability assessment on the basis of various information and data that you carry out has to be almost error free. We know that it is not possible because lot of modeling exercise, secondary data is also involved for this assessment. So, there will be little bit of uncertainty but our effort should be to minimize that uncertainty.

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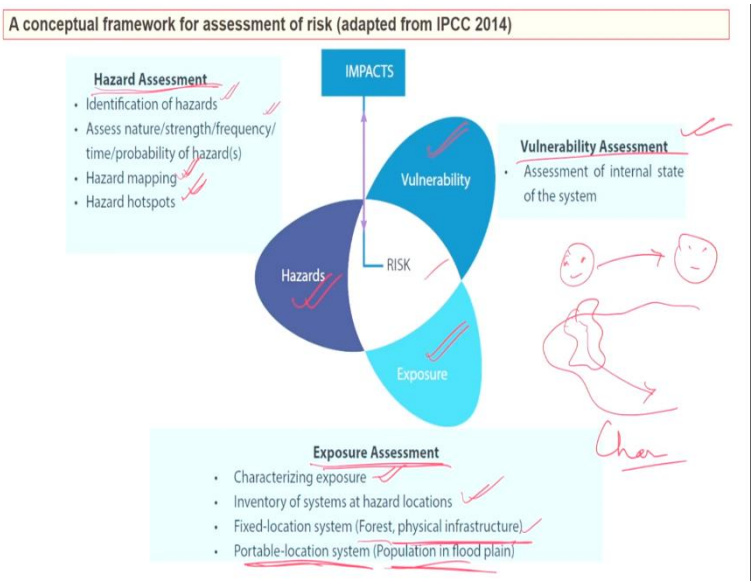

Conceptual framework, for assessment of risk. Again IPCC has given a good amount of information, knowledge in their report. So, look at that these 3 major what you call factor of creating risk. So, we have hazard. You can also do hazard assessment by identification of the

hazard then you assess the nature or the strength or the frequency of a particular hazard. You can go for hazard mapping.

Again here, your GIS remote sensing could play a very important role. We have already discussed about this aspect. Finally then you go for hazard hotspot. So, that you identify few hot spot where probability of hazards is much higher. That gives you some opportunity to manage in case of any kind of event to reach there as soon as possible.

Vulnerability assessment. We already discussed. You have assessed the internal or external a variability factors to assess the vulnerability.

Exposure assessment. Exposure assessment you can carry out by characterizing the exposure by inventorizing the systems of various hazards locations.

Then fixed location system like forest and different physical infrastructure analysis.

Portable location system also like population or flood plain. Because population, human being and flood plain actually they can move from one place to the other. Here today there is a flood plain and the water goes and brings some of the land into this river then that part is lost. So, this kind of situation in Brahmaputra Valley is very common in Northeast where we call this as a char land, char. So, population and flood plain are portable location system because they can shift from one place to the other.

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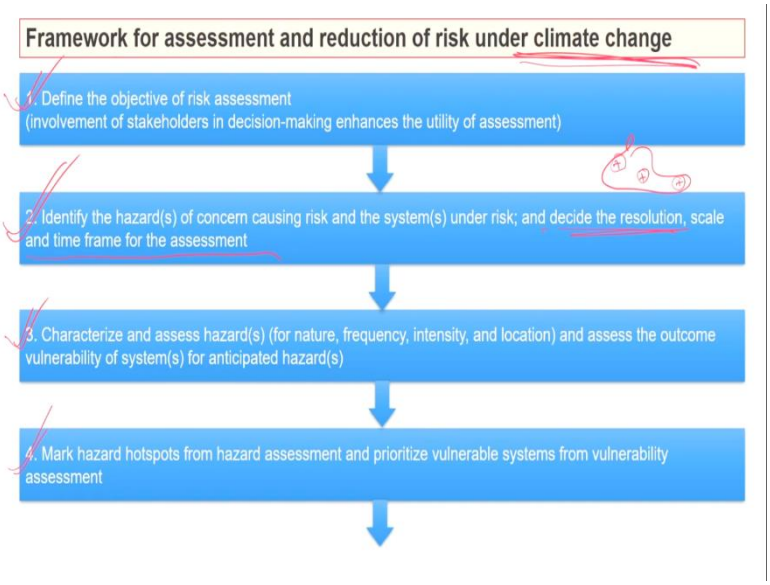

Now, framework for assessment and reduction of risk under climate change. And these directly actually regulate the availability or accessibility of natural resources to an individual or a community. Now, what we need to do? First, we need to define the objective of risk assessment and this should be carried out involving various stakeholders, government, non-government, community, people, anyone whoever is potentially impacted by any kind of risk in that particular area.

Once you define that then you go identify the hazards, the hazards which are concerned for you, and the hazards which are creating risk for you and then you decide the resolution of those hazards, the scale intensity, time frame for the assessment. When that is done then you go to the third step, characterize and assess the hazards, their type, their nature, frequency, intensity, where it comes more, the locations and assess the outcome vulnerability of these systems.

Once you have done this, then you go to this step 4 where you mark those hazard hotspot. Suppose, this is any area, this you can mark that these 3 areas are cloud hazard prone. So, the system, government or any stakeholder will be aware that every rainy season they have to be especially careful of this hotspot of a hazard which is flood. Same way you can identify hotspot for many other hazards.

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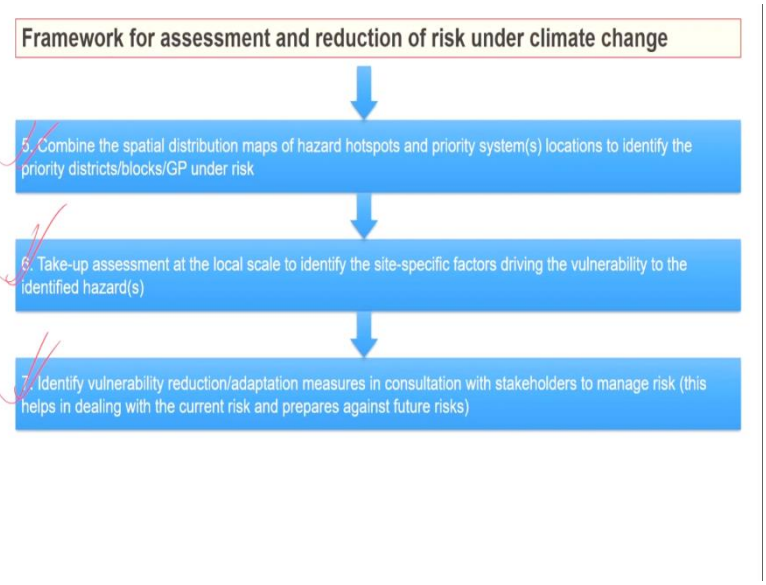

Next step, combine the spatial distribution maps of hazard hotspots and the system, priority system location. For what? To identify the priority districts or blocks which are potentially

under risk or has the higher chance of potentially under risk. Means that gives you an opportunity to foresee and keep your system ready for any kind of eventuality.

Number 6. Take up the assessment at the local scale and then identify the site-specific factors which are actually causing the vulnerability to the people for that particular hazard, say flood. Identify those factors. Why it is taking in that particular location every time flood? Identify those reasons. What are making those people in that particular area vulnerable?

Then only you can address this issue properly. Next, identify vulnerability, reduction and adaptation measure. If you find that yes, this particular area will have flood, now or then; then you enhance their adaptive capacity, coping capacity in consultation with community, NGOs, government department, bring everyone to enhance the adaptive capacity of the people.

If you find that, that particular location or the group of people anywhere they will have to face flood then you enhance their capacity in such a way, if any flood occurs they are not going to be impacted beyond a certain limit, which is manageable. This is how actually we should process.

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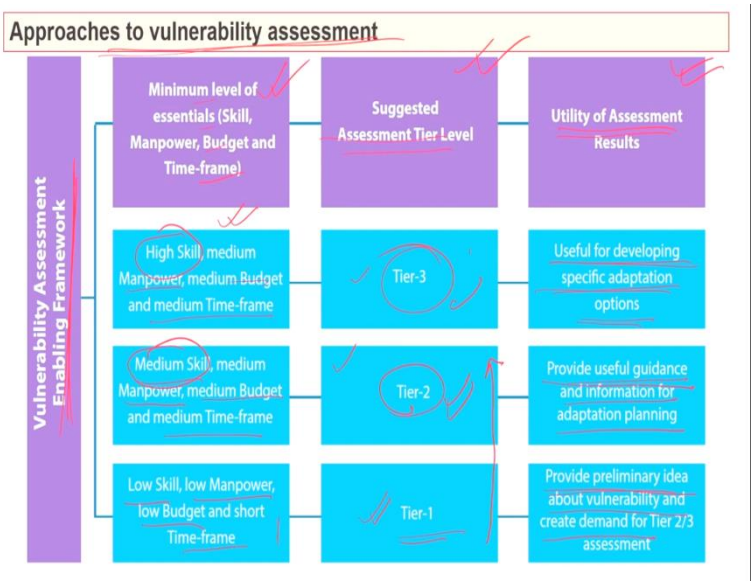

Now, next the approaches of vulnerability assessment. We talked about vulnerability assessment couple of minutes back. Now, vulnerability assessment enabling framework is a very talked or discussed topic. Now, for minimum level of skill, manpower, budget and time frame that is required for vulnerability assessment.

They actually with minimum skills and manpower or budget or time frame they can actually suggest an assessment different kind of level that what level of assessment is actually recommended. Then the next is the utility of the assessment and the final result that you get. So, there are 3 different aspect of vulnerability assessment approach under which there is different things taking place. Let us see.

Now, if you have high scale and medium manpower and medium amount of budget and medium time frame in hand, your suggested assessment tier level is tier 3. What you get through tier 3 assessments? This is useful for developing specific adaptation options. What is tier 2? Medium skill, medium manpower, medium budget, medium time frame.

So, difference between tier 3 and tier 2 is, in tier 3 you have high skill; in tier 2 you have medium skill, rest all are same. What is the result you are getting? It provides useful guidance and information for adaptation planning. Let us come to tier 1. Tier 1 low skill, low manpower, low budget, short time frame, everything is low.

When you have tier 1 assessment level, what you get? You get preliminary idea about the vulnerability. You can create a demand for tier 2 or tier 3 assessment. So, from here the process starts, from tier 1 tier 2 then tier 3. So, this is how the vulnerability assessment approach works in the field.

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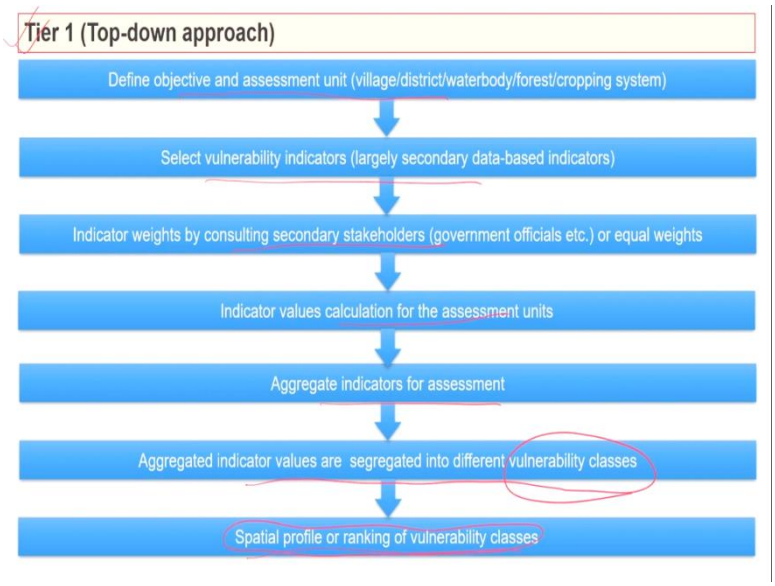

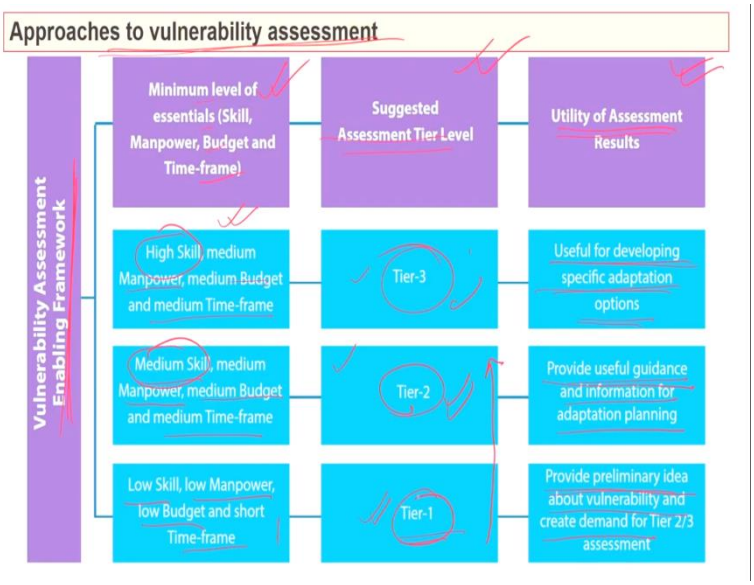

Now, I will quickly discuss about these 3 approaches or 3 level of vulnerability assessment. First one is your tier 1. Tier 1 approach is your this approach where you define, tier 1 approach is basically you define the objectives assessment. Then you select vulnerability indicators. Then indicators you give the weightage. Then you calculate, aggregate it and then aggregated indicators values will give you a particular vulnerability class. And then you spatially profile them and rank according to the vulnerability classes.

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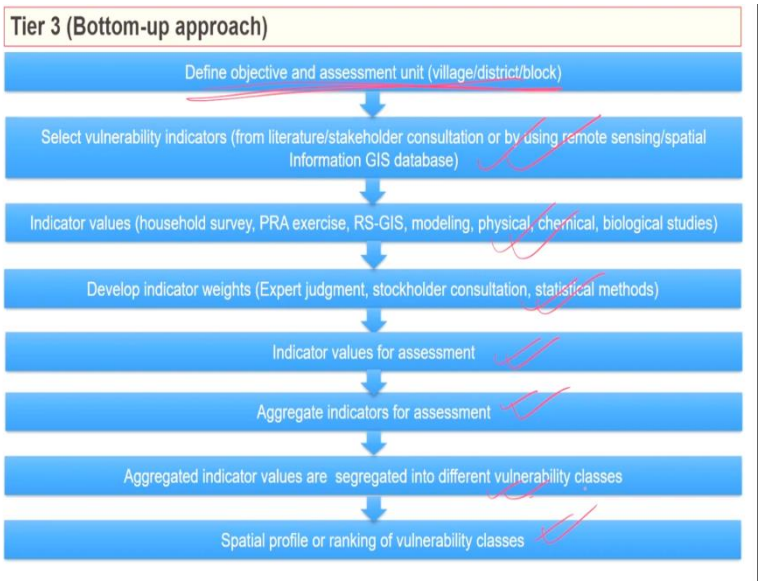

So, tier 3, you again define the objective and assessment unit, start from there. Then select vulnerability indicators. Then you give indicator value, define the weightage of those indicators, go for assessment then aggregate them. Aggregated value then are segregated into

different vulnerability classes and finally spatial profiling or ranking of those vulnerability classes.

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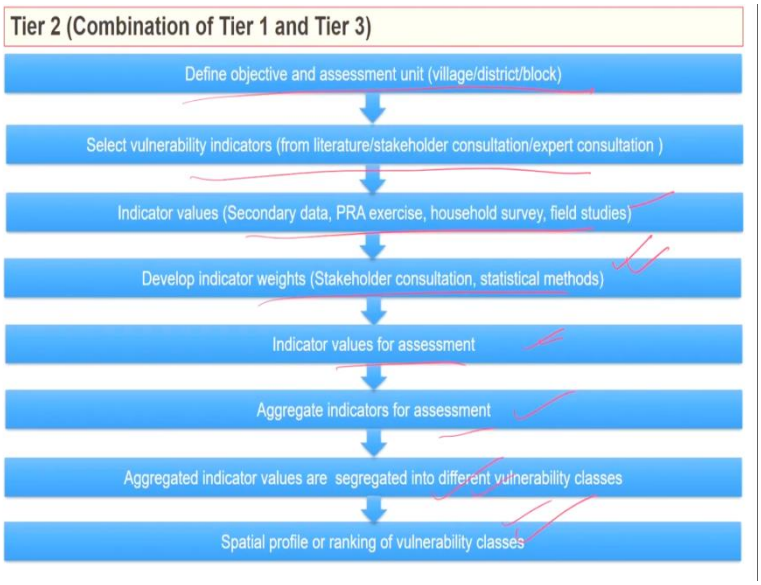

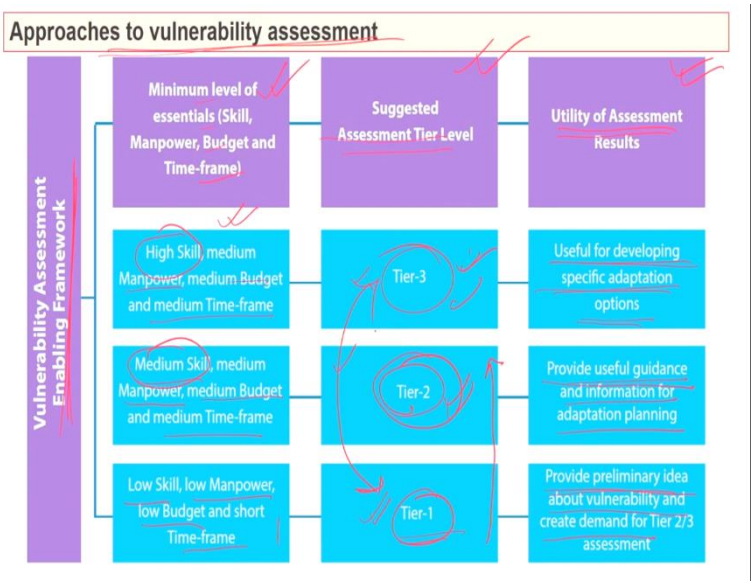

Now, tier 2 is the combination of tier 1 and tier 3 where you define again objective or assessment unit; follow almost the same path that you have done for the other 2, tier 1 and tier 2. So, basically, tier 2 is the middle one as you saw here in this figure. So, tier 2 is the combination of tier 1 and tier 3, basically.

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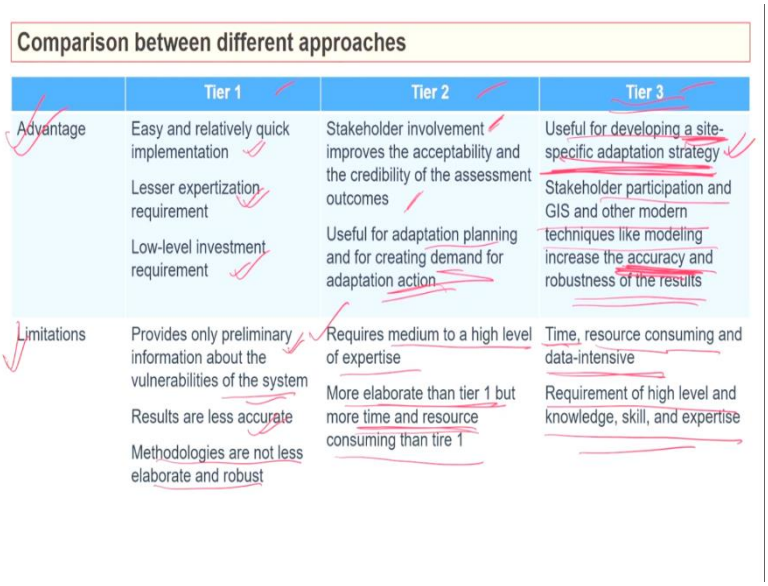
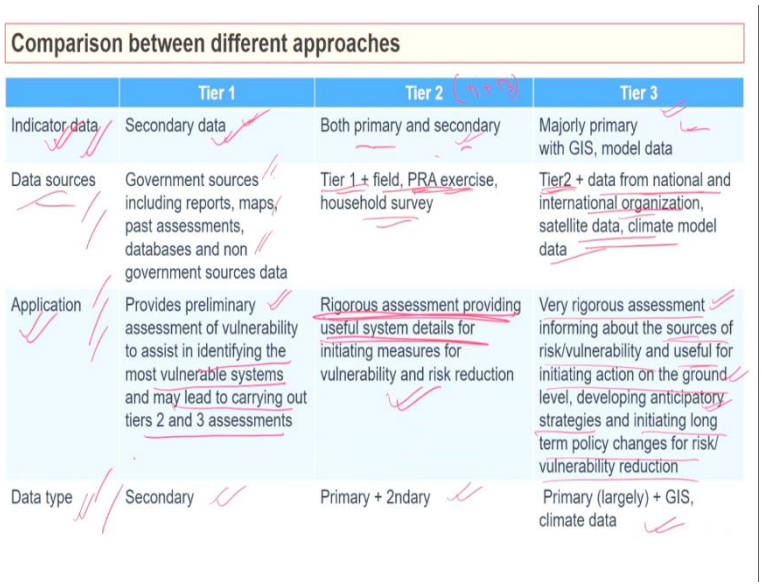


Comparison between different approaches

	Tier 1	Tier 2	Tier 3
Advantage	Easy and relatively quick implementation Lesser expertization requirement Low-level investment requirement	Stakeholder involvement improves the acceptability and the credibility of the assessment outcomes Useful for adaptation planning and for creating demand for adaptation action	Useful for developing a site-specific adaptation strategy Stakeholder participation and GIS and other modern techniques like modeling increase the accuracy and robustness of the results
Limitations	Provides only preliminary information about the vulnerabilities of the system Results are less accurate Methodologies are not less elaborate and robust	Requires medium to a high level of expertise More elaborate than tier 1 but more time and resource consuming than tire 1	Time, resource consuming and data-intensive Requirement of high level and knowledge, skill, and expertise



Comparison between different approaches

	Tier 1	Tier 2	Tier 3
Indicator data	Secondary data	Both primary and secondary	Majorly primary with GIS, model data
Data sources	Government sources including reports, maps, past assessments, databases and non government sources data	Tier 1 + field, PRA exercise, household survey	Tier2 + data from national and international organization, satellite data, climate model data
Application	Provides preliminary assessment of vulnerability to assist in identifying the most vulnerable systems and may lead to carrying out tiers 2 and 3 assessments	Rigorous assessment providing useful system details for initiating measures for vulnerability and risk reduction	Very rigorous assessment informing about the sources of risk/vulnerability and useful for initiating action on the ground level, developing anticipatory strategies and initiating long term policy changes for risk/ vulnerability reduction
Data type	Secondary	Primary + 2ndary	Primary (largely) + GIS, climate data

Now, let us compare between these 3 approaches, tier 1, tier 2, tier 3. Indicator data. What you need for tier 1? Secondary data. Tier 2 both primary, secondary. Tier 3 mainly primary. Because tier 2 is tier 1 and tier 3. So, secondary data, primary data both are here required.

Data sources. For tier 1, government sources, reports, non-government sources also. Tier 3, tier 2, tier 1 plus field and PRA exercise. You remember PRA exercise we discussed, participatory rural appraisal. So, it will require everywhere almost. So, for this also vulnerability assessment you need that. In case of tier 3, tier 2 plus data from national and international organization, satellite data, climate model data, etc.

Then comes application. Tier 1 provides preliminary assessment vulnerability to assist the identifying the most vulnerable systems and this may lead to carrying out tires 2 and tier 3 assessment. Tier 2, rigorous assessment it provides useful system details for initiating measures for vulnerability and risk reduction.

Tier 3, in case of applications, very rigorous assessment. It informs about the sources of risk and vulnerability. It is useful for initiating action on the ground level. It helps developing anticipatory strategies, initiating long-term policy changes for risk or vulnerability reduction.

Data type. What kind of data is required? For tier 1, mostly secondary. Tier 2 primary secondary. Tier 3 primary largely, GIS and climate data also will be required.

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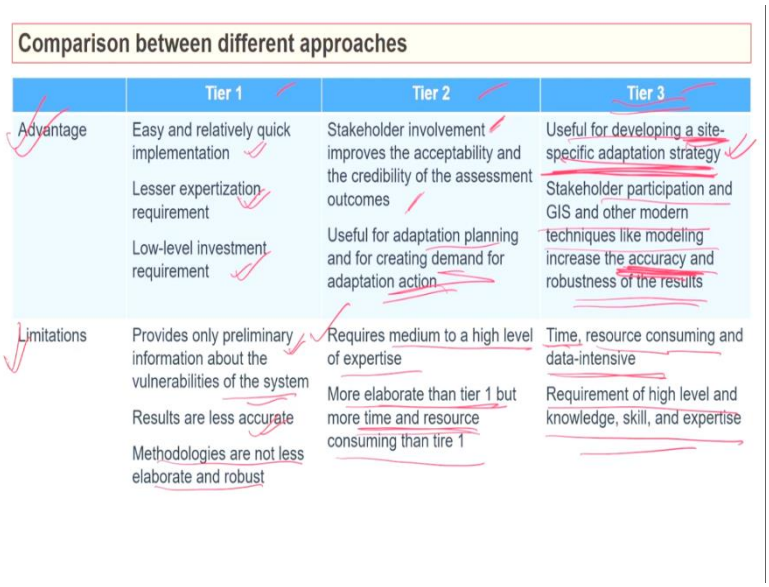

Next is the advantage. If we look at the advantages of these 3 levels tier 1, tier 2 and tier 3, tier 1 is relatively easy and quick for implementation. It is also, it requires less expertise, so you can actually get this done with the unskilled people, semi skill people. Low level of investment is needed for tier 1.

In case of tier 2, vulnerability assessment stakeholder involvement is always required for improving the acceptability and the credibility of the assessment. Its useful for adaptation planning and for creating the demand for adaptive actions. Whereas in case of tier 3, it is useful for developing site-specific adaptation strategy and here stakeholder participation, GIS and other modern techniques like modeling increases the accuracy and robustness of the analysis of the result.

What are the limitations? Tier 1 as it is carried out by relatively low skill or semi-skilled manpower, so, it provides only preliminary information about the vulnerability of the system on the basis of secondary data. Results are less accurate. Methodologies are also less elaborate and robust.

Tier 2 requires medium to high level of expertise and it is more elaborated than tier 1 but more time and resource are required than tier 1. Certainly, if you want a better output you need better skill manpower and also better are higher amount of resources.

Tier 3. Time and resource consuming and very very data intensive. Because here your accuracy level is also high and you are going for site specific strategy. So, certainly, your time and resources will be much more higher requirement. High level of knowledge and skill and expertise is required for tier 3 level of analysis.

So, these are all together the various aspect that are under tier, different tiers levels of vulnerability assessment that we discussed. So, in the following classes we will get into the different aspect of vulnerability and climate change, how actually it can impact the different area or different field of research related with natural resources management.