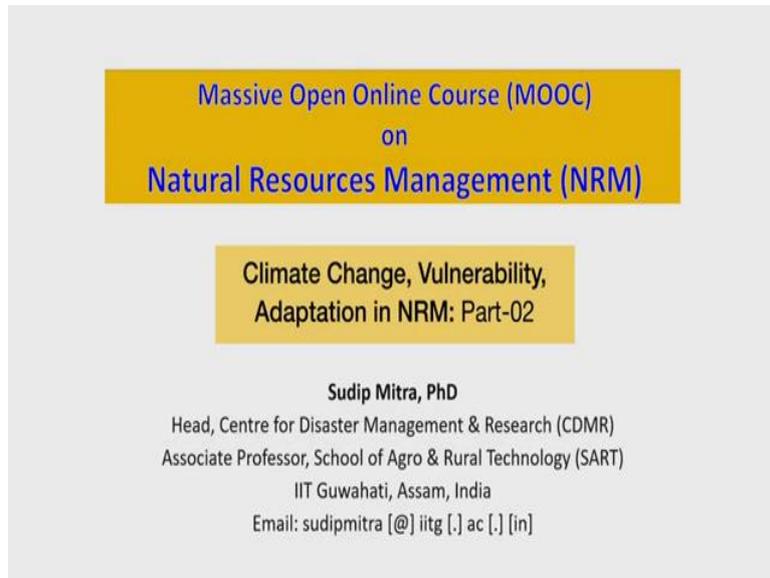**Natural Resource Management (NRM)**
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Discipline - Agriculture Engineering
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Week - 11
Lecture - 59
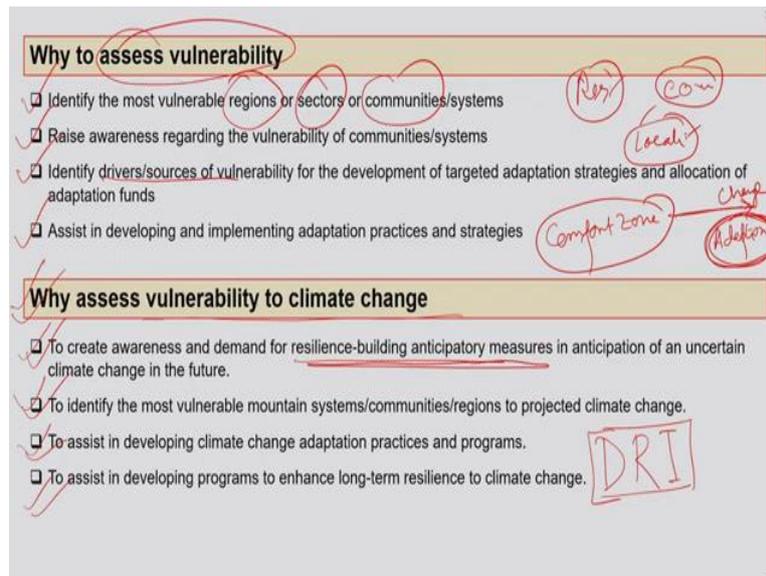**Climate Change, Vulnerability, Adaptation in NRM: Part 02**

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So, in continuation to the lecture of Climate Change Vulnerability Adaptation in Natural Resource Management. In this part 2 lecture, we will continue with the discussion on vulnerability assessment. Now, why actually we need to assess vulnerability.

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First of all, that we need to know in case of Natural Resource Management, we need to know that who are the people are vulnerable, which resources are vulnerable? Say for take an example of water, we need to also analyze that if this water resources are vulnerable in a particular area means that the availability of water is actually under question, maybe there is some stresses or over exploitation of water resources.

Now, why do we assess actually vulnerability? We carry out vulnerability assessment to identify the most vulnerable regions or sectors or communities. So, here I gave an example of water that is a sector. So, the people who are residing at that particular region, they are the communities.

So, you have communities then you have the resources and then also the location. So, these 3 factor you have to actually remember while you go for assessing vulnerability We also assess vulnerability to raise awareness among the people regarding the vulnerability of the communities themselves and also the system.

System means the water resource systems or the surrounding, even entire ecosystem of a particular area, how much they are already under stress, if there is any kind of environmental stress, etc. So, that also we can understand from vulnerability analysis.

Vulnerability assessment also helps us to identify the drivers. Remember, in previous lecture, we discussed about 2 major drivers natural and anthropogenic. So, it helps us to identify the drivers or the reasons for vulnerability.

These exercise vulnerability assessments also help us to assist in developing and implementing adaptation practices and strategies. Bbecause if you can identify that, that particular community in this particular location for these particular sectors, say water, land, agriculture, fishery, they are vulnerable, then it becomes much more easy for the administrators or the various stakeholders who are responsible for actually taking care of that community in that particular area. So, they will then bring in various adaptive capacities adaptation practices, and that will slowly enhance their coping capacity under any kind of changes.

Now, next is why to assess vulnerability to climate change per se. Well, we need to assess vulnerability to climate change to generate awareness and also the demand for resilience building anticipatory measures. Where you actually promote and help in implementing the various resilience building anticipatory measure, because anticipatory measures means, you anticipate that there could be kind of a problem because of a climate change probably we anticipate that in a particular area, there may be no rainfall in during Kharif season June, July.

So, accordingly, we will then make your irrigation ready. So, that means the planning, the planning for building the resilience means increasing the capacity of the people to withstand any kind of changes that happened due to climate change.

I mentioned that, whenever we are pushed out of our comfort zone, we feel stressful and then there are some people who can still continuing doing their work in appropriate manner means they have adapted to this change. But there will be some people who may not be able to carry on their daily schedule or a proper walk, if they are pushed out of their comfort zone. That means, they are adaptive capacity is low probably they are not trained aware or inborn capacity to adjust with a change is much less. So, they will suffer.

Assessment of vulnerability to climate change also help us to identify the most vulnerable system, community, people in any area where there is a projection of potential climate change. Now, we know that this projection of climate change, you can study through various model global circular model, GCMs RCMs, we discuss that and from this climate model, the output goes into the water model or crop model and then you come up with an estimation evaluation of change in cropping, crop production or yield due to certain changes in the climate. These also help us to assist in developing climate change adaptation practices and

programs. These also assist in developing programs to enhance long term resilience to climate change.

Now, let me give you one example, suppose, you are in an area where, flood is a recurrent phenomena. So, you live near to a river. So, that means, the house that you reside that has to be taken care of in an appropriate manner means, you should be looking for Disaster Resilience infrastructure in brief, we call it DRI. So, that means, your building or your house should be made in such a way that in condition of flood also it will not get affected. Now, when you know that area is a recurrent flood prone area, you need to look for resilient road, resilient home infrastructure. These we call as DRI, Disaster Resilient infrastructure a very upcoming field. So, this is clear that vulnerability assessment is important for a various set of regions and this is true for even vulnerability assessment under climate change.

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Now, if you look at different stakeholders, because whenever there is a event flood or drought or anything, so, in that particular moment, who are the people it comes to your mind definitely there will be public works department PWD, health sanitation, agriculture. So, these are the department; water resources, they will definitely get into picture immediately if there is suppose a flood situation.So, who are the stakeholders and what are their functions in vulnerability assessment very, very important to understand.

Now, take us most of your case researchers now, how researchers as a stakeholder can help in vulnerability assessment. The purpose of researchers in this assessment is to understand the

system vulnerability, knowledge of the system vulnerability. They can help in vulnerability maps creation by different software, different tools.

local communities and institutions, they can take part in adaptive capacity enhancement and also vulnerability reduction.

Next, non government organization NGOs they also play a role in vulnerability risk reduction training awareness.

Next, multilateral agencies like say UNEP, UNDP GTZ, you name it, there are various organization, even UNICEF, and these are all multilateral organizations, which are working for various kind of projects across the world.

Now, what they can play? They can help prioritization of resource allocation, natural resource to the region's for resilience building means they will help to find out the resource allocation in an appropriate manner so, that the community or people individuals become resilient to any change.

Next national level or state level decision makers, finally, they have to play a major role in implementing any kind of policy changes or technological changes in the system. So, they help in privatization of state district and agriculture system, forest, villages for adaptation planning and policy initiatives. So, if all works, and if there is some issue here, then the entire effort might not get into translate it into some meaningful action on the ground, and that is why stakeholder is very, very important.

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Different vulnerability assessment

Indicators	Application	Applicants
Biophysical (Ex: natural resources)	Impact study of natural resource degradation on vulnerability Identification of the biophysical factors contributing to vulnerability Prioritize natural resources to be considered in adaptation planning	Watershed managers, Forest department, agriculture department, world bank, multilateral funding agencies
Socio-economic (Ex: different communities)	Identification of the contribution of social and economic factors to vulnerability Target adaptation interventions on social and institutional factors	Local communities, NGOs, community, government, and non-government organizations
Integrated (Ex: watershed (above 2))	Prioritizing socioeconomic and biophysical factors causing vulnerability Designing technological, institutional, social and economic interventions to reduce vulnerability and adaptation strategies in production systems	Watershed managers, Agriculture forest, fisheries, water resources, animal husbandry department, World Bank, and multilateral funding agencies

Now, let us see another important aspect of vulnerability assessment and that is to do it indicator. For any kind of assessment, you need sound indicators. Now indicators, we have biophysical indicators, socio economic indicator and integrated indicator, what are their applications and who the applicants are.

This is a very interesting table. So, please concentrate on this particular table for few minutes. Now, Biological Indicators, example natural resources, which is our topic, how actually these indicators play a role, it helps in impact the study of natural resource degradation on vulnerability indicator also helps in identification of various biological factors contributing towards that vulnerability.

Suppose, I given an example, a particular Biomedicine plant is a natural resource and could actually generate livelihood; could also provide some important medicine and compound. Now, suppose there is a climate change in particular area; temperature goes very high and that particular plant survives in low temperature. So, then you can understand that, that how that high temperature will affect the plant, overall biological activity.

So, those factors like say, chlorophyll opening, closing different hormone like gibberellin, cytokinin, all these hormone content in the plant, the biochemical processes within the plant system. So, these cn actually get change and plants may become vulnerable.

Biophysical indicator also helps in prioritizing natural resources which are to be considered for your adaptation planning. Now, let us see who are the applicants for biophysical indicators? Watershed managers, forest department, agriculture department and various other

amino lateral agencies, individuals, organizations, whoever is working with biological components of the ecosystem.

Socio-economic another important indicator, it helps identifying the contribution of social and economic factors to vulnerability. This also helps to find out the target adaptation intervention on social and institutional factor. This actually clearly tells you that where is the issue with social and economic aspect, because at the end of the day, if there is any kind of changes in the system, the livelihood of the people get affected and if that is affected, then the entire social system fabric might get disturbed and socio economic indicator basically helps you to understand that. Now, who are the people actually work on this aspect; local community, NGOs, government and various non-government organizations.

Finally, we come to another indicator, it is integrated indicator and these indicators help in prioritizing socio-economic and biophysical these two factors. They help in designing technological, institutional, social and economic intervention to reduce vulnerability and adaptation strategies in production system. Now, who are the applicants, watershed managers, agriculture, forest fisheries, people from Water Resource Department, animal husbandry and then of course, the multilateral funding agencies. So, indicators, applications and the people who actually work for or this particular indicator based analysis of vulnerability assessment.

Hazard specific indicato;r different hazards can takes place flood hazard, drought hazard. So, what actually it helps these indicators intervals in identifying the drivers which mainly contribute towards vulnerability it helps in identifying the most vulnerable exposure you needs to climatic hazards say for flood, drought. It also helps in focusing on the high damage causing events and the regions for vulnerability as well as risk reduction programs.Who are the people or individuals, applicants, disaster management expert development planning department, various organizations who are associated with drought flower landside earthquake, it could be many people whoever is working in this particular field.

Now, look at the aspect; quantity of indicator means, how many indicators that you may need it is very critical for a very smart study to carry out the vulnerability assessment. Now, if you go for very less number of indicators, definitely it will be easy for collection the data information and also the time consumption will be less we can finish the work very quickly. But there is a disadvantage and that is many drivers probably will miss and may not be able to cover if you go for very less indicator. In case of this your indicators might be very general and drivers may not be duly recognized.

The other option is that if you choose suppose many indicators, then it can provide you in depth and viewed database huge amount of information or data will be time consuming it will be also very costly affair and it will definitely be very difficult to collect so much of data. So, the best thing would be that you go in between these two extreme; medium level data and that you can decide on the basis of the particular location and the particular issue in hand.

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Indicator categories for vulnerability

Indicators	Examples
Physical	Slope, elevation, soil physical, hydraulic property, drainage density
Chemical	Soil, water, air quality
Biological	Crop types, forest types, Invasive species
Economical	Landholding capacity, occupation, diversified income sources
Social	Gender, caste, marginality, inaccessibility
Institutional	Presence of community-based organizations, banks, insurance, watershed management programs, social security, awareness program, etc.

Categories of indicator for vulnerability assessment are another important part. So, you could have physical, chemical, biological, economical, social, institutional type of indicators. The examples for physical indicators are slope, elevation, soil, physical properties, hydraulic properties, etc. In chemical soil, water air quality, because these all you analyze through chemical analysis.

Biological crop types, forest types, various kinds of invasive species which compete with your crop. Economical indicator, land holding capacity, occupation, diversified income sources from various livelihood options. Social indicators; gender cost, marginality and accessibility, various issues. Institutional projects of community based organizations, village level organizations like VDC, Village Development Councils, banks, insurance, and watershed management program and awareness program, so, anything which has to do with people in the society community. So, these are your indicators for vulnerability assessment.

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Example (Biological indicator): Crop type, yield

❑ Crop yield unit generally ton/ha, kg/ha, etc. or local units

❑ Number of different crops planted in a single cropping season for the crop diversity

❑ Data can be obtained by field observations or household surveys. Questions can be like land holding capacity, irrigation, annual income, crop yield, and crop type cultivated can be asked in the household survey.

❑ Field observations need to be done during the cropping season and household surveys at the end of the cropping season

❑ Sample selection may be done based on land holding (may be in a stratified way)

Example (Physical indicator): Groundwater level (GWL)

❑ Measured by generally m bgl (i.e. below ground level)

❑ Secondary data of GWL data collecting organizations, soil data, hydrogeologic data, rainfall data, household data (no of bore wells, well depth, etc.) for different agencies.

❑ Field observations by vertical electrical survey

❑ Getting subsurface data in field measurement needs expertization and many subsurface hydrogeologic properties disturb electrical signals thus inaccuracy in readings. The household survey can give only very general information which might not be useful.

Different stakeholders functions in vulnerability assessment

Stakeholders	Purpose
Researchers	Understanding system vulnerability, knowledge of system vulnerability, vulnerability maps creation by using GIS, MCDM, modeling etc.
Local communities and institutions	Adaptive capacity enhancement and vulnerability reduction
Non governmental organization	Vulnerability/risk reduction, training, and awareness
Multilateral agencies	Prioritization of resource allocation to regions for resilience building
National level or state level decision-makers	Prioritization of state, districts, agricultural systems, forests, villages for adaptation planning and policy initiatives

Indicator categories for vulnerability

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Now, quickly example for biological indicator, we already talked about crop type and yield. So, here you try to find out various crop type and their corresponding yield, whether under certain conditions in climate change, whether they are giving more yield or less yield because both condition can takes place. So, that you can also study physical indicator groundwater level suppose, is very, very critical for your agriculture groundwater level.

So, how groundwater level as a physical indicator can help, it can be measured very easily and then you can actually use it for various kinds of model exercise to predict that under this kind of situation or depending climate change, how groundwater level will actually go down or come up. So, these are various aspects that you can actually think about or various indicators for vulnerability assessment.

One more important thing that we need to keep in mind, especially from the point of view of applications, that it is the, the role of these various stakeholders to carry out a much focused vulnerability assessment. And if your assessment vulnerability assessment is robust; means if you can really identify the vulnerable system, vulnerable section of people, then the adaptive measures or resilience building of the society will also be very robust.

So, a large amount of responsibility resides on stakeholder, the stakeholder who actually, involved with the vulnerability assessment. And you and I and our community is also an important stakeholders. The researchers, we need to play a very, very important role as it is mentioned here for not only technical analysis, but also knowledge building awareness disseminations. So, we need to play a very important role. And we can do that when we

ourself develop our own skill and development of skill can only takes place through appropriate training, training and knowledge building exercises.

So, participants, in this particular lecture, we have understood the various facets of vulnerability assessment, its importance and who are the different stakeholders and what role they play, then the amount of data whether we should go for less data or very high data or in between. Then finally we discussed about the various indicators that help us in vulnerability assessment and their role also, into this assessment exercise.