Urbanization and Environment
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Module - 01
The Urban and the Environment during the Era of the "Overlapping Cenes"
Lecture - 03
The Nine Planetary Boundaries Framework

So, in this presentation, the focus would be on the Nine Planetary Boundaries Framework. So, we will discuss several concepts within the nine planetary boundaries framework.

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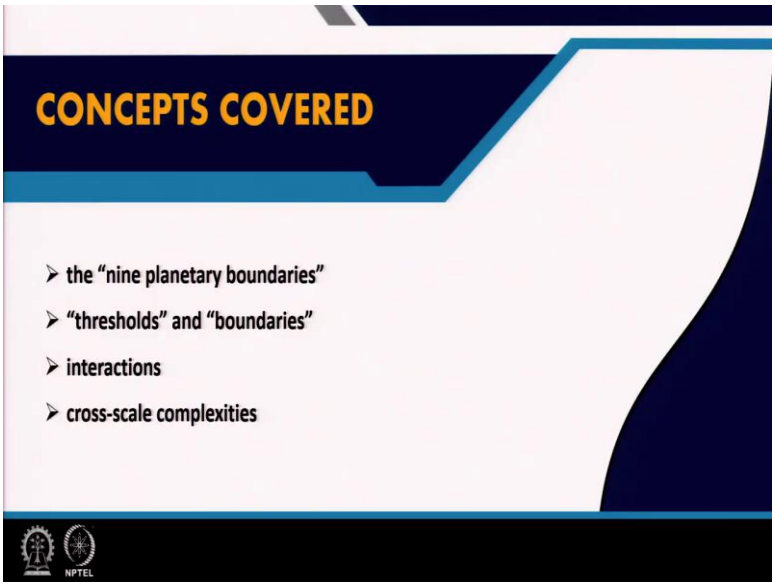

And these concepts are the nine planetary boundaries themselves, what are these nine planetary boundaries. And before you know knowing this least of nine boundaries, we also need to know that what are thresholds and what are boundaries as per the as per the conceptualization or assessment of the Stockholm Resilience Center and more specifically Johan Rockstorm and his team, we will discuss that.

And we are also going to talk about the interactions or the overlaps the overlapping interactions and the feedback loops across these nine planetary boundaries. So, we would and this is related to you know this cross scale complexities. So, we will see that how you know these planetary boundaries and they converge they interact with

each other from local, regional, continental and planetary scales across you know all these four scales.

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So, you know we had discussed in the last presentation that how the period of Holocene was period of stability, but then the irony of the Holocene was that you know as the epoch visualized or encountered growth economic growth. So, this exponential economic growth after a particular point of time, it had impacts on you know it kind of destabilized the biophysical components or processes of planet earth.

And caused abrupt and irreversible changes on environment and unfortunately with a deleterious and oblivious effect on human wellbeing; so, we can see or we can understand you know this we can understand you know this relationship between economic growth and ecological sustainability is inversely proportional.

So, and so as this exponential economic growth had lot of impact on the environment. So finally, it became very important to kind of search or to identify you know what would be the Safe Operating Space – SOS for humanity.

Now, this man Johan Rockstorm and his team, they did a brilliant you know they conducted brilliant research on kind of quantifying the thresholds and, but you know they also discussed the limitations of quantification as a method or you know the limitations of quantification procedure and I will discuss all this.

But what will what is most important is that you know the I think personally I also feel that you know this contribution of this Stockholm Resilience Center, Rockstrom and his team has been enormous in terms of in terms of formulating this framework called the nine planetary boundaries to kind of validate the scientific truth of the present epoch of the anthropocene.

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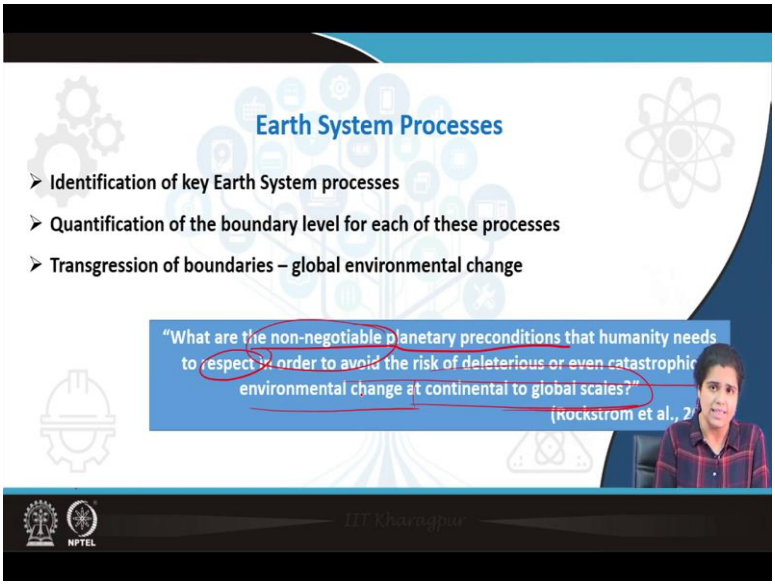

Yes. So, they were earth system scientists, and they wanted to kind of trace these earth system processes by identifying key earth system processes. And how you know this could have been done through the quantification of the boundary level for each of this earth system or for each of these biophysical processes and components.

And the final argument was that you know that if these planetary boundaries are transgressed, if they are crossed, then you know then we will be in major trouble. So, this transgression of boundaries will trigger or each time a boundary is crossed, it triggers like global environmental transformation or change at an irreversible scale alright.

And I think this particular quote by Rockstrom et al is very very significant and to me the keyword is non-negotious, non-negotiable. Non-negotiable is a key word. So, these are the planetary preconditions which are you know non-negotiable. So, which means that we have to perform or we have to kind of we have to keep our economic activities in control. We have to develop or innovate methods, mechanisms, small

scale practices environmentally benign you know processes or technologies that is a different discussion altogether.

But what is most important is that through these planetary boundaries framework they could finally you know talk about the non-negotiable which means conditions with which negotiations are no more possible. So, I personally I very much you know I am quite influenced by this framework.

Why? Because they try to address this particular question I think which is the question of this century. And what is this question? This question is what are the non-negotiable planetary precondition that humanity needs to respect? And this is the second key word. This is the second key word.

A second most important keyword to me because we really need to respect you know this non-negotiable planetary preconditions. And why do we need to respect this? For our own benefit. For the larger benefit of planet earth for the larger benefit of you know all other species with which we cohabit you know this particular planet.

So, what are the non-negotiable planetary preconditions that humanity needs to respect in order to avoid the risk of deleterious or even catastrophic environmental change at continental to global scales? So, these again remain so very important that you know this these changes are occurring across all scale from local to regional to continental to global.

And so we discuss that you know in the Holocene period maybe you know the planet also encountered some changes some ecological changes, but the repercussions were not the repercussions were not enormous in terms of spacial scales. But now the kind of changes that we are encountering we must remember that you know these changes, they are occurring at every scale at all scales you know across local, regional, continental and global scales.

So, you have to remember you know this particular question which is so important and which is so loaded and which explains the context which explains the reason or the rationale which validates the rationale that why the Stockholm Resilience Center and why Rockstorm and his team plunged into this robust exercise of you know

coming up with a framework through which the anthropocene could actually be kind of questioned and also validate it more importantly.

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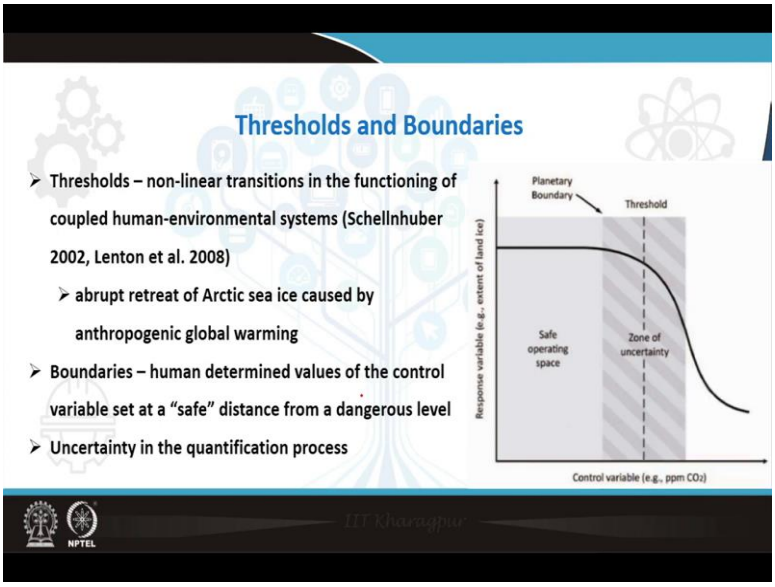

So, Rockstrom talk about talked about thresholds and boundaries. So, they use these two concepts to kind of quantify you know this changes in the biophysical processes of the earth system. So, what are thresholds? So, thresholds are, they explain thresholds as non-linear transitions in the functioning of coupled human environmental systems.

So, these are non-linear transitions for example, which can be explained through the abrupt the recent abrupt retreat of arctic sea ice caused by anthropogenic global warming and you know they pointed out they explained that this for all the different biophysical processes it is the thresholds are actually not known.

So, for example, and also the whole idea that you know these thresholds they are the intrinsic features or they are the non-linear features of this biophysical processes which are also determined by the position of control variables. So, for example, temperature or for example, ice Albedo effect alright in case of sea ice for that matter.

And I was saying that you know it is it was difficult to because all the thresholds are not known. So, it is not possible to kind of to kind of have a concrete knowledge and

understanding about these thresholds. So, for example, land use change. So, for land use change from the continental to the global scale, the threshold is unknown.

But on what basis then they did the calculations, they do the calculations? So, for example, though the threshold is not known from continental to global scale, we are talking about land use change, but at least you know this has been validated that through you know through continuous decline of key ecological functioning like carbon sequestration for that matter.

And if this keeps on getting accumulated or aggregated, then definitely it will trigger or it will have an impact on you know on a global scale threshold for that matter climate change. Again at the same time this will also impact local or regional scale processes like by bringing down or maybe you know having some impact on the threshold in terms of in terms of like lakes or reservoirs or forests alright like savannahs etcetera.

So, the whole idea is that you know through the through by a proper understanding of or a proper mapping of increase or decline or decrease of key ecological functioning, some conclusions could have some conclusions could be arrived at. Now, what is a boundary?

So, the boundary is actually human determined values of the control variable set as a safe distance from a dangerous level. And that is why you know this showed and they said that you know crossing each boundary will be extremely problematic because then our survival would be at stake, the survival of planet earth would be at stake. So, this boundary remain a very important concept to kind of to set this a safe distance from a dangerous level.

But then you know again as thresholds most of the thresholds are unknown. So, we do not know we do not have concrete data about thresholds. It is and these are unknown. So, definitely you know the limitation in this boundary concept is that as it depends on the knowledge relating to thresholds.

So, and as knowledge about thresholds are not have not come down to us. So, there is a whole lot of certainty uncertainty about this. So, already you know this boundary framework, it has this problem of uncertainty ingrained in it. And there is

another point which I would also like to highlight here that is it is not only the uncertainty in the quantification process in terms of in uncertainty about the uncertainty about the threshold, but it is also about you know there are some normative judgments which are also there you know in this process.

Because for example how different complex societies would respond to the risks and uncertainties these are also some questions, and we do not have really you know a hardcore numerical data on this. So, it is quite difficult to kind of make linear conclusions or statements so far as these boundaries are concerned.

So, it has its limitation, but at the same time this is important because at least you know it enable us to kind of be more aware and also engage ourselves in this process of understanding the changes in biophysical processes of planet earth caused by largely by economic activities you know of human beings. So, human induced planetary change.

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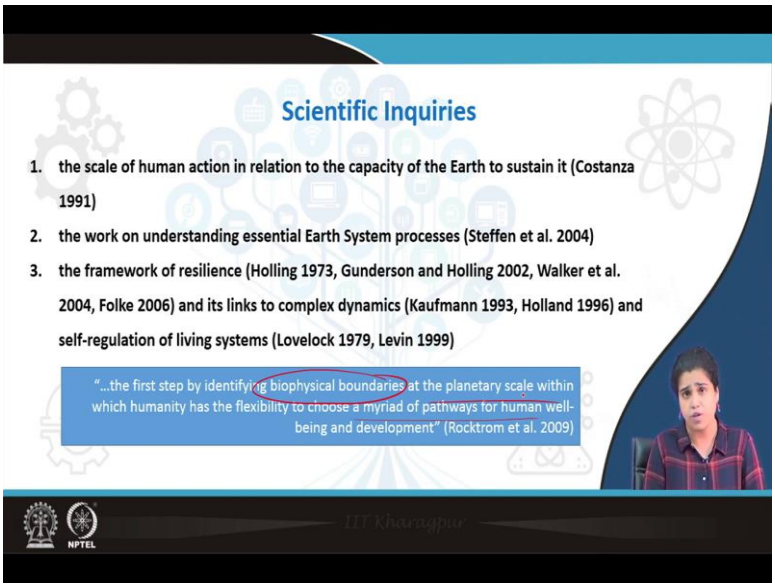

Now, this planetary boundaries framework again it rests on or on three key scientific enquiries. So, the first is the first addresses the scale of human action in relation to the capacity of the earth to sustain it. So, human action on one hand and then the capacity.

So, at what point it, so at what particular point the earth actually reaches you know its saturation point alright. So, the capacity the, so the carrying capacity of the earth, so the scale of human action in relation to the capacity of the earth to sustain it. And I must say that you know it draws largely here they drew largely from the ecological economics frameworks. And for example, you know the works initiated by Costanza and his team.

And the second is the work on understanding essential earth system processes. So, here they drew heavily from sustainability science and from earth system science. And the third is the framework of resilience and its links to complex dynamics and self-regulation of living systems emphasizing on like multiple basins of attraction and threshold effects. So, these are the three important scientific enquiries on which the planetary boundaries framework actually rest.

And again Rockstrom, they argue that the first step by identifying biophysical boundaries at the planetary scale within which humanity has a flexibility to choose a myriad of pathways for human well being and development. This is a very important statement which is close to my heart because they said you know they say that it is not a doomsday message. It is not a doomsday message, but this exercise is important.

This exercise is important because through this exercise we will be in a position to kind of identify you know these biophysical boundaries at the planetary scale, at the global scale. And then we will understand that what are our limits. So, what is the boundary, and we also discussed about this non-negotiable planetary preconditions.

So, if we are aware of you know of the of each boundary, then we will have we will be in a position to think about our next course of actions. So, then we can choose we can select a myriad of pathways you know for our own being for our own well-being for the own for the well-being of the planet earth at large.

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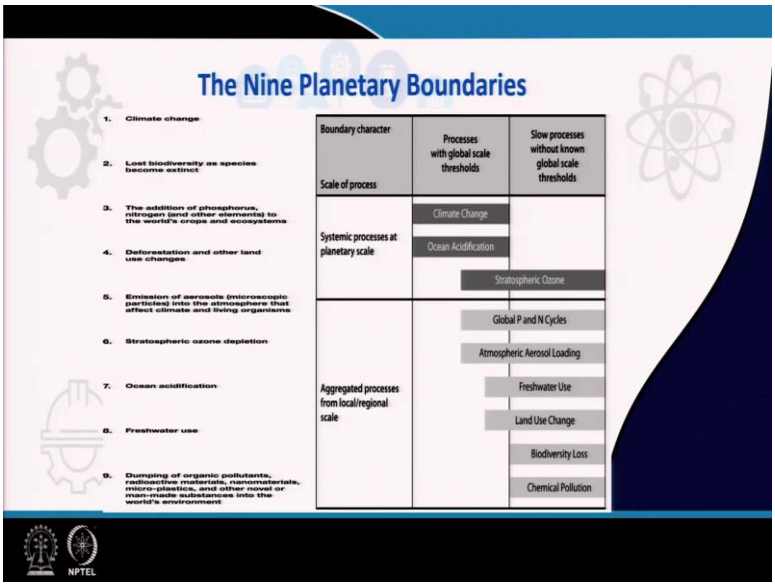

So, these are the nine planetary boundaries, climate change, loss of species, biodiversity extinction of species, addition of phosphorus and nitrogen, so phosphorus and nitrogen cycles, deforestation and land use change, emission of aerosols, then statographic stratospheric sorry ocean depletion, ozone depletion.

So, this is ozone depletion stratospheric, ozone depletion, and ocean acidification, fresh water use, and dumping of organic – so chemical pollution. So, these are the nine planetary boundaries which they identified.

And there also this group made a distinction between boundaries which were directly related to sharp you know planetary scales. Here you can see the distinction and also the slow boundaries where you know the there is no clear cut evidence till date about the threshold.

And which also shows the underlying resilience of planet earth in the form of you know in the form of functioning as sink, and also regulating you know water, then mineral, and other you know the other mineral nutrient fluxes etcetera. So, this distinction is also very much there in this in the identification and mapping of these nine planetary boundaries.

And I think one important point is that that though they made this distinction between you know more direct and rapid variable and slow variables, but till they

you know they kind of provided a warning. So, there is also a warning note in this distinction that if even you know slow variables they keep on aggregating and accumulating for a period of time, then of course they can trigger major changes at the planetary scale for which we really I mean so which should draw you know our concern which should draw our concern.

So, this it is important to understand the nature of these boundaries and how these processes are at play across again the interplay of constant and not so constant variables. And also they talked about you know large scale or maybe you know planetary scale processes like for that matter climate change which also has lot of impact on a sub earth system, on sub earth system processes and scales.

So, for example, this climate change it is itself at least associated with the nine subsystem tipping elements which are all sensitive to climate change. So, I think the beauty of this planetary boundaries framework is that it also addresses the cross scale you know complexity. So, the cross scale complexities have been addressed I mean quite systematically and scientifically in this nine planetary boundaries approach.

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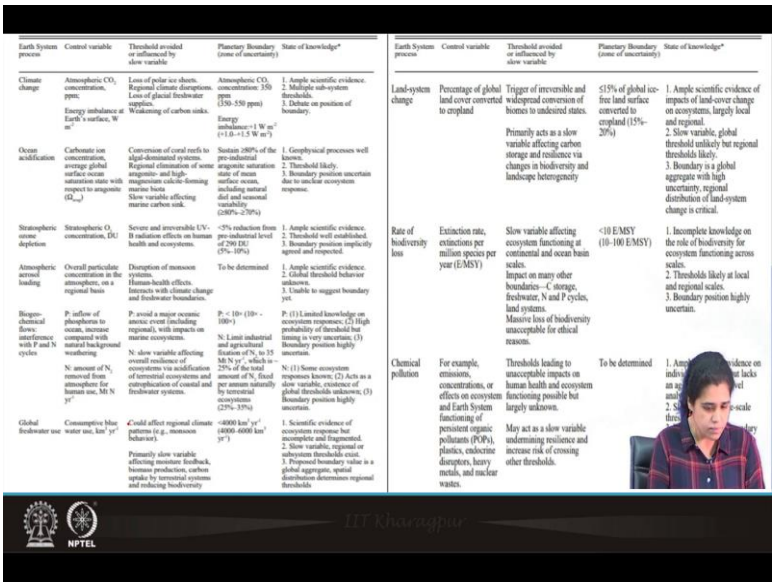

So, this is a very complex table. And in the reading in the reading list, you will see that I have you know I have provided you with this reference. This is this article by Rockstrom and his team which was published in 2009 in Ecology and Society. And

you have no option, you have to really go through this article in great detail if you have to have a better understanding of this nine planetary boundaries framework.

And is it will be crucial not only for this urbanization and environment course. Of course you have to have a I mean great deal of understanding about these about anthropocene and urbanocene and all other cenes like technocene capitalocenes etcetera which will cover in our subsequent lectures.

But I think this is very very important for researchers who are working in the domain of the environment, be it from the natural science perspectives, or the social science perspective or a combination of both. So, please you cannot avoid this framework and this article by Rockstrom and team.

And this is the table and this table itself is like it is loaded. But at the same time it is quite explanatory, self explanatory. So, it is explanatory by itself. So, I will not go into the details, but here they talk about all these earth system processes, the control variables, the you know boundary as zone of uncertainty.

And what is our knowledge? So, what is our knowledge about each boundary? But just the disclaimer that you know this the data is not updated here. Because this is the data which pertains to this to 2009 because this article came out in 2009, but after that Stockholm Resilience Center has conducted number of research on you know kind of updating this information.

So, and you will see the I will also talk about this in the last leg of this lecture that you know by now how some planetary boundaries unfortunately have already been transgressed. And because here the here also like if you see the table it also talks about you know how climate change the first boundary has already been transgressed. So, we are not in the safe operating space so far as the first planetary boundary that is climate change is concerned.

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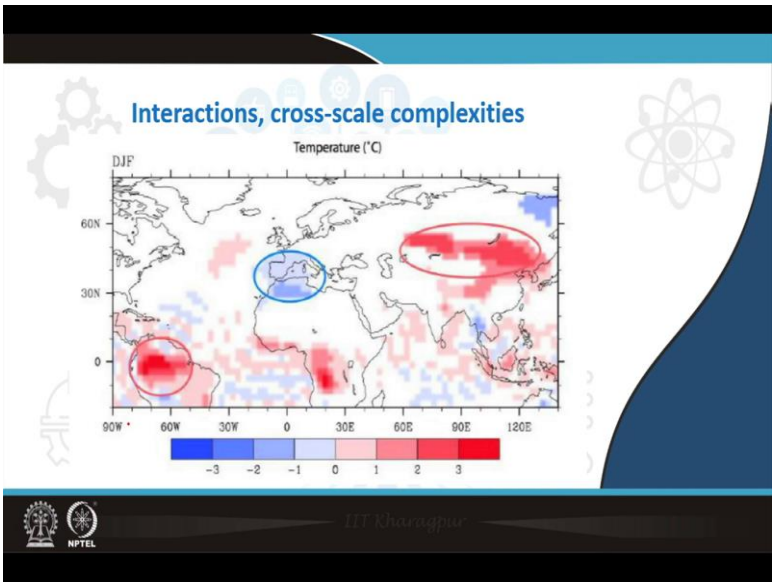

So, this is again a very significant simulation diagram or a simulation model which was developed by the CCM3 climate model. And this simulation model it clearly shows the interactions, and cross-scale complexities which are there in terms of you know changes in a particular region and how that how a particular change in a specific region can have a whole lot of impact on other spatial sites.

So, what are the cross connection, what are the what are the interactions, what are the overlaps, what are the what are the you know cross scale complexities that this through which can also be understood by you know applying or this by deploying this planetary nine planetary boundaries framework as the frame of analysis?

So, here for example I will give an example. Let us take the example of Amazon Forest right. So, Amazon Forest you know in the Amazon Forest a considerable amount of water, a considerable amount of water is recycled through vegetation alright. And the forest also forest and vegetation also like it flushes aerosol particles. And these aerosol particles are again remain this aerosol particles remains crucial for the formation of clouds alright.

And so if there are changes in you know concentration in concentration of particles in, so if there are transformations or there are changes in particle concentration, then it can impact the rains precipitation and also the strength of the convective circulation on the on that region on that belt.

So, this can again have some form of impact on you know on aerosols itself. And moreover like you know this deforestation it has deforestation and land use change in Amazon, it definitely it has a lot of it can trigger change, it can destabilize the regular precipitation pattern. And this can again have an impact on the vegetation and on the aerosols.

So, this is a clear cut example of a feedback loop that is there in the Amazon basin. And one can understand that you know if this change continues for a long period of time, then the there can be replacement of the entire Amazon so that we can see a change in the nature of the Amazon Forest where you know it can even transform into a savannah like forest by the end of the 21st century. So, we can understand you know how this feedback loop actually works.

Now, the next argument is that you know these interactions are not only limited within this regional scale of the Amazon, but it has more advanced repercussions. So, for example it will not be an exaggeration. If I say and this has been proved and justified with the simulation model that changes in Amazon, it will influence it will have an impact on the surface temperature of Tibet for that matter.

So, like for example, the changes in precipitation level, it can affect the energy balance of the again of the convective circulation. And this can cause a northward shift of the inter tropical convergence zone which will again you know have an impact on the weather conditions. And finally, you know this will affect surface temperature in Tibet.

The story does not end here. So, the surface temperature change in Tibet will have repercussions on the water resources of Asia. So, for example, you know this 15,000 glaciers in the Himalayan Hindu Kush region are responsible for 12,000 cubic kilometers of fresh water for this entire basin for this entire region. And I mean it caters to the need of like 500 inhabitants, 500 million inhabitants and plus an additional like 200 million inhabitants in China.

And so you know these changes in this glaciations pattern change changes in that glacier belt, it will definitely have impact on floods. And it in the short term, it can cause increased run off, it will trigger floods or flood even flood vulnerability in the region.

And it will have sets of impact on you know on precipitation variability. So, you can understand that how you know all these planetary boundaries are interconnected to each other through this cross-scale in you know interactions and overlaps.

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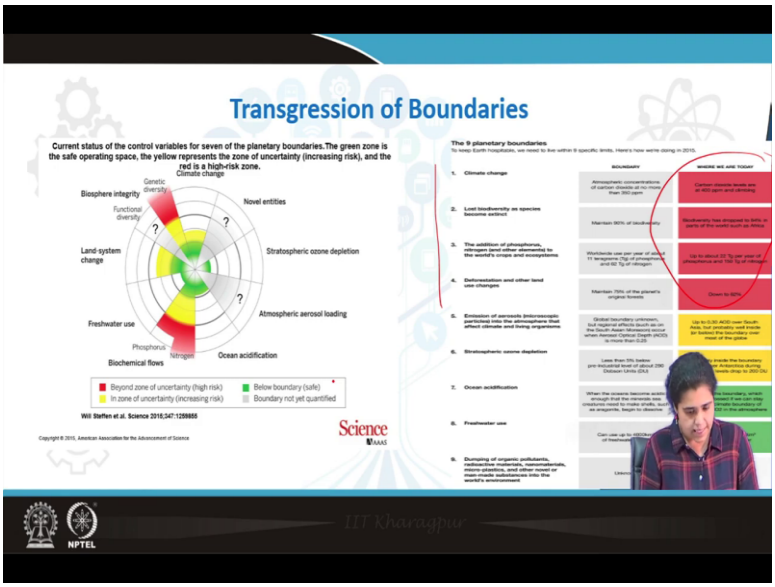

Yes. So, I was also talking about the transgression of the boundaries. So, you can see that how you know yeah. So, out of this nine planetary boundaries, how already you know we have kind of crossed. So, these are crucial thresholds, and unfortunately no more we are in the safe operating space so far as these four thresholds are concerned.

So, you can take a more detailed look into this slide to get an understanding of our present situation because that is the idea through planetary boundary we need to know and understand our present situation. So, that we can design and develop and innovate you know innovate strategies through which we will be in a position to remain within this safe operating space, yes.

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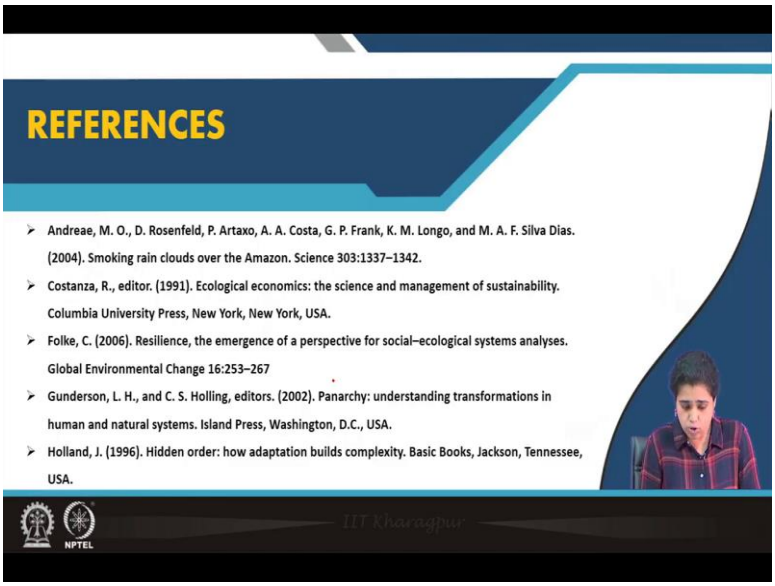

So, these are the references again, and I would definitely you have no option.

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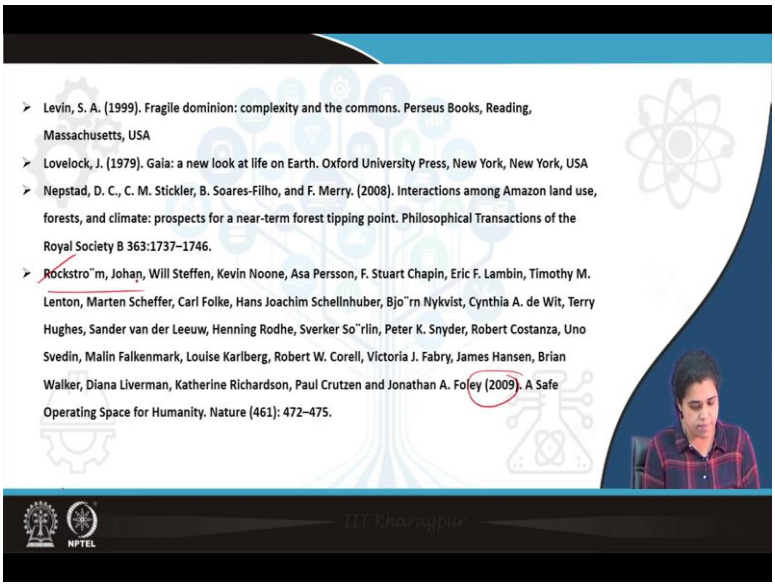

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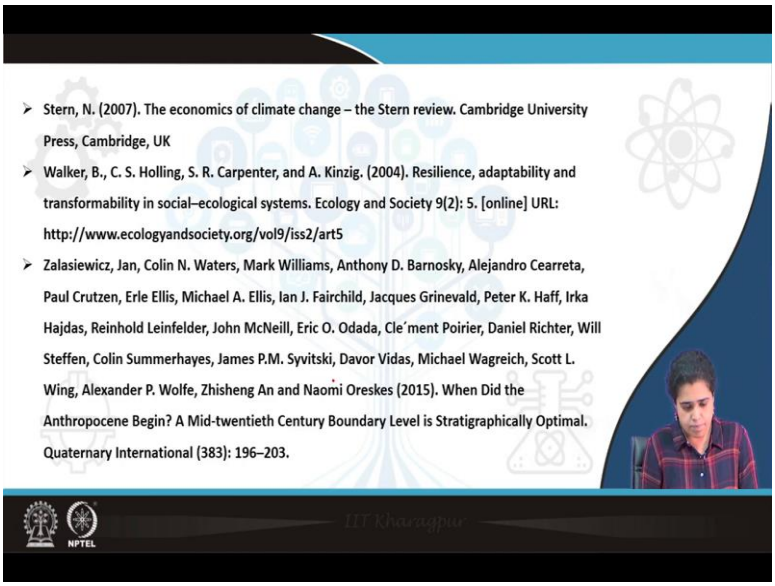

But you have to go through the particular article by yes; by Steffen and Rockstrom and team and these. So, these two articles. So, this one which so which came out in 2009 in Ecology and Societies Rockstrom and his team.

And this particular article by Will Steffen, and the you will find similar names because they updated the information in 2015. So, I showed you the table from the 2009 article, but if you also go through 2015 article it will be little bit updated you will have updated information and facts about you know where we are at this particular stage, yes.

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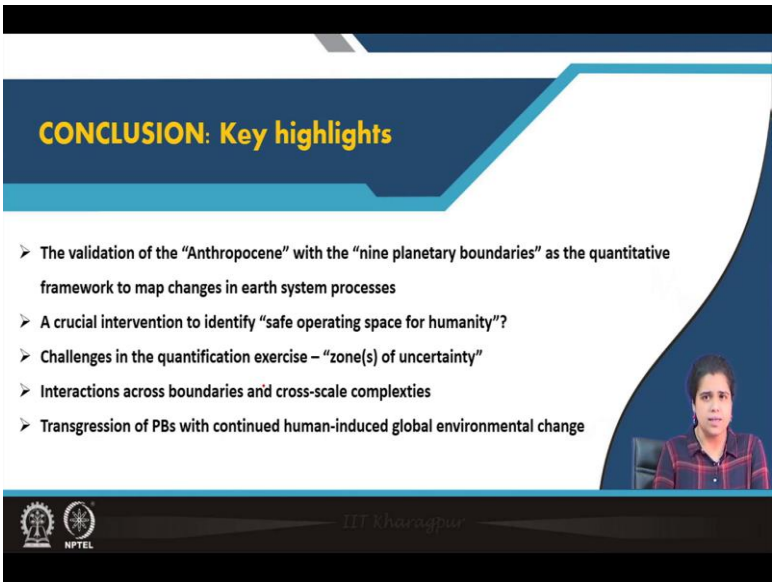

So, let us conclude the lecture with the key highlights. So, what we did here is we discussed planetary boundaries. So, why did we discuss planetary boundaries as a topic?

Because it is an important tool of analysis, it is an important quantitative framework through which you know anthropocene actually has been validated; that yes we are on a new era we are on a watershed on a watershed epoch where the earth is changing at a very fast space.

And so it is important for us to identify safe operating space for humanity. And there are so there are some challenges there are some limitations because we do not have we do not have proper knowledge about these thresholds.

So, they I mean these planetary boundaries can also be considered to be zones of uncertainties, but you know at least you know this boundary is this threshold and boundary concept are important because they enable us to understand our position and enable us to understand you know the changes that are occurring at the biophysical that are occurring at the biophysical components from local to the planetary scales.

And finally, there are interactions among boundaries. So, maybe even if a boundary is at a safe position now, but even continuous decline in key ecological functions can

actually trigger and destabilize the system and it can be a concern for humanity in the long run. So, that is the that warning is also there.

And if you understand planted boundaries properly, we will be in a position to understand that you know this how transformations in these scales can really have an impact across time across space and you know at the global scale. And finally, we also learned that already the earth has transgressed some of this planetary boundaries, but again I do not want to end with a doomsday message because I think that we also have hopeful stories to cherish and to relish upon.

For example, through concerted human action, some changes I mean some improvement could actually occur so far as this planetary boundary of stratospheric ozone depletion is concerned. So, please go through I will encourage you to go through Montreal protocol. And how you know through concerted human action the world could manage and tackle this particular problem of ozone depletion and where we are right now.

So, the whole idea is that through you know through deliberate concerted actions, we can really act and enact if we have the will. But is will the keyword? So, that is what we are going to discuss in our next lecture on the capitalocene.

Thank you.